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USDA
1400 Independence Avenue, SW
Room 2646-S, STOP 0268
Washington. DC 20250-0268

To whom it may concern.

Regarding our petition of November 4, 2011 which requests the addition of vinasse to section 205.601 of the National Organic Program's (NOP) National List of Allowed and Prohibited Substances (National List).

We would like to state the following:

There is no specific required information contained in the petition that is considered to be confidential business information or confidential commercial information and the basis for that determination.

Sincerely,

Jetze de Raad

National List Coordinator
USDA/AMS/NOP, Standards Division
1400 Independence Ave. SW
Room 2646-So., Ag Stop 0268
Washington, DC 20250-0268

Re: Petition to add Vinasse (beet-, cane-) as a synthetic substances allowed for use in organic crop production, § 205.601

Dear NOSB Committee,

BioBizz Worldwide NV requests that the National Organic Standards Board (NOSB) review the enclosed petition to add Vinasse (beet-, cane-) as a synthetic substances allowed for use in organic crop production, § 205.601.

Vinasse (beet-, cane-) is a by-product of the distillation of alcohol liquors and from yeast and amino/organic acid production through the fermentation of sugarcane and/or sugar beet molasses, a by-product of sugar manufacturing. Studies of the use of molasses vinasse as an agricultural fertilizer have been documented since the 1940's. Studies indicate that vinasse is high in important minerals, vitamins, and organic acids necessary for crop production, and improves the soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances.

Molasses vinasse (beet-, cane-) has previously been classified as a non-synthetic substance by accredited certification agencies (ACA's) and the Organic Material Review Institute (OMRI). In January, 2010, OMRI notified BioBizz Worldwide NV that molasses vinasse was determined to be a synthetic substance due to inclusion of sulfuric acid or sulfur dioxide during processing of sugar and alcohol, yeast or amino/organic acid products.

Thank you in advance for you time and effort.

Jetze de Raad
BioBizz Worldwide N.V.
C/O BB Products, BV
Koldingweg #7
9723HL Groningen – The Netherlands

Submitted for BioBizz World Wide by:
The Organic Consulting Firm
28999 Old Town Front St. Suite 101
Temecula, CA 92590
760-802-0134

Vinasse (Cane-, Beet-)

Crop Production

A. *Please indicate which section or sections the petitioned substance will be included on and/or removed from the National List.*

- Synthetic substances allowed for use in organic crop production, § 205.601.

B.

1. *Substance chemical or material common name:*
   Vinasse (beet-, cane-)
   Byproduct obtained after fermentation of beet or cane molasses during the production of alcohol, yeast, and amino/organic acids. Also known as molasses vinasse, stillage, molasses stillage, distillery wastewater, distillery slops, cane molasses solubles (CMS).

2. *Manufacturer or producer name, address, phone & contact information:*
   BioBizz Worldwide, NV
   BB Products BV
   Koldingweg 7 a 9723 HL
   Groningen, Holland
   Tel: ++31(0)50-5492618
   Fax: +31(0)50-5497883
   Info@biobizz.nl

3. *The intended or current use of the material.*
   Vinasse (beet-, cane-) used as a Plant Nutrient/Soil Amendment in organic crop production.

4. *A list of the crop, livestock, or handling activities for which the substance will be used. If for crops, the substance's rate & method of application must be described.*
   Vinasse is used as a plant fertilizer and soil amendment in crop production. Depending on soil and plant nutrient requirements and cultural practices, vinasse may be applied at 1-2% diluted solution to land (80-160 liters per acre) through irrigation or foliar spray for direct absorption by the plant. Vinasse may be used as a compost ingredient in the composting of raw manure and/or other plant materials such as straw, plant residues, etc. When applied directly to land, it may be applied 30-40 days prior to planting which allows the organic matter in the vinasse to naturally break down; increasing beneficial microbial activity and mineralization in the soil. Vinasse may be mixed with a nitrogen source, such as fish emulsion, for a more complete liquid fertilizer.

5. *Source of the substance and detailed description of its manufacturing procedures from the basic components to final product.*
   The production of Vinasse (beet- and cane-) begins with the processing of Sugarcane and Sugar Beets to produce sugar, pulp, and molasses. Vinasse (beet-, cane-) is a byproduct of the further processing of Molasses (beet-, cane-) during the production of alcohol, yeast, and amino/organic acids.

The processing procedures described in this petition were researched through literature listed in the reference section. The literature reviewed indicates that sugar beets and sugarcane are similarly processed around the world with some variation due to region or government concerns. The most common method of production is summarized below.

Sugar Manufacturing Process:
The main purpose of processing raw sugarcane and sugar beets is to extract sugar (sucrose) to be sold as raw or refined crystalline sugar and syrup.

- Byproducts of sugar beet processing are beet pulp and molasses. Beet pulp may be mixed with molasses, dried, and sold as livestock feed.
- Byproducts of sugar cane processing include bagasse, molasses, and filtercake. Bagasse, the fibrous residue of cane, is primarily used as a fuel source for boiler and lime kilns at the processing plant, but also for the production of various paper and panel board products, as agricultural mulch, and as a raw material for the production of chemicals. Dried filtercake is used as an animal feed supplement, agricultural fertilizer, and as a source of sugarcane wax.
- Sugar Beet and Sugarcane processing produces two forms of molasses: edible syrup and blackstrap (inedible for humans). Blackstrap molasses (beet and cane) is used as an animal feed additive and to produce alcohol (ethanol) liquors, compressed yeast, and amino and organic acid products.

Sugar beets and cane are harvested and shipped to a processing facility where they are cleaned, chopped, pressed, and/or crushed to extract juice. Water and/or juice may be added during the extraction stage. In addition, in accordance with governmental requirements, mill sanitation, or available technology, sulfur dioxide, chlorine, ammonium bisulfite, or commercial government-approved biocides may be used as disinfectants during the juice extraction process to prevent bacterial growth in the raw juice.

The raw juice is clarified, evaporated, crystallized, separated from byproducts by centrifugation, and dried. The clarification process may be performed prior to or after the evaporation process. Some sugars are further refined prior to storage and packaging.

Clarification is done almost exclusively with heat and lime (as milk of lime or lime saccharate). A small amount of soluble phosphate and polymer flocculent may also be added. The juice is blended with milk of lime. Milk of lime [$Ca(OH)_2$] is added to absorb or adhere to the impurities of the mixture. CO_2 gas is bubbled through the mixture to precipitate the lime as insoluble calcium carbonate crystals. The small insoluble crystals are separated from the clarified juice by gravity or through centrifugation and filtration. After filtration, a small amount of sulfur dioxide (SO_2) may be added to the juice to inhibit reactions that lead to darkening of the juice. SO_2 is primarily used in the processing of beets and green, immature cane. Most facilities purchase SO_2 as a liquid but a few produce SO_2 by burning elemental sulfur in a sulfur stove. The clarified juice (also known as thin juice) is transferred to the evaporators.

Clarified juice passes through a series of five evaporators to concentrate the juice. Crystalline sugars produced later in the process may be added to the juice and dissolved in the high melter. This mixture, standard liquor, is filtered and proceeds to the crystallization process.

Sugar crystallization is a two-step process and starts by low temperature boiling in vacuum pans. The standard liquor is boiled until it is supersaturated and then discharged to the mixer (crystallizer). To begin crystal formation, the liquor is either “shocked” using a small quantity of powdered sugar or is “seeded” by adding a mixture of finely milled sugar and isopropyl alcohol. The crystals are grown through careful control of the vacuum, temperature, feed-liquor additions, and steam. When the crystals reach the desired size, the mixture of liquor and crystals known as massecuite (A massecuite) is transferred to high-speed centrifugal machines, in which the mother liquor (A molasses) is separated from the sugar crystals. The A molasses is returned to the vacuum pans and re-boiled to yield a second massecuite (B massecuite), that in turn yields a second batch molasses (B molasses) and sugar crystals. The raw sugar is combined with the first crop of crystals, which may be packaged and distributed as raw sugar or further processed into refined sugar.

The B molasses is boiled again to form a low-grade massecuite (C massecuite), which yields black strap molasses and a low grade sugar. This low-grade sugar is mingled with syrup and is sometimes used in the vacuum pans as a “seeding” solution.

Raw sugar that is further processed to refined sugar is washed to remove residual molasses. The syrup from the wash water, called affination syrup, is transferred to a remelt processing station and reduced in volume to form massecuite. The molasses and sugar crystals are separated from the syrup through centrifugation. The molasses is known as blackstrap molasses.

Blackstrap molasses (molasses) from the third stage of raw sugar production and first stage of refined sugar production is a dark, thick, viscous liquid. Molasses contains 45 to 55 weight percent fermentable sugars, in the forms of sucrose, glucose, and fructose, and organic content including vitamins, minerals, proteins, and amino acids. There are several grades of molasses depending on the sugar content, ash content, and color. Molasses (beet, cane, or a combination of both) is primarily used as a livestock feed additive and as a feedstock in the fermentation process of ethanol as a beverage, industrial chemical, or biofuel, and in yeast propagation, and amino and organic acid production.

Molasses Fermentation Process: Alcohol, Yeast, and Amino/Organic Acid Production

Molasses Fermentation Principles

The principles of fermentation of molasses in alcohol, yeast, and amino/organic acid production processes are the same throughout the world, although specific processes may vary in some regions due to feedstock type and quality, cultural practices, available technology, and governmental requirements. Additionally, the distillation process for alcohol production may vary according to the purpose of the alcohol, such as industrial ethanol, or varying types of beverages, such as rum and whiskey.

Blackstrap molasses is transferred to storage tanks at a distillery or processing facility. Molasses is transferred from storage tanks to the fermentation tank where it is tested for pH, bacterial, and essential mineral levels. Sulfuric acid is used to adjust and maintain the pH level during fermentation. Water and yeast are added to the molasses mixture to start fermentation. The molasses mixture is allowed to ferment for 12-40 hours for rum and industrial grade alcohol, biofuel, yeast propagation, and amino/organic acid production. Strains of bacteria may be present in the molasses from the local environment of the sugar manufacturer, may be present in the local water of the distillery which is used during fermentation, or specific strains of cultured bacteria may be added to the molasses mixture at the same time as the yeast cultures during the fermentation process. In some areas due to cultural practices or governmental requirements and depending on the grade and contamination level of the molasses, the molasses may be sterilized by high-pressure steam, by the use of antibiotics such as penicillin, or the use of bactericides such as chlorine dioxide, ammonium bifluoride, or quaternary ammonium compound prior to fermentation. Ammonium compounds or yeast extracts may also be used to raise the nitrogen level of the solution to required levels necessary for fermentation.

Alcohol Distillation Process

Ethanol (C_2H_5OH), also called ethyl alcohol, pure alcohol, grain alcohol, drinking alcohol, or simply as alcohol or spirits, is an organic compound in the class of alcohols that is naturally produced through the fermentation of sugars (carbohydrates) with yeast. The production of ethanol, from sugar crops, starch crops, dairy products, or cellulosic feedstock co-produces stillage. Stillage, also called distillery wastewater, distillery pot ale, distillery slops, distillery spent wash, dunder, mosto, vinasse, and thin stillage, is the aqueous byproduct from the distillation of ethanol following fermentation of carbohydrates.

After fermentation, as described in the “Molasses Fermentation Principles” section of this petition, the yeast, which has settled to the bottom of the tank, is separated from the liquor mixture called fermented beer. The separated liquor mixture is fraction distilled. Batch distillation may be performed with various types of equipment. The simplest form is a single simple pot still. The fermented beer is heated in a pot fitted with a vapor pipe, which leads to a condenser coil immersed in a water tank. As the beer is heated, the alcohol and other volatile congeners are distilled off, condensed, and run into a storage tank. The process is continued until most of the alcohol has been distilled out of the beer. The beer residue, or stillage, is emptied out of the pot and the distillate is returned from the storage tank to the pot to be redistilled to increase the proof. Stillage (vinasse) is removed from the first distillation tank.

Yeast Propagation

Yeast propagation follows the fermentation process described in the Molasses Fermentation Principles section of this petition, including the usage of an additional nitrogen source, and may include the addition of vitamins, as well as phosphates and magnesium, in the form of phosphoric acid, phosphate salts, and magnesium salts. Yeast cells are grown in a series of fermentation vessels. Yeast fermentation vessels are operated under aerobic conditions. Once the optimum quantity of yeast has been grown, the yeast cells are recovered at the final fermentation stage by centrifugal yeast separators. Vinasse is the remains of the feedstock after the final fermentation stage.

Amino Acid/ Organic Acid Production

Production of amino acids, i.e. glysine or glutamic acid, and organic acids, i.e. lactic or citric acid, follows the fermentation process described in the "Molasses Fermentation Principles" section of this petition. Amino acid production, such as glutamic acid, mainly uses specified bacterium for microbial fermentation and may use oleic acid as an antifoam agent when necessary. Organic acid, such as lactic acid, generally require complex nutrients such as amino acids and vitamins for cell growth. Yeast extract is the most commonly used nitrogen source which provides vitamin B complex content, in addition to organic nitrogen. The buffering capacity of molasses is an advantage in slightly lowering and maintaining pH balance.

Vinasse Resource Recovery

Since the 1980's, environmental awareness has promoted more stringent requirements for proper disposal or renewable resource recovery of the large amounts of solid waste (bagasse, pulp) and wastewaters (molasses, vinasse). Vinasse is used as feedstock in biofuel production and as an agricultural fertilizer and soil conditioner. Vinasse has important qualities as an organic fertilizer, containing macro nutrients such as nitrogen, potassium, calcium sulfate and magnesium, and chelate organic material with micronutrients such as iron, manganese, zinc, and copper. Due to the high content of complex B vitamins and amino acids from yeast autolysis, vinasse is also used as a soil conditioner for the production of beneficial microorganisms in the soil and as an ingredient in the animal feed formulations.

BioBizz Worldwide, as the fertilizer manufacturer submitting this petition to the USDA National Organic Program and the National Organic Standards board, purchases vinasse as a complete ingredient and is not involved in the sugar, alcohol, yeast, or acid production processes. The vinasse ingredient obtained is packaged for sale by BioBizz Worldwide with either no further processing, or is mixed with fish emulsion and may be diluted with water prior to packaging for use as liquid fertilizer products.

6. *Summary of any available previous reviews by State or Private certification programs or other organizations of the petitioned substance. If information is not available, petition must state so.*

Vinasse (beet-, cane-) has been classified as a non-synthetic substance by accredited certification agencies (ACA's) and the Organic Material Review Institute (OMRI).

OMRI recently withdrew its approval of Vinasse due to the inclusion of sulfuric acid or sulfur dioxide during processing of sugar and the processing of molasses into alcohol, yeast, and amino/organic acid products. Molasses is currently listed on the generic OMRI list as an allowed nonsynthetic crop fertilizer and soil amendment with the annotation stating the material may be from nonorganic sources and must be from non-genetically modified plants.

BioBizz products containing beet/cane vinasse were removed from the OMRI List of Approved Products in January 2010, when BioBizz submitted a new MSDS, provided by the supplier, indicating that sulfuric acid was used during processing of the vinasse ingredient. Research for the OMRI appeal process and for this petition, including the estimated percentage of organic sugar production and sales worldwide, indicates that over 95% of molasses vinasse contains sulfuric acid from some point in the sugar manufacturing and the fermentation of molasses in alcohol, yeast, and amino/organic acid production processes.

International Organic Regulations

European Union 889/2008

Annex 1, Fertilsers and soil conditioners as referred to in Article 3(1): allows

- Stillage and stillage extracts, excluding ammonium stillage, for use in organic crop production.
- A composted or fermented mixture of vegetable matter from product obtained from mixtures of vegetable matter, which have been submitted to composting or to anaerobic fermentation for biogas production.
- Industrial lime from sugar production a by-product of sugar production from sugar beet

Annex V, Feed materials referred to in Article 22(1), (2) and (3): allows

- Section 1.4 Tuber, Roots, their products and by-products: Sugar beet pulp
- Section 1.7, Non-Organic Feed Materials of Plant Origin, Other plants, their products, and by-products: Molasses.

Annex VI, Feed additives and certain substances used as in animal nutrition referred to in Article 22(4):

- Section 3, Substances allowed for silage production: sugar, sugar beet pulp, and molasses.

Annex VIII, Section B- Processing Aids and other Products, which may be used for processing of ingredients of agricultural origin from organic production: allows

- Sulfuric acid for sugar(s) production.

Codex Alimentarius, Annex 2, (Codex Alimentarius, 2009)

Annex 2, Permitted Substances For The Production of Organic Foods

Table 1: Substances for use in soil fertilizing and conditioning: allows

- Stillage and stillage extracts, excluding ammonium stillage
- By-Products of the sugar industry (e.g. Vinasse), Need recognized by the certification body or authority.

Table 4, Processing Aids which may be used for the preparation of products of agricultural origin referred to in section 3 of these guidelines: allows

- Sulfuric Acid for pH adjustment of extraction water in sugar production.

<u>CARTV- Canadian Organic Regulation CAN/CGSB-32.311-2006</u>, amended December 2009
Section 4.2 Soil Amendments and Crop Nutrition: allows Non GMO

- Molasses, Shall be organic molasses unless not commercially available.
- Sugar, Organic sugar may be used as an ingredient in a crop production aid.
- Stillage and stillage extracts, ammonium stillage is prohibited

7. *Information regarding US FDA, EPA & state regulatory authority registration, including registration numbers. If this does not exist, state so in petition.*
   No US FDA, EPA, or state regulatory authority requires registration of beet or cane molasses vinasse.

8. *Identify CAS #. If none, petition should state so.*
   There is no CAS # or EINECS # assigned to Beet or Cane Vinasse, molasses stillage, CMS, or any other common name used for beet or cane vinasse.

9. *Describe physical properties & chemical mode of actions including:*
   Physical and chemical properties:
   Physical state at 25° C : Low viscosity liquid
   Color : Very dark brown
   Odor : Weak caramel non-pungent
   pH value : About 5.4 to 6.8
   Initial boiling point (0°C) : >100
   Flammability, Flash point (0°C) : Not applicable
   Explosion limits (lower) (kg/m^3) : Not applicable
   Relative Density at 20°C (Kg/l) : About 1.33
   Viscosity (cps) at 20°C : About 100
   Solubility in water (% weight) : Forms infinite aqueous solution
   Vapor pressure (hPa) : Not applicable

   a. *Chemical interactions with other substances, especially with substances used in organic production.*
   Vinasse (beet-, cane-) is stable under normal ambient conditions and is not listed as a hazardous substance. No special handling precautions are required. Burning can produce CO_2, and water, N compounds. Avoid microbiological contamination or

dilution with water. Vinasse is microbiologically stable unless diluted with >5% water when yeast, mold and some harmless bacterial (eg Lactobacillus spp.) growth may occur in warm temperatures. Pathogens will not grow, indeed are killed. Vinasse (beet-, cane-) is incompatible with strong acids and alkalis and oxidizing agents. Heat (> 90° C) and mixing vinasse with incompatible products can release NO_x.

The characteristics of the organic content in concentrated vinasse are, basically, high hygroscopicity, which accelerates the humidification and agglomeration of particles, and a high presence of chelated organic compounds, especially as molecules of different alcohols (4.3%), carboxylic acids (5.6%), and fulvic acids (35%), which characteristically produce very stable chelates. The organic acids found are, basically, acetic, lactic, aconitic, matic and citric acids. The fulvic acids found in the vinasse have a molecular average weight of 4500 gl/mol, which is foliarly assimilable, and due to its capacity of generating coordinated bonds with bivalent and trivalent cations, generates complex chelates of iron, copper, manganese, zinc and boron.

b. *Toxicity and environmental persistence.*
Vinasse (beet, cane) contains no toxic chemicals. Oral, dermal and inhalation toxicity is rated as not applicable. Vinasse is not carcinogenic. There is no bioaccumulation of vinasse or components of vinasse as it easily decomposes by micro-organisms in soil or water. Because of the high decomposition rate of the organic matter, the components of the material do not accumulate.

c. *Environmental impacts from its use and or manufacture.*
Several studies have been performed on the environmental effects of sugar manufacturing and distillation effluents or wastewaters, including molasses and vinasse. Sugar and distilled products from sugar byproducts have been manufactured worldwide for centuries. In the past century, sugar production, processing, and distillation have grown tremendously with consumer demand. Since the 1980's, environmental awareness of the polluting effects of sugar manufacturing and distillery wastes has influenced changes in production and processing methods to reduce intensive water and energy usage and has promoted more stringent requirements for proper disposal or renewable resource recovery of the large amounts of solid waste (bagasse, pulp) and wastewaters (molasses, vinasse).

Research for recovering valuable resources from the industry wastes, such as vinasse usage on agriculture land, began as far back as the 1940's. Since vinasse is mainly of plant origin, with some microbial residue (yeast), it does not contain any toxic chemicals or residue. Many studies exist reporting that vinasse is a good fertilizer, a potential source of organic matter and plant nutrients, especially for its P and K values, a soil conditioner which stimulates growth of beneficial microorganisms in the soil, and allows better uptake of nutrients into the plant.

No significant environmental hazard or adverse effect from human or animal exposure resulting from accidental release of this material is anticipated. Its components are used in food and feed and there is no LD_{50} (Median Lethal Dosez). The components of vinasse are biodegradable and are readily metabolized and utilized by microorganisms as energy sources. Due to the organic matter composition, vinasse has high Biological Oxygen Demand/BOD (mgO_2/g ds) of about 300 and Chemical Oxygen Demand/COD of about 350. For agricultural usage of vinasse as a fertilizer or soil condition, the application of the material 40-60 days prior to planting or composting with raw manure or other plant materials will give sufficient time for the natural oxidation of the organic matter.

Environmental impacts from its manufacture worldwide has shown that high volume release of vinasse as a wastewater directly into waterways causes discoloration of water, strong odor, and salinization of fresh waterways. In extreme cases, eutrophication may temporarily occur, where the decomposition of the organic matter decreases the oxygen in the water and increases algae growth, which disrupts or harms the waterway ecosystem. High volume disposal of vinasse on land increases soil salinity and compaction levels, but because of the high decomposition rate of the organic matter, the components of the material do not accumulate in the soil, including NO_3 and NO_4. Proper disposal of the material and notification of accidental spillage is currently required in most countries.

d. *Effects on human health.*
Vinasse (beet, cane) does not contain toxic chemicals, has no safety measures required by state, federal, or international regulations, and has no harmful effects on human health. The components of molasses vinasse (proteins, amino acids, carbohydrates, vitamins and minerals) are used as food, food additives, and distilled alcohol for human consumption, and as ingredients in livestock feed. Vinasse has been successfully fed to livestock worldwide for many years without adverse effects on human health.

e. *Effects on soil organisms, crops, livestock.*
Vinasse (beet, cane) does not contain toxic chemicals or residue, has no safety measures required by state, federal, or international regulations, and has no harmful effects on human health. The components of molasses vinasse (proteins, amino acids, carbohydrates, vitamins and minerals) are used as food, food additives, and distilled alcohol for human consumption and as ingredients in livestock feed. Vinasse has been successfully fed to livestock worldwide for over 70 years. Studies have indicated that feeding high amounts of vinasse to infant animals is not suitable due to the salinity level in the material.

Many studies exist reporting that vinasse is a good fertilizer, indicating it is a potential source of organic matter and plant nutrients, especially for its P and K values and as a soil conditioner which stimulates growth of beneficial microorganisms in the soil and allows better uptake of nutrients into the plant. Vinasse is mainly of plant origin, with some microbial residue (yeast). The components of vinasse are readily metabolized and utilized by micro-organisms as energy sources. Studies indicate that uncomposted cane vinasse, composted beet and cane vinasse, and cane and beet vinasse composted with raw manure or solid plant materials increases crop yield, structural stability of soils, soil microbial biomass, C-CO_2 respiration rates, N cycle functioning, and enzymatic activities values, while exchangeable sodium percentage remained under critical sodicity values of about 15. In addition, when vinasse is composted with other agricultural wastes, decomposition rates increase. (20) Studies also indicated that uncomposted beet vinasse in general has higher salinity rate values than cane vinasse and, when applied to soil in high volume, decreases soil physical and biological properties and crop yield.

10. *Safety information including MSDS & substance report from National Institute of Environmental Health Studies. If none, state so in petition,*
    There is no substance report for beet or sugar cane vinasse, or any industrial waste from the sugar industry from the National Institute of Environmental Health Studies. MSDS sheets are attached. Tate & Lyle MSDS & Technical Datasheet

11. *Research info about the substance which includes comprehensive substance research review and research bibliographies, including contrasting position information. Should include research concerning why the substance should be permitted in the production of organic products, including alternatives and commercial availability*.

    Studies selected for this petition are from different periods of time (1970's to current), and from various nations worldwide, including the major sugar production countries, such as the United States, India, and Brazil, to compare technologies, evaluations and conclusions reported in the studies. Information from these studies have been described throughout this petition.

    The environmental effects of sugar manufacturing and distillation effluents or wastewaters, including molasses and molasses vinasse, have been extensively studied worldwide. Since the 1980's, environmental awareness of the polluting effects of sugar manufacturing and distillery wastes has influenced changes worldwide in production and processing methods to reduce intensive water and energy usage and has promoted more stringent requirements for the proper disposal or the renewable resource recovery of the large amounts of solid waste (bagasse, pulp) and wastewaters (molasses, vinasse). Technological developments, using aerobic and anaerobic biodegradation methods, significantly reduce undesirable COD and BOD levels, odor, and colorization in vinasse products in order to meet the stringent guidelines for disposal or byproduct recovery and usage. Research indicates molasses vinasse can be profitably recycled and worldwide interest in using sugar by-products is growing, largely due to the decrease in production cost and environmental liabilities. Studies indicate that vinasse is co-produced at a rate of 9-14 liters per liter of alcohol produced and the total volume of vinasse commercially available is approximately 6.87 million m^3/annum.

    Ten studies were selected for research on the fertilizing efficiency of beet and cane vinasse. The studies used varying materials and methods, i.e. fresh, condensed, or composted vinasse of beet or cane origin; laboratory, greenhouse, or field studies;

varying topography, climate and soil compositions; and varying time periods from one growing season for nutrient evaluations, up to four growing seasons documenting the residual and cumulative effects on soil properties and crop yield. Some studies also used an additional N source fertilizer in conjunction with the vinasse usage. In addition, some studies include starch and cellulosic stillage products for evaluation comparisons. Studies indicate both cane and beet vinasse is a good fertilizer, indicating it is a potential source of organic matter and plant nutrients, especially for its P and K values and as a soil conditioner which stimulates growth of beneficial microorganisms in the soil and allows better uptake of nutrients into the plant. All the studies consistently indicated that the usage of vinasse may reduce the amount of fertilizers required for optimum crop yield. Long term studies indicated that vinasse does not promote increase in N-NO3, N-NH4 and N-total in soil profile tested even for 33 weeks after application. However, it is apparent when comparing all the studies that results varied depending on the quality of the raw material, soil composition, and specific crop requirements.

Vinasse is mainly of plant origin, with some microbial residue (yeast). The components of vinasse are readily metabolized and utilized by microorganisms as energy sources. A field study was conducted over a four-year period to compare vinasse influence on soil properties and crop yield. The study indicates that uncomposted cane vinasse, composted beet and cane vinasse, and cane and beet vinasse composted with raw manure or solid plant materials increases crop yield, structural stability of soils, soil microbial biomass, C-CO_2 respiration rates, N cycle functioning, and enzymatic activities values, while exchangeable sodium percentage remained under critical sodicity values of about 15. In addition, when vinasse is composted with other agricultural wastes, decomposition rates increase. The study also indicated that uncomposted beet vinasse in general has higher salinity rate values than cane vinasse and, when applied to soil in high volume, decreases soil physical and biological properties and crop yield.

A greenhouse experiment was conducted to assess production of wheat. Vinasse was applied at three rates 5, 10 and 20 mL $L_{-}1$ in irrigation water along the period of plant growth. The data obtained revealed that the addition of vinasse to sandy soil increased the productivity of wheat yield with the highest yield obtained with the rate of 5 mL L-1 of vinasse applied. The vinasse application increased the uptake of nitrogen, phosphorus, and potassium. The residual available N, P and K and organic matter in the soil after harvesting generally increased with increasing rates of vinasse applied. It was concluded that vinasse is a good source of available P and K when applied to soil and its application may reduce the amount of fertilizers required for optimum crop yield. It is suggested that vinasse could substitute for about 62% of P and 100% of K required for wheat yield. It was also concluded that vinasse has an indirect effect consisting of an improvement of utilization of absorbed nutrients.

The effects of different characteristics of the original raw material on the biochemical composition of vinasse and their C and N mineralization in soil were investigated. Vinasse samples were obtained from similar industrial fermentation processes based on the growth of microorganisms on molasses from different raw material (sugar beet or sugar cane) and vinasse concentration (dilute or concentrated). The nature of the raw material used for fermentation had the greatest effect on the nature and size of resistant organic pool. This fraction included aromatic compounds originating from the raw material or from complex molecules and seemed to be quantitatively related to acid-insoluble N. Samples derived from sugar beet were richer in N compounds and induced greater net N mineralization. The effect of evaporation varied with the nature of the raw material. Concentration led to a slight increase in the abundance of phenolic compounds, acid-insoluble fraction, and a slight decrease in the labile fraction of vinasse partly or totally derived from sugar beet. The effect of the dilute vinasse from sugar cane was greater. The concentrated vinasse had a smaller labile fraction, induced N immobilization at the beginning of incubation and exhibited greater N concentration in the acid insoluble fraction than the dilute vinasse.

A field trial was carried out on a Quartzpsament soil, cropped with sugarcane in the same place 2 consecutive years, to study different forms of N leaching in a soil profile and to observe a possible water contamination. The experimental design was a split-split- plot in randomized blocks with four replicates. The experiment used 5 treatments at main plot level (control, mineral fertilizer and 3 doses of vinasse); 4 depths of soil sampling at split plot level and 3 soil sampling periods at split-split plot level. As final conclusion, the vinasse rates used in this study for 2 years (residual and cumulative effects) which can be considered as usual in commercial sugarcane fields, did not promote increase in N-NO3, N-NH4 and N-total in soil profile tested even for 33 weeks after application.

12. *Petition Justification statement for A) Synthetic substances on 205.601*
    a. *Explain why synthetic substance is necessary for the production or handling of an organic product.*
    Vinasse is a good source of available P and K when applied to soil and its application may reduce the amount of fertilizers required for optimum crop yield. Vinasse is mainly of plant origin, with some microbial residue (yeast). The components of vinasse are readily metabolized and utilized by microorganisms as energy sources and do not accumulate in the soil or contaminate ground water with proper usage. Studies indicate that vinasse increases crop yield, structural stability of soils, soil microbial biomass, C-CO_2 respiration rates, N cycle functioning, and enzymatic activities values, while exchangeable sodium percentage remained under critical sodicity values of about 15. In addition, vinasse is a beneficial feedstock for use in composting raw manure and other plant materials such as straw, hay, and greenwaste due to the high organic content which increases decomposition. It was also concluded that vinasse has an indirect effect consisting of an improvement of utilization of absorbed nutrients due to the chemical composition of the substance.

    b. *Describe any non-synthetic substance, synthetic substance on the National List or alternative cultural methods that could be used in place of the petitioned substance.*
    As alternatives, organic crop producers could use synthetic substances that are already allowed in organic crop production to amend soils listed in 7 CFR 205.601. They include: 1) elemental sulfur; 2) magnesium sulfate; 3) soluble

boron products; 4) sulfates, carbonates, oxides, or silicates of zinc, copper, iron, manganese, molybdenum, selenium, and cobalt; and 5) vitamins B1, C and E. Depending on the crop of interest and the micronutrient that is in deficiency, some decision would have to be made about which one or combination would be most appropriate to use.

c. *Describe the beneficial effects to the environment, human health, or farm eco-system from use of the substance that supports use instead of use of nonsysnthetic substance on the National List or alternative cultural methods.*
As found in 7CFR 205.205, organic crop producers must implement a crop rotation including but not limited to sod, cover crops, green manure crops and catch crops that provides for maintaining and improving soil organic content and managing deficient or excess plant nutrients. More specifically 7 CFR 205.203 states that organic crop producers: 1) must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize erosion; 2) must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials; and 3) must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances. When these practices prove insufficient to prevent deficient or excess nutrients in soils or plants, a substance on the National List of Synthetic Substances allowed for use in organic crop production (7CFR 205.601) may be applied to maintain adequate nutrients for plant productivity and health.

Vinasse is mainly of plant origin, with some microbial residue (yeast). The components of vinasse are readily metabolized and utilized by microorganisms as energy sources and do not accumulate in the soil or contaminate ground water with proper usage. Vinasse is a good source of available P and K when applied to soil and its application may reduce the amount of fertilizers required for optimum crop yield. Studies indicate that the total volume of vinasse commercially available is approximately 6.87 million m^3/annum. The beneficial effects to the environment of using vinasse as a plant nutrient and soil conditioner reduces the amount of vinasse as a waste product that must be disposed in catch ponds or applied to nonagricultural land for decomposition. Research indicates molasses vinasse can be profitably recycled and worldwide interest in using sugar by-products as a recovered resource is growing, largely due to the decrease in production cost and environmental liabilities.

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Agronomic evaluation of fertilizing efficiency of vinasse

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Abstract

Vinasse as an industrial waste is being a problem for getting disposed from sugar industries. It represents the residues from molasses fermentation. The sugar and integrated industries company in Hawamdyia produces more than 2,000 m^3 d^{-1} of vinasse. The large amount of vinasse can harm the environment, causing salinization and river Nile pollution. Therefore it was though useful to try overcoming the created problem using it in agriculture land. Greenhouse experiment was conducted to assess and evaluate the nutritional value of Vinasse and its effect on nutrient uptake and yield production of wheat. Vinasse was applied at three rates 5, 10 and 20 mL L^{-1} in irrigation water along the period of plant growing. The obtained data revealed that the addition of vinasse to sandy soil increased the productivity of wheat yield. Highest yield was obtained with 5 mL L^{-1} of vinasse applied. Also vinasse application increased the uptake of nitrogen, phosphorus and potassium. The residual available N, P and K and organic matter in soil after harvesting generally increased with increasing rates of vinasse applied. As an organic fertilizer, the optimum level of addition of vinasse in sandy soil with irrigation was 5 mL L^{-1}. Finally, it could be concluded that vinasse is a good source of available P and K when applied to soil and its application may reduce the amount of fertilizers required for optimum crop yield. It is suggested that vinasse could substitute for about 62% of P and 100% of K required for wheat yield.

Keywords: fertilizing efficiency, sugar cane and vinasse

Introduction

Disposal of industrial wastes and by-products is an increasing concern for most industries. Disposal of vinasse has become a problem in sugarcane-growing countries where the distilling industry has recently expanded. Vinasse contains many useful elements and can be profitably recycled to improve soil properties and increase crop yield while alleviating environmental pollution (Pande *et al.*, 1995). Worldwide, the interest in using sugarcane by-products is growing, largely owing to the decreases in production cost and environmental liabilities.

Gomez (1996) stated that, in 3-year field trials, the application of vinasse increased significantly sugarcane yield without reducing quality. He also suggested that vinasse could substitute for 55% of N, 72% of P and 100% of K required for sugarcane in Venezuela. Korndorfer and Anderson (1993) stated that application of vinasse increased significantly the sugarcane, wheat pigeon pea and maize yield as well as N, P, K, S and Ca uptake; however, the predominant effect was mainly to K and S.

In Egypt, the sugar and integrated industries company (Hawamdyia) produce more than 2,000 m^3 d^{-1} of vinasse. It represents residues from molasses fermentation processes. Vinasse as an industrial waste is being a problem for getting disposed from sugar industries. The large amount of vinasse can harm the environment, causing salinization and river Nile pollution. Therefore, it was though useful to try overcoming the created problem using it in agriculture land.

The objective of this study is to evaluate the nutritional value of vinasse and its effect on nutrients uptake and yield of wheat.

Materials and Methods

A pot experiment was conducted on sandy soil in greenhouse to evaluate the effect of vinasse on the yield and nutrients uptake of wheat. The experimental design of the greenhouse study was randomized by complete block with three replicates in plastic pots, each pot contained 8 kg of air dried soils. This soil was classified as typic torripsamments (92.9% sand, 5.3% salt and 1.8% clay) and it had pH-H_2O 8.25, EC 5.8 dSm^{-1} (1:1), 0.69% organic matter, 3.6% $CaCO_3$, 8.8 meq^{-1} 100 gm soil CEC, 0.02% total N, 0.69 total P, 11.9 mg kg^{-1} soil, $NaHCO_3$ extractable P, 0.21% total k and 352 mg kg^{-1} soil NH_4OAc extractable K.

Some chemical properties of distillery vinasse used in this study are presented in Table 1. Three levels of diluted vinasse being: 0.5%, 1% and 2% were used in irrigation. Potable water, available in experimental site, was used to dilute the vinasse to get water with different fertilizer levels. Chemical characteristics of the diluted vinasse were determined by using the methods described by the US salinity lab staff (1954) and presented in Table 2.

Table 1 Some chemical characteristics of Vinasse.

Characteristics		Values	Characteristics		Values
pH	.	4.43	Total K	%	0.6
EC	dSm^{-1}	21.0	Total Ca	%	0.54
Organic Carbon	%	3.10	Total Mg	%	0.27
Organic matter	%	6.2	Total Na	%	0.068
Fulvic acid	%	0.83	SO_4	%	0.6
Humic acid	%	0.32	Total Solids	g L^{-1}	90.0
Total N	mg L^{-1}	1204	Soluble Solids	g L^{-1}	83.0
NH_4	mg L^{-1}	87.6	Total COD	g L^{-1}	100
NO_3	mg L^{-1}	182.4	Soluble COD	g L^{-1}	85
Total P	mg L^{-1}	423	Total BOD	g L^{-1}	39
Soluble P	mg L^{-1}	185	Soluble BOD	g L^{-1}	35

Treatments were as follows, control (no vinasse or fertilizers applied), reference fertilizer of NPK (100, 50 and 50 mg kg^{-1} soil) added as NH_4NO_3, $Ca(H_2PO_4)_2$ $CaSO_4$ and K_2SO_4 respectively and the investigated vinasse, added in three rates in irrigation water (Table 3). The total amount of irrigation water was 13.5 L pot^{-1} along the period of plant growth. Before sowing, the soil equilibrated for one week at 60% of moisture content at value of max. water holding capacity. After the equilibration, twenty seeds of wheat plants (Triticum aestivum L., cv Seds 3) were sown in each pot and the population thinned to 5 plants per pot after emergence. At the maturity stage, the plants were harvested and separated into grain and straw. Dry weights were recorded and biomass ground and prepared for analysis. Samples were digested with acid mixture. Total nitrogen in plant and KCl extractable N of soil were determined according to method described by Bremner and Mulvany (1982). P, K and Mg were determined according to method described by Cottenie *et al.*, 1982.

Statistical analyses of all results were accomplished using (NLSD) according to Gomez and Gomez (1984).

Table 2 Some chemical characteristics of diluted Vinasse.

Character		Treatments		
		5 mL L^{-1}	10 mL L^{-1}	20 mL L^{-1}
pH		6.45	6.00	4.69
EC	dS.m^{-1}	0.70	1.00	1.70
Inorganic N	mg L^{-1}	13.5	28.0	55.4
Soluble P_2O_5	mg L^{-1}	21.2	44.6	89.8
K_2O	mg L^{-1}	360	732	1440

Table 3 Nutrients applied within the Vinasse treatments to the soil (mg kg^{-1} soil).

Nutrients mg kg^{-1}	Treatments		
	0.5%	1%	2%
N	22.7	47.3	93.5
P_2O_5	35.8	75.3	151.5
K_2O	607.5	1235	2430

Results and Discussion

Wheat yield production in relation to vinasse application

Data in Table 4 represent the wheat production under different treatments of vinasse. The addition of vinasse within all tested rates, resulted in significantly increase in both grain and straw yields of wheat compared to control treatment. However, there were no significant differences in wheat yield between reference fertilizer and vinasse treatments. The increase in total wheat yield in vinasse treatments over control (N_0 P_0 K_0) ranged between 66% to 74%, while in reference fertilizer treatment was 66%. Also, it seen from data in table: that 2% of vinasse applied in irrigation water caused highly significant increased in wheat grain yield. The percentage increase in grain yield over control was 66%. However, the differentiation between the values of grain yield was very closed for all tested rates of vinasse applied and reference fertilizer treatment. The percentage increase in grain yield over reference fertilizer (N_2 P_1 K_1) treatment was 6% for at rate of 2% vinasse applied. From the above-mentioned results, the increasing of wheat yield as a result of vinasse application may be attributed to better growth under favorable physical condition of treated soil and can be related to the beneficial affect of vinasse containing a considerable amount of organic matter of nutritional elements for plant growth.

Similar finding was observed by Pande (1994) and Gomez (1996), who reported that the use of vinasse in irrigation water to fertilizer some crops (wheat, sugarcane, pigeon, pea) caused in a significant increase in yield compared to commercial liquid fertilizers of N, P and K.

Table 4 Effect of vinasse treatments on grain and straw yield of wheat.

Treatments	*Addition Rate %	Yield, g pot $^{-1}$		Grain/ Straw Ratio
		Grain	Straw	
Control (N_0 P_0 K_0)	-	9.7	19.4	0.50
Vinasse I	0.5	14.6	33.8	0.43
Vinasse II	1.0	15.0	35.0	0.43
Vinasse III	2.0	16.1	34.4	0.47
Reference Fert. (N_2 P_1 K_1)		15.2	33.1	0.46
L.S.D. 0.05		2.79	5.41	

*Addition rate of vinasse in irrigation water (v/v)

Plant composition

The effect of vinasse on NPK concentrations and its uptake by wheat plants are shown in Tables 5 and 6. Data showed that application of vinasse at a rate 1% and 2% had approximately the same effect on N content in both grains and straw relative to reference fertilizer treatment. While increasing rates of vinasse application progressively increased N uptake and this was parallel to the grain and straw yield increase. This phenomenon could be explained by the fact that the total amount of inorganic N added within vinasse along the growing period sufficient to meet the N required for wheat crop, especially at application rate 2% vinasse. In this respect, Gomez (1996) reported that vinasse could substitute for 55% of N required for sugarcane yield in Venezuela.

Table 5 Effect of vinasse treatments on nutrients content in wheat plants.

Treatments	Addition Rate%	Nutrients content, mg kg $^{-1}$					
		Grain			Straw		
		N	P	K	N	P	K
Control (N_0 P_0 K_0)	-	1.31	0.28	0.65	0.23	0.08	2.42
Vinasse I	0.5	2.0	0.37	0.73	0.62	0.09	3.32
Vinasse II	1.0	2.25	0.40	0.79	0.60	0.09	3.45
Vinasse II	2.0	2.14	0.41	0.76	0.67	0.11	3.44
Reference Fert. (N_2 P_1 K_1)		2.24	0.44	0.76	0.62	0.09	3.32

Table 6 Effect of vinasse treatments on nutrients uptake by wheat plants.

Treatments	Addition Rate% v/v	Nutrients uptake, mg pot $^{-1}$					
		Grain			Straw		
		N	P	K	N	P	K
Control (N_0 P_0 K_0)	-	127	27.2	63.1	44.6	15.5	469
Vinasse I	0.5	292	55.5	107	210	30.4	1122
Vinasse II	1.0	338	60.0	119	210	31.5	1208
Vinasse III	2.0	345	66.0	122	230	37.8	1183
Reference Fertilizers (N_2 P_1 K_1)	-	340	66.9	115	205	30.0	1099
L.S.D. 0.05		47.88	9.11	19.98	39.28	7.61	125.59

With regard to the P content in both grain and straw of wheat, the pronounced increase in P was observed with 2% vinasse applied. Plant P concentrations increased continuously with increasing vinasse rate applied from 0.5% to 2%. Increasing rate of vinasse added up to 2% had a significant increase in uptake in both grain and straw in comparison to 0.5% vinasse added. This indicates that the P uptake was positively affected by the rate of vinasse applied, which may due to the increase P content in vinasse amended soil (Table 1), microbial activities which increase nutrients availability and their uptake, chemical changes in the soil and increasing root distribution. These results are in good agreement with that obtained Gomez (1996) and Orlando (1996), they stated that the application of vinasse can provide added nutrients to sugarcane, similar to mineral fertilizers application, besides the benefits of organic matter and micronutrients addition to the soil.

Potassium concentration and uptake in wheat plants exhibited several differences, but consistent trends (Tables 5 and 6). The values of K concentration in grain yield of wheat were increased slightly by high vinasse rates. The magnitude variation of K concentration in straw with respect to application of vinasse relative to control was very clear. The highest values of K uptake (122 mg pot^{-1}) was recorded at application 2% vinasse, followed by 119 mg k pot $^{-1}$ for 1% vinasse and 115 mg k pot^{-1} for reference fertilizer treatment ($N_2 P_1 K_1$).

Chemical characteristics of soil after harvesting

Table 7 summarizes the effect of vinasse treatments on some chemical characteristics of the treated soil after cropping. Concerning the pH, it was observed that the application of vinasse to the investigated soil had slight effect on soil pH. The effect on pH may be explained by the production of the organic acids and hydrogen ion (H^{+}). The decomposition process accelerates the release of CO_2 and organic acids that would reduce soil PH. This finding confirms those obtained by El-Leboudi *et al.* (1988) and Arafat (1994). Data also show that the soluble salts (EC) values of the untreated and treated soil decreased after cropping. These results could be attributed to the amount of water applied during the growth period of crop, consequently more elements are dissolved and taken by plants as well as more salts are leached out from the root zone.

Table 7 Some chemical characteristics of soil investigation after wheat harvesting.

Treatments	Addition Rate%	pH	EC dSm $^{-1}$	OM %	Nutrients content, mg kg $^{-1}$ soil		
					Inorganic N	*Ext. P	**Ext. K
Control ($N_0 P_0 K_0$)	0.0	8.31	3.67	0.73	14.5	5.62	296
Vinasse I	0.5	8.25	3.82	0.83	19.3	7.83	521
Vinasse II	1.0	8.24	4.22	0.91	24.3	10.2	674
Vinasse III	2.0	8.12	4.28	1.14	30.0	11.9	940

*$NaHCO_3$ extractable P
**NH_4OAc extractable K

The most striking change was the tremendous increase in soil organic matter content, as a result of treated the soil with vinasse especially at higher rate application. The percentage increase in organic matter content was 41% at applied rate 2% relative to control. Similar results were obtained by Orlando Fillo (1996), who stated that addition of vinasse to soil led to an increase in the amount of organic matter content.

It was observed from the data in the same table that the extractable concentration of NPK in the soil treated with vinasse increased relative to non-treated soil. The rate of increase depend mainly on the rate of vinasse applied. The magnitude variation of residual extractable Potassium with respect to application rate of vinasse was observed. Highest value of extractable K (940 mg kg $^{-1}$ soil) at 2% of vinasse was recorded. The greatest increase in extractable values of K is most probably due to contain a vinasse in agreement with those obtained by Zende *et al.* (1995) and Kwong *et al.* (1997).

Finally, it could be concluded that application of vinasse to field crops is a viable method for its disposal. Also, it had direct effect as a good source of element and an indirect effect consisting of an improvement of utilization of absorbed nutrients. It is obvious that vinasse may be having as K fertilizer.

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Madras Agric. J. 92 (4-6) : 349-354 April-June 2005

Research Notes

Effect of integrated use of distillery effluent and fertilisers on soil properties and yield of sugarcane in sandy loam soil

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Distillery effluent from molasses based distillery industry is considered as a potential source of organic matter and plant nutrients. Since it is mainly of plant origin (from sugarcane) with some microbial residue (yeast sludge), it does not contain any toxic chemicals or residue. The distillery effluent application improves the soil fertility and health and support good plant growth leading to saving of fertilizers (Thiyagarajan, 2001). The only problem with distillery effluent is excessive Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and electrical conductivity. These problems could be overcome by the application of distillery effluent well before the planting of the crop (40 to 60 days before planting) to give sufficient time for the natural oxidation of organic matter. Hence, the present study was undertaken to find out effect of application of treated distillery effluent along with different combinations of fertilisers on soil properties and yield of sugarcane crop.

The pre-treated distillery effluent was collected from EID Parry (I) Ltd., Distillery, Nellikuppam and analysed for its physico-chemical properties. Field experiments were conducted at BID Parry (I) Ltd., Nellikuppam cane farm using sugarcane (variety - Co.6032) as test crop. The main plot treatments include application of treated distillery effluent (TDE) @ 1.25 (M_2), 2.5 (M_3), 3.75 (M_4), 5.0 (M_5) and 6.25 (M_6) lakh litres per hectare and control (M_1). The subplot treatments include no NPK (S_1),-N alone (S_2), NP (S_3) and NPK (S_4). The experiment was laid in split plot design and replicated thrice. Treated distillery effluent was applied 40 days before planting and kept for natural oxidation. The NPK fertilisers were applied at 75% of the recommended doses *viz.,* 206, 45, 84 kg of N, P_2O_5 and K_20, respectively, per hectare as per the treatment details. The initial and post harvest soil samples were collected and analysed for physico-chemical properties and fertility status. The data were statistically analysed using ANOVA.

Initial properties of soil

The experimental soil was sandy loam. The pH was near neutral (7.32) and it was low in EC (0.10 dSm^{-1}). The soil rated medium in organic carbon (0.50%), low in available N (219 kg ha^{-1}), medium in available P (18.5 kg ha^{-1}) and high in available K (255 kg ha^{-1}). It contained 7.38 cmol(p+)kg^{-1} exchangeable Ca, 3.05 cmol (p+)kg^{-1} exchangeable Mg and 0.51 cmol(p+)kg^{-1} exchangeable Na. The available micronutrient contents of the soil was 1.32, 5.31, 2.13 and 9.31 mg kg^{-1} of Zn, Fe, Cu and Mn, respectively.

Properties of distillery effluent

The treated distillery effluent (TDE) is dark brown in colour and has an unpleasant smell of burnt or caramelised sugar. The TDE is near neutral (pH 7.8) in reaction and had very high salt load (EC 28.5 dSm^{-1}). The TDE recorded high BOD (4500 mg /1), COD (48,000 mg/1), total solids (85,000 mg/1) and organic carbon content (27.5 per cent on dry weight basis). It contained 1350 mg/1 of N, 550 mg/1 of P_2O_5, 9,500 mg/1 of K_2O, 2300

Table 1. Influence of PTDE and fertilizers on sugarcane yield, properties, available nutrient status and microbial population of post harvest soil.

	Cane yield	pH	EC	OC	Av-N	Av-P	Av-K	Ex. Ca	Ex. Mg	Ex. Na	ESP	Av-Zn	Av-Fe	Av-Cu	Av-Mn	B*	F*	A*
	t/ha-1		dSm	%			kg ha^{-1}		cmol(p+)kg^{-1}		%			mg kg^{-1}		10^6	10^4	10^3
M_1S_1	42.0	7.35	0.11	0.48	213	17.2	242	7.30	3.08	0.52	4.65	1.23	6.15	2.11	9.25	51.3	7.00	3.33
M_1S_2	73.1	7.31	0.11	0.53	238	17.0	236	7.30	3.02	0.51	4.59	1.20	6.01	2.02	9.11	52.3	7.30	4.00
M_1S_3	91.6	7.29	0.11	0.54	239	19.2	230	7.24	2.98	0.50	4.55	1.19	5.93	1.98	0.02	52.3	7.70	4.33
M_1S_4	103	7.33	0.11	0.54	240	19.5	257	77.22	2.95	0.49	4.47	1.18	5.88	1.95	8.98	52.1	7.70	5.00
M_2S_1	58.1	7.38	0.12	0.51	228	18.2	263	7.85	3.25	0.56	4.68	1.31	7.41	2.22	9.56	51.0	7.33	4.00
M_2S_2	89.0	7.39	0.12	0.52	248	17.6	259	7.83	3.23	0.52	4.38	1.28	7.35	2.16	9.50	51.6	7.70	4.67
M_2S_3	109	7.41	0.12	0.51	245	19.7	255	7.81	3.21	0.55	4.64	1.27	7.35	2.18	9.48	52.6	8.30	5.00
M_2S_4	110	7.39	0.12	0.52	247	19.2	277	7.78	3.22	0.55	4.64	1.27	7.34	2.17	9.50	54.0	9.00	5.33
M_3S_1	72.0	7.39	0.13	0.54	230	18.9	278	8.07	3.81	0.63	4.91	1.36	8.13	2.43	9.88	52.3	8.00	4.33
M_3S_2	101	7.41	0.13	0.55	252	18.5	271	8.00	3.78	0.60	4.73	1.32	8.03	2.39	9.82	53.6	8.30	5.00
M_3S_3	115	7.40	0.13	0.56	249	21.3	266	7.98	3.78	0.59	4.66	1.35	7.98	2.36	9.78	54.3	8.70	5.33
M_3S_4	115	7.39	0.13	0.54	251	21.1	288	7.98	3.79	0.57	4.50	1.34	8.00	2.38	9.78	55.0	9.70	6.00
M_4S_1	82.5	7.42	0.15	0.57	232	19.8	298	8.61	4.35	0.69	4.93	1.48	9.21	2.61	10.1	55.0	9.00	4.67
M_4S_2	108	7.44	0.14	0.57	257	19.0	291	8.56	4.31	0.64	4.62	1.45	9.17	2.57	10.1	54.6	10.0	5.33
M_4S_3	120	7.43	0.15	0.58	258	21.7	287	8.57	4.30	0.63	4.56	1.44	9.15	2.56	10.0	55.3	10.3	6.00
M_4S_4	119	7.44	0.15	0.57	256	21.4	307	8.55	4.28	0.67	4.84	1.44	9.15	2.56	10.0	56.3	10.7	6.33
M_5S_1	86.0	7.46	0.15	0.63	245	21.2	333	9.01	4.92	0.71	4.73	1.61	10.5	2.98	11.3	56.6	12.3	5.67
M_5S_2	112	7.45	0.15	0.64	270	19.7	327	8.97	4.88	0.69	4.63	1.58	10.4	2.94	11.3	58.6	12.7	6.66
M_5S_3	122	7.46	0.15	0.65	262	22.8	324	8.96	4.87	0.73	4.89	1.57	10.3	2.91	11.2	59.6	13.0	7.00
M_5S_4	123	7.49	0.16	0.64	261	22.6	345	8.95	4.88	0.72	4.82	1.58	10.3	293	11.2	58.9	13.3	7.33
M_6S_1	89.1	7.50	0.17	0.67	265	22.6	365	9.57	5.17	0.78	4.89	1.85	12.2	3.15	12.6	56.3	12.0	5.33
M_6S_2	16	7.48	0.17	0.68	274	21.5	360	9.54	5.15	0.75	4.73	1.83	11.9	3.13	12.6	57.3	12.3	6.66
M_6S_3	124	7.51	0.17	0.69	272	24.5	353	9.54	5.12	0.76	4.80	1.82	1.8	3.13	12.5	59.0	12.7	6.66
M_6S_4	125	7.51	0.17	0.68	275	24.3	377	9.55	5.13	0.77	4.85	1.82	11.9	3.14	12.5	58.0	13.0	7.00
M_1	77.5	7.32	0.11	0.52	233	18.2	241	7.27	3.01	0.51	4.57	1.94	4.61	2.02	9.09	52.1	7.40	4.17
M_2	91.6	7.39	0.12	0.52	242	18.7	264	7.82	3.23	0.55	4.58	2.09	6.68	2.18	9.51	52.3	8.10	4.75
M_3	101	7.40	0.13	0.55	246	20.0	276	8.01	3.79	0.60	4.70	2.16	7.79	2.39	9.82	53.8	8.70	5.17
M_4	107	7.43	0.15	0.57	251	20.5	296	8.57	4.31	0.66	4.74	2.40	8.31	2.58	10.1	55.3	10.0	5.58
M_5	111	7.47	0.15	0.64	260	21.6	332	8.97	4.89	0.71	4.77	2.78	9.16	2.94	11.2	58.9	12.8	6.66
M_6	114	7.50	0.17	0.68	272	23.2	364	9.55	5.14	0.77	4.82	2.99	9.67	3.14	12.6	58.0	12.5	6.41
S_1	71.6	7.42	0.14	0.48	236	19.7	297	8.40	4.10	0.65	4.80	2.43	7.73	2.58	10.5	53.7	9.30	4.55
S_2	99.9	7.41	0.14	0.53	257	18.9	291	8.37	.06	0.62	4.61	2.39	7.70	2.54	10.4	54.7	9.70	5.39
S_3	114	7.42	0.14	0.54	254	21.5	286	8.35	4.04	0.63	4.68	2.38	7.70	2.52	10.4	55.5	10.1	5.72
S_4	116	7.43	0.14	0.54	255	21.4	309	8.34	4.04	0.63	4.69	2.37	7.68	2.52	10.3	55.7	10.6	6.17
CD																		
M	5.3	0.08	0.02	0.01	2.9	0.28	5	0.28	0.12	0.06	0.21	0.05	0.10	0.04	0.31	0.6	0.5	0.46
S	4.7	NS	NS	NS	2.6	0.26	6	NS	NS	NS	NS	NS	NS	NS	NS	0.4	0.3	0.30
SxM	7.1	NS	NS	NS	4.5	0.59	9	NS	NS	NS	NS	NS	NS	NS	NS	0.9	0.8	0.74
MxS	6.8	NS	NS	NS	4.9	0.62	9	NS	NS	NS	NS	NS	NS	NS	NS	0.9	0.9	0.79

* B - Bacteria ; F - Fung; A - Actinomycetes

mg/1 of Ca, 2150 mg/1 of Mg, 4500 mg/1 of SO_4 –S, 450 mg/1 of Na, 7500 mg/1 of Cl, 10 mg /1 of Zn, 65 mg/1 of Fe, 4.2 mg/1 of Cu, and 5.5 mg/1 of Mn.

Soil pH and EC

Application of graded doses of distillery effluent gradually increased the pH and EC of the post harvest soil (Table 1). The increase in pH and EC was significant beyond 2.5 lakh litres ha^{-1}. The highest increase in pH of 0.18 was recorded in the treatment which received distillery effluent @ 6.25 lakh litres ha^{-1} over control. Sweeney and Graetz (1991) reported that the addition of distillery effluent regardless of rate, raised the soil pH , owing to increase in soil K, Ca, Mg and Na levels. Mattiazo and Ada Gloria (1985) found that the organic matter oxidation brought out by microbial activity was responsible for increased pH of the soil treated with distillery effluent. Similarly, the highest increase in EC was 0.06 dSm^{-1} in the treatment which received distillery effluent @ 6.25 lakh litres ha^{-1} over control. The studies conducted by Anon (1993) indicated that one time application of treated undiluted effluent before planting of the crop and ploughed into the soils slightly raised the pH and soil EC was not raised beyond 0.25 dSm^{-1} even at 500 t/ha of treated effluent application. Thus the pH and EC of the soils were maintained within the safe limits even in the fields receiving up to 6.25 lakh litres per hectare of treated distillery effluent. No significant difference was observed among the fertiliser treatments. Similarly the interaction effects were also not significant.

Exchangeable cations and ESP

Application of treated distillery effluent significantly increased the exchangeable cation contents (Table 1) of the post harvest soil. The exchangeable Ca and Mg had increased by 5 to 10 times due to increase in distillery effluent application from 1.25 to 6.25 lakh litres ha^{-1}. The exchangeable Na increased to the tune of 0.26 cmol (p+)kg^{-1} in the treatment received the highest dose of distillery effluent (6.25 lakh litres per hectare) over control. The Ca, Mg and Na present in the distillery effluent may have increased the exchangeable cations concentration of the post harvest soil. Devarajan *et al.* (1996b) observed an increase of available Ca and Mg from 1400 ppm to 2200 ppm and 126 ppm to 470 ppm, respectively due to the application of 10 times diluted distillery effluent. The increase in the contents of these elements might be the reason for the little increase in the pH of post harvest soil upon effluent application. Though the application of distillery effluent slightly increased the exchangeable Na content of the soil, it did not increase the ESP of the soil significantly (Table 1) due to increase in the content of other beneficial cations *viz.* Ca and Mg. There was no significant difference among the fertiliser treatments and their interactions.

Organic carbon

The organic carbon content (Table 1) of the post harvest soil had increased due to application of distillery effluent. The high organic load of the distillery effluent might be the reason for the increased the organic carbon content of the post harvest soil. This is in accordance with Racault (1990) who reported that the distillery effluent was concentrated with soluble forms of organic matter.

Available nutrients in soil

The available N, P and K contents (Table 1) of the post harvest soil significantly increased due to application of distillery effluent. The contribution of N from distillery effluent (one lakh litres will supply 135 kg N) and increased microbial activity on the added organic matter might have increased the available N level of the post harvest soil (Subash Chandra Bose *et al,* 2002). Application of nitrogen through fertiliser also increased the available N status of the post harvest soil. Higher values were observed in the treatments which received both N fertilisers as well as TDE @ 6.25 lakh litres ha^{-1}. In addition to the P contributed by the effluent, HCO_3 content of distillery effluent and the organic acids produced during the decomposition of distillery effluent would have helped to solubilize the native soil P (Rajukkannu *et al.* 1996). Somashekar *et al* (1984) opined that the mineralization of organic material as well as the nutrients present in the effluents are responsible for the increase in the availability of plant nutrients. Application of phosphorus through fertiliser increased the available P contents of the post harvest soil. The increase was higher in the treatment which received both P fertilisers as well as highest dose of effluent (6.25 lakh l ha^{-1}) which may be due to cumulative effect of both fertilisers and distillery effluent. Bertranou *et al.* (1989) reported that the available K was increased by 4 to 5 times due to effluent irrigations which might be due to the fact that K is the component supplied in large quantities. Application of potassic fertilizer also increased the available NPK contents of the post harvest soil. The highest values were observed in the treatment which received both K fertilizers as well as effluent @ 6.25 lakh l ha^{-1}.

The DTPA extractable micronutrients (Fe, Mn, Zn, Cu) of the post harvest soil were increased (Table 1) with distillery effluent application. Devarajan *et al.* (1996a) reported that the available micronutrients *viz.,* Zn, Fe, Cu and Mn of the post harvest soil were increased from 2.2 to 3.9 ppm, 22.9 to 31.6 ppm, 4.1 to 7.3 ppm and 15.5 to 25.8 ppm, respectively, due fertigation with 10 times diluted distillery effluent. The increased availability might be due to direct contribution from the effluent as well as solubilisation and chelation effect of organic matter supplied by the effluent (Baskar *et al.,* 2003). There was no significant change in the content of available micronutrients of the soil due to fertiliser treatments.

Microbial population dynamics

Application of distillery effluent significantly increased the microbial population (bacteria, fungi and actinomycetes) of the post harvest soil (Table 1). The results showed that there was no reduction in microbial population of the post harvest soil even at higher doses of distillery effluent application. The population dynamics of bacteria, actinomycets, fungi, Azospirillum and Azotobacter in the field soils grown with turmeric, rice, sesame, cotton, banana and groundnut showed that the 50 times and 40 times diluted distillery effluent irrigations enhanced or maintained the microbial populations in the soils (Devarajan *et al.,* 1993). Application of different combination of NPK fertilisers also increased the microbial population of the post harvest soil over control. The increase in nutrients and organic carbon supplied by distillery effluent and fertiliser application increased the microbial population of the post harvest soil.

Cane yield

The yield of sugarcane (Table 1) had significantly increased upto 3.75 lakh litres ha^{-1} of treated distillery effluent application. The supply of all essential nutrients and the improvement in physical properties by organic matter addition due to TDE application might have increased the yield of sugarcane. Anon (1986) reported that the application of distillery effluent @ 150 and 300 t/ha increased the sugarcane yield by 44.0 and 53.8 % respectively, when compared with untreated control. Application of spent wash increased sugarcane yield in Philippines (Gonzales and Tianco,1982), Australia (Usher and Wellington, 1979), Cuba (Vieira, 1982) and South America (Scandaliaris *et al,* 1987). Application of fertilizers also significantly increased the yield of sugarcane over no fertilizer. However, the difference between applications of NP & NPK fertilizers was not significant indicating that there is no need for K application

The interaction effect showed that the response cane yield to application of fertilizer nutrient was significant for each and every nutrient applied when no Treated Distillery Effluent (TDE) was applied. Irrespective of the quantity of TDE applied there was no yield difference between NP and NPK, indicating that the supply of K through TDE is sufficient even at lower level (1.25 lakh litres ha"[1]). Booth and Lightfoot (1990) observed that the use of ethanol sillage (vinasse) had removed the necessity for annual dressing of P and K fertilisers in more than 4000 hectares of cane lands in Zimbabwe.The results indicated the need for P fertilizer along with N in sandy loam soil even at higher dose of TDE.' Based on the above results we can say that application of 3.75 lakh litres ha'[1] of TDE with NP fertilizer will be the best for getting the higher yield in sugarcane in sandy loam soil.

Acknowledgment

The authors express their sincere thanks to EID Parry (I) Ltd., Nellikuppam for the financial assistance and facilities provided by them to carry out this study.

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(Received : December 2003; Revised : August 2005)

Madras Agric. J. 92 (4-6) : 354-358 April-June 2005

Research Notes

Relationship of selected traits of mango growers with adoption behaviour

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Among the horticultural commodities mango ranks first with 42,894.93 tonnes in the form of fresh fruits, jam, jelly, squash, ketch-up and other processed products being exported worth of Rs.7,359.61 lakhs during 2002-2003. But the discouraging and disappointing scenario is the reduction in the quantity of fruits exported over-years including mango. The quantity of fruits and vegetables exported during 1991-92 was 4,93,611.39 tonnes which has reduced to 3,87,429.57 tonnes during 2002-2003. This reduction in productivity and export of fruits including mango is of great concern and Deeds to be addressed. *The reasons that could be attributed to this* reduction may 6e many. One among that is lack of awareness and adoption of recommended technologies for mango cultivation. For achieving higher yields, farmers have to resort to scientific farming by adopting innovative and improved technologies. Rogers and Shoemaker (1971) defined adoption as the mental process through which an individual passes from first hearing about an innovation to final adoption.

This adoption behaviour bound to be affected by varied characteristics of mango growers including personal, socio-economic and psychological

NATIONAL STANDARD OF CANADA

CAN/CGSB-32.311-2006

Supersedes part of CAN/CGSB-32.310-99

Amended
October 2008 and December 2009

ORGANIC PRODUCTION SYSTEMS PERMITTED SUBSTANCES LISTS

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE.

Prepared by the
Canadian General Standards Board

Approved by the
Standards Council of Canada

Published September 2006 by the
Canadian General Standards Board
Gatineau, Canada K1A 1G6

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Acknowledgment is made for the translation of this National Standard of Canada by the Translation Bureau of Public Works and Government Services Canada.

CAN/CGSB-32.311-2006

Supersedes part of CAN/CGSB-32.310-99

Amended
October 2008 and December 2009

CANADIAN GENERAL STANDARDS BOARD

ORGANIC PRODUCTION SYSTEMS PERMITTED SUBSTANCES LISTS

PREFACE

This National Standard of Canada, *Organic Production Systems — Permitted Substances Lists*, was published in September 2006 and amended in October 2008. This standard, amended again in December 2009, includes significant changes in content, and, consequently, a list of revised paragraphs has not been provided.

Supersedes part of CAN/CGSB-32.310-99

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INTRODUCTION (Informative)

Organic operations in Canada remain subject to all applicable laws and regulations. Substances that appear in CAN/CGSB-32.311, *Organic Production Systems — Permitted Substances Lists*, are subject to the *Pest Control Products Act* (PCPA) or the *Food and Drugs Act* (FDA) when used in Canada as pesticides or disinfectants. Health Canada's Pest Management Regulatory Agency (PMRA) is the federal authority responsible for the regulation of pest control products (including sanitizers) under the PCPA and Regulations. Disinfectants are regulated by Health Canada's Therapeutic Products Directorate (TPD) under the FDA and Regulations.

Substances that appear in CAN/CGSB-32.311, *Organic Production Systems — Permitted Substances Lists*, are subject to the *Food and Drugs Act* when used in Canada as veterinary drugs destined to food-producing animals and to the *Feeds Act* when used in Canada as livestock feed. Health Canada's Veterinary Drugs Directorate is the federal authority responsible for the regulation of veterinary drugs under the *Food and Drugs Act* and Regulations. Livestock feeds are regulated by the Animal Feed Division of the Canadian Food Inspection Agency under the *Feeds Act* and Regulations and the *Health of Animals Act* and Regulations.

Supersedes part of CAN/CGSB-32.310-99

Amended
October 2008 and December 2009

CANADIAN GENERAL STANDARDS BOARD

ORGANIC PRODUCTION SYSTEMS PERMITTED SUBSTANCES LISTS

1. SCOPE

1.1 This standard[1] provides additional information to CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards.* It consists of requirements for adding or amending permitted substances in the following lists, organized by category of use.

1.2 Quantities and dimensions in this standard are given in metric units with yard/pound equivalents, mostly obtained through soft conversion, given in parentheses. The metric units shall be regarded as official in the event of dispute or unforeseen difficulty arising from the conversion.

2. REFERENCED PUBLICATIONS

2.1 The following publications are referenced in this standard:

2.1.1 Canadian General Standards Board (CGSB)

CAN/CGSB-32.310 — Organic Production Systems — General Principles and Management Standards.

2.1.2 Canadian Council of Ministers of the Environment (CCME)

Guidelines for Compost Quality.

2.1.3 Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction du milieu rural

Guidelines for the Beneficial Use of Fertilizing Residuals.

2.1.4 Pest Management Regulatory Agency (PMRA)

REG2007-04 — Regulatory Note: PMRA List of Formulants.

2.2 A dated reference in this standard is to the issue specified. An undated reference in this standard is to the latest issue. The sources are given in the Notes section.

3. REQUIREMENTS FOR ADDING OR AMENDING SUBSTANCES IN THE LISTS

3.1 Section 10 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, outlines the requirements for adding or amending substances in the lists.

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[1] *References throughout this document to "this standard" refer to CAN/CGSB-32.311,* Organic Production Systems — Permitted Substances Lists.

4. PERMITTED SUBSTANCES LISTS FOR CROP PRODUCTION

4.1 **Classification** — Crop production substances are classified according to the following uses and applications:

a. **Soil Amendments** are substances applied to the soil to improve fertility and tilth and to correct soil problems. Fertilizers, plant foods and soil amendments are primarily used for their plant nutrient content and may be applied to the soil or to the foliage of plants.

b. **Crop Production Aids and Materials** are substances used in conjunction with other substances, which may or may not be directly applied to the crop or soil, or substances used to control diseases or pests. Examples include

  i. adjuvants, insect traps and plastic mulch

  ii. vertebrate animal pest management substances

  iii. plant disease management substances

  iv. insect pest management (invertebrates), mites, molluscs and crustacean substances

  v. nematode management substances.

c. **Weed Management.**

4.2 **Soil Amendments and Crop Nutrition** — Unless otherwise specified, the soil amendments and crop nutrients listed below shall not contain substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, or not permitted by this standard.

Common Name(s)	Origin and Usage
Agar	For use in initial mushroom spawn production.
Alfalfa meal and pellets	Use organic alfalfa unless commercially unavailable. Ensure non-organic alfalfa is not a product of genetic engineering.
Algae	See *Aquatic plant products*.
Amino acids, non-synthetic	Amino acids produced by plants, animals and micro-organisms that are not from genetic engineering and that are extracted or isolated by hydrolysis or by physical or other non-chemical means are considered non-synthetic. Non-synthetic amino acids may be used as plant growth regulators or chelating agents.
Animal manure	See sections 5 and 6 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*.
Animal manure, processed	Manures that are treated by mechanical and/or physical (including heat) methods and/or to which are added biological, mineral or other substances listed in par. 4.2 are allowed. Manure sources shall conform to par. 5.5.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*. The operator shall be able to demonstrate that best practices known to eliminate human pathogens during the treatment have been used or that the requirements in par. 5.5.2.5 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, have been met.
Aquatic plant products	Shall not contain synthetic preservatives, such as formaldehyde, or fertilizing substances not listed in this standard. Natural (non-synthetic) extracts are allowed. Extraction with synthetic solvents is prohibited except for potassium hydroxide or sodium hydroxide, provided the amount of solvent used does not exceed the amount necessary for extraction. The manufacturer shall prove the need to use sodium hydroxide.

Common Name(s)	Origin and Usage
Ash	Ash from plant and animal sources only. Ash from burning minerals, manure, coloured paper, plastics or other synthetic substances is prohibited. Ash obtained from off-farm sources shall not exceed the limits (category C1) for acceptable levels (mg/kg) of arsenic, cadmium, chromium, copper, lead and mercury specified in the *Guidelines for the Beneficial Use of Fertilizing Residuals*, published by the Quebec Ministère du Développement durable, de l'Environnement et des Parcs, Direction du milieu rural. Shall not cause buildup of heavy metals in soil over repeated applications.
Basalt	Mined or quarried volcanic rock minerals.
Bentonite	See *Mined minerals and unprocessed mined minerals.*
Biodynamic preparations for soil and plants	
Biotite (iron, magnesium or aluminum silicates)	
Blood meal	Allowed only if sterilized.
Bone meal	Permitted only if guaranteed free of specified risk materials including the skull, brain, trigeminal ganglia (nerves attached to the brain), eyes, tonsils, spinal cord and dorsal root ganglia (nerves attached to the spinal cord) of cattle aged 30 months or older; and the distal ileum (portion of the small intestine) of cattle of all ages.
Borate	Shall only be used for a documented deficiency relative to the type of crop. See also *Boron products.*
Borax (sodium tetraborate)	See *Boron products.*
Boron products	The following soluble boron products may be used: sodium tetraborate (borax and anhydrous) and sodium octaborate. Shall only be used for a documented deficiency relative to the type of crop. See also *Trace elements (micronutrients)* for documentation requirements.
Calcium carbonate	See *Limestone.*
Calcium chloride	Natural sources only. May be used to adjust nutrient deficiencies and physiological disorders. Shall not cause buildup of salts in soil over repeated applications.
Calcium, natural sources	Sources include shells from aquatic animals.
Calcium sulphate (gypsum)	See *Gypsum (calcium sulphate).*
Cannery wastes	Use only if organically grown or as composting feedstocks. See *Composting, feedstocks* for mandatory composting requirements.
Cardboard	Cardboard that is not waxed or impregnated with fungicide or substances not on these lists; may be used as mulch or compost feedstock.
Clay	Bentonite, perlite and zeolite as a soil amendment or seed pellet additive. These are also listed individually in this standard. See also *Mined minerals and unprocessed mined minerals.*
Compost	See *Compost obtained from off-farm sources, Compost produced on the farm, Compost tea, Composting feedstocks.*

Common Name(s)	Origin and Usage
Compost obtained from off-farm sources	Compost obtained from off-farm sources shall conform to the criteria in *Composting feedstocks*. In addition, compost obtained from off-farm sources: a. shall not exceed the maximum acceptable levels of trace contaminants (mg/kg) and foreign matter outlined for unrestricted use (Category A) compost as specified in the Canadian Council of Ministers of the Environment (CCME) publication *Guidelines for Compost Quality*; b. shall not cause a buildup of heavy metals in soil over repeated applications; c. shall meet criteria for acceptable levels (MPN/g total solids) of human pathogens as specified in the CCME publication *Guidelines for Compost Quality*. See *Worm castings* for information on vermicompost; *Microbial products* for information on compost starters.
Compost produced on the farm	Compost produced on the farm shall conform to the criteria in *Composting feedstocks*. In addition if made from animal manures or other likely sources of human pathogens, compost produced on the farm shall: a. reach a temperature of 55°C (130°F) for a period of four consecutive days or more. The compost piles shall be mixed or managed to ensure that all of the feedstock heats to the required temperature for the minimum time; or b. meet limits for acceptable levels (MPN/g total solids) of human pathogens specified in the Canadian Council for Ministers of the Environment publication *Guidelines for Compost Quality*; or c. be considered as aged or raw manure rather than compost (i.e. meet the requirements specified in par. 5.5.2.5 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards).* See *Worm castings* for information on vermicompost; *Microbial products* for information on compost starters.
Compost tea	Compost tea shall be made from composts conforming to the criteria in *Compost produced on the farm* or *Compost obtained from off-farm sources* or *Worm castings*. Other substances listed in CAN/CGSB-32.311, *Organic Production Systems — Permitted Substances Lists*, may be added to compost tea. If compost tea is applied directly to the edible parts of plants, the operator shall be able to demonstrate that best practices known to eliminate pathogens during the processing have been used OR that the requirements for raw manure in par. 5.5.2.5 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, have been met. See the definition of *Compost Tea* in section 3 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*.

Common Name(s)	Origin and Usage
Composting feedstocks	Acceptable feedstocks include: a. animal manures conforming to par. 5.5.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*; b. animal, animal products and by-products (including fishery); c. plants and plant by-products (including forestry and source-separated yard debris, such as grass clippings and leaves); d. soils and minerals conforming to this standard and CAN/CGSB 32.310, *Organic Production Systems — General Principles and Management Standards*. The following are prohibited as composting feedstocks: sewage sludge; compost starter and feedstocks fortified with substances not included in this standard or prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*; leather by-products; glossy paper; waxed cardboard; paper containing coloured ink; and animal, animal products and animal by-products that are not guaranteed free of the risk materials specified in *Bone meal*. Except for animal manures, feedstocks that may be contaminated with substances not included in this standard or prohibited by par. 1.4.1 of CAN/CGSB-32.310, shall require documentation to confirm the absence of these substances OR documentation substantiating the common degradation of such contaminants during the composting process. See *Microbial products* for information on compost starters.
Copper products	These products shall be used in a manner that prevents excessive copper accumulation in the soil. Buildup of copper in soil may prohibit future use. Use with caution. No visible residue shall be allowed on harvested crops. Basic copper sulphate, copper oxide, copper sulphate and copper oxysulphate may be used to correct documented copper deficiencies. Copper ammonia base, copper ammonium carbonate, copper nitrate and cuprous chloride are prohibited as sources of copper for plant nutrients.
Dolomite	See *Limestone*.
Enzymes	Acceptable if derived microbiologically from natural substances and not fortified with synthetic plant nutrients. Ensure enzymes are not obtained through genetic engineering.
Epsom salts	See *Magnesium sulphate*.
Feather meal	
Feldspar	See *Mined minerals and unprocessed mined minerals*.
Ferric and ferrous compounds	Includes ferric oxide, ferric sulphate and ferrous sulphate. See *Iron products, Trace elements (micronutrients)*.
Fish emulsions or solubles	See *Fish products*.
Fish farm wastes	Shall be composted.
Fish hydrolysate	See *Fish products*.
Fish meal, powder	Natural substances or those derived from natural substances, without the addition of ethoxyquin or other chemically synthesized substances or chemical treatment. See also *Fish products*.

Common Name(s)	**Origin and Usage**
Fish products	Natural substances or those derived from natural substances without the addition of ethoxyquin or other chemically synthesized substances or chemical treatment except that liquid fish products as soil and plant amendments may be pH adjusted with (in preferential order) organic vinegar, organic citric acid, phosphoric acid or sulphuric acid. The amount of acid used shall not exceed the minimum needed to reach pH 3.5. Shall not contain synthetic preservatives or fertilizing substances not listed in this standard.
Fulvic acid	Dilute neutral to acidic extracts of humates.
Granite dust	Sources that are mixed with petroleum products, such as from stone engraving, are prohibited. See also *Mined minerals and unprocessed mined minerals.*
Greensand (glauconite)	See *Mined minerals and unprocessed mined minerals.*
Guano, bat or bird	Shall be decomposed, dried deposits from wild bats or birds. Domesticated fowl excrement is considered *manure*, not guano. See *Compost.*
Gypsum (calcium sulphate)	Mined source; for correcting calcium and sulphur deficiencies and for amending soil salinity problems documented by soil and plant tissue testing. Sulphates produced using sulphuric acid are prohibited.
Humic acid	Dilute potassium hydroxide extracts of mined sources
Humus from worms and insects (vermicompost)	See *Worm castings.*
Inoculants	See *Microbial products.*
Iron products	Ferric oxide, ferric sulphate, ferrous sulphate, iron citrate, iron sulphate or iron tartrate may be used where a soil or plant nutrient-deficiency is documented by soil or tissue testing.
Iron sulphates	Sulphates produced using sulphuric acid are prohibited. See also *Iron products.*
Kelp and kelp products	See *Aquatic plant products.*
Kieserite	See *Magnesium sulphate, Mined minerals and unprocessed mined minerals.*
Langbeinite	Mined sulphate of potash magnesia.
Leaf mould	
Limestone	Magnesium carbonate and calcium carbonate. May cause buildup of magnesium. Use with caution. Shall be from a natural source. Oyster shell flour, limestone, dolomite (not slaked), aragonite, eggshell meal, lime from sugar processing and mined calcium carbonate are acceptable. Calcium products that have been used in controlled atmosphere storage are prohibited.
Magnesium carbonate	Naturally occurring in dolomite and magnesite.
Magnesium chloride	Natural sources only.
Magnesium rock	Natural substances or those derived from natural substances, without the addition of chemically synthesized substances or chemical treatments. See also *Mined minerals and unprocessed mined minerals.*
Magnesium sulphate	Allowed for use with a documented magnesium deficiency. Mined as kieserite or epsom salts (see also *Mined minerals and unprocessed mined minerals*) or synthetically produced epsom salts.
Manganese products	Manganous oxide and manganese sulphate may be used to correct documented manganese deficiencies. See *Trace elements (micronutrients).*
Manure, composted	See *Compost.*
Manure, non-organic manure source	See conditions in par. 5.5 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards.*
Mica	See *Mined minerals and unprocessed mined minerals.*

Common Name(s)	Origin and Usage
Microbial products	Allowable microbial products include rhizobium bacteria, mycorrhizal fungi, azolla, yeast and other micro-organisms on compost, plants, seeds, soils and other components of the organic operation. Ionizing radiation is allowed for use on peat moss carrier only, before the addition of microbial inoculants. Radiation is otherwise prohibited.
Micronutrients, synthetic	See *Trace elements (micronutrients).*
Milk	
Mined minerals and unprocessed mined minerals	A mined mineral shall not have undergone any change in its molecular structure through heating or by combining with other substances. Acceptable if the substance is not processed or fortified with synthetic chemicals. Mined minerals are regarded as supplements to a balanced, organic soil-building program. Some of the minerals that are mined can also be made synthetically or are by-products of industry; investigate the source of any new substance. Sodium nitrate is prohibited.
Molasses	Shall be organic molasses unless not commercially available.
Molybdenum products	To correct documented molybdenum deficiencies. See also *Trace elements (micronutrients).*
Mulches	Organic plant residue: where organic materials are not readily available, non-organic straw, leaves, grass clippings or hay that are not the products of genetic engineering may be used. Substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, shall not have been used on these materials for at least 60 days before harvest. Sawdust, wood chips and shavings: from natural sources or that derive from natural substances are permitted for mulching if they are from wood, trees or logs that have not been treated with paint or substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards.* Newspaper mulch: glossy paper and coloured ink are prohibited. Paper: glossy paper and coloured ink are prohibited.
Mushroom compost	See *Compost.*
Naturally occurring biological organisms (e.g. worms) and their products	See *Worm castings.*
Oilseed meals	Use organic sources unless commercially unavailable. Shall not be from genetically engineered oilseeds.
Oyster shell lime	Ground shells from oysters. See also *Limestone.*
Peat moss	
Perlite	
Phosphate rock	Shall not be fortified or processed with synthetic chemicals. Cadmium shall not exceed 90 mg/kg P_2O_5.

Common Name(s)	Origin and Usage
Plants and plant by-products	Includes plant preparations of aquatic or terrestrial plants or parts of plants, such as cover crops, green manures, crop wastes, hay, leaves and straw. Parts of plants used as soil amendments and foliar feeds are permitted. Wastes from crops that have been treated or produced with substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, are prohibited. Only substances listed in par. 6.3 and 6.6 may be used in the processing of plant by-products. Plant by-products not meeting this restriction may be used as composting feedstocks. Sawdust, wood chips and shavings: from natural sources or that derive from natural substances are permitted if they are from wood, trees or logs that have not been treated with paint or substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards.*
Pomaces	Feedstocks shall be from organically grown fruits or vegetables, or the material shall be aerobically composted before use.
Potassium chloride (muriate of potash and rock potash)	Mined potassium salts (e.g. sylvinite and kainite). Shall not cause buildup of salts in soil over repeated applications.
Potassium rock powders	Includes basalt, biotite, mica, feldspars, granite and greensand.
Potassium sulphate	Only if from langbeinite or other natural sources. See also *Mined minerals and unprocessed mined minerals.*
Potassium sulphate magnesia	Langbeinite.
Potting soil	Shall not contain synthetic wetting agents or synthetic fertilizers.
Pumice	
Rock dusts (stone meal), unprocessed	See *Mined minerals and unprocessed mined minerals.*
Sand	
Seaweed and seaweed products	Aquatic plant products are prohibited if they contain other synthetic preservatives, such as formaldehyde, or are fortified with other prohibited plant nutrients. See also *Aquatic plant products.*
Shells from aquatic animals	
Soil	From organic sources in accordance with this standard for 36 months.
Sphagnum moss	Shall not contain synthetic wetting agents.
Stillage and stillage extract	Ammonium stillage is prohibited.
Sulphate of potash magnesia	From langbeinite. See also *Mined minerals and unprocessed mined minerals.* Natural substances or those derived from natural substances, without the addition of chemically synthesized substances or chemical treatment.
Sulphates of zinc or iron	May be used only to correct for deficiencies determined by soil or plant tissue testing. Sulphates produced using sulphuric acid are prohibited. See also *Iron products.*
Sulphur, elemental	Sulphur may be used as a soil amendment where more buffered sources of sulphur are not appropriate, and as a foliar application. Natural substances or those derived from natural substances without the addition of chemically synthesized substances or chemical treatment.

Common Name(s)	Origin and Usage
Trace elements (micronutrients)	Includes micronutrients from natural sources that are unchelated or chelated by substances listed as allowed. To be used when soil and plant deficiencies are documented by soil and plant testing.
Vermicasts	See *Worm castings.*
Vermiculite	
Vitamins	Non-synthetic sources of all vitamins and synthetic sources of vitamins B_1, C and E may be used in organic crop production.
Wood ash	See *Ash.*
Worm castings	Worm castings (also called vermicompost, worm compost, vermicast, worm humus or worm manure) are the end product of the breakdown of organic matter and compounds by some earthworm species. Feedstocks for these earthworms shall meet the criteria in *Composting feedstocks.* The operator shall be able to demonstrate that worm castings produced on the farm and obtained from off-farm sources meet the limits for acceptable levels (MPN/g total solids) of human pathogens specified in the Canadian Council of Ministers of the Environment publication *Guidelines for Compost Quality* OR that best practices known to eliminate human pathogens during vermicomposting have been used. See *Microbial products* for information on compost starters.
Yeast	See *Microbial products.*
Zeolite	See *Mined minerals and unprocessed mined minerals.*
Zinc products	Zinc oxide and zinc sulphate may be used to correct a documented zinc deficiency.

4.3 **Crop Production Aids and Materials** — Unless otherwise specified, the crop production aids and materials listed below shall not contain substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, or not permitted by this standard.

Common Name(s)	Origin and Usage
Acetic acid	As an adjuvant and pH regulator.
Adhesives for sticky traps and barriers	
Alcohol	Non-synthetic ethyl alcohols are allowed as solvents to extract botanical insecticides.
Amino acids, non-synthetic	Amino acids produced by plants, animals and micro-organisms that are not from genetic engineering and that are extracted or isolated by hydrolysis or by physical or other non-chemical means are considered non-synthetic. Non-synthetic amino acids may be used as plant growth regulators or chelating agents.
Ammonium carbonate	As an attractant in insect traps.
Arthropod pathogens	See *Biological organisms.*
Arthropod predators and parasitoids	See *Biological organisms.*
Arthropods	See *Biological organisms.*
Ascorbic acid	Only non-synthetic sources may be used as a pH regulator and for promoting natural growth.
Baits for rodent traps	Baits shall not contain synthetic substances.

Common Name(s)	**Origin and Usage**
Bentonite	See *Mined minerals and unprocessed mined minerals.*
Biodynamic preparations for compost	
Biological organisms	Living organisms that benefit plant production by reducing pest populations, such as *Bacillus thuringiensis*, spinosad, granulosis (e.g. viruses, bacteria, protozoa, fungi, insects and nematodes). No organisms from genetic engineering.
Borate	Sodium tetraborate and octaborate may be used as wood preservatives. Only mined sources acceptable.
Boric acid	May be used for structural pest control (i.e. ants). No direct contact witb organic food or crops is allowed.
Botanical pesticides	Botanical pesticides shall be used in conjunction with a biorational pest management program but shall not be the primary method of pest control in the farm plan. The least toxic botanicals shall be used in the least ecologically disruptive way possible. All label restrictions and directions shall be followed including restrictions concerning crops, livestock, target pests, safety precautions, pre-harvest intervals and worker re-entry.
Calcium chloride	Natural sources and food-grade quality only. May be used to adjust nutrient deficiencies and physiological disorders.
Calcium lignin sulphonate	See *Lignin sulphonates.*
Calcium polysulphide	See *Lime sulphur.*
Carbon dioxide	For soil and greenhouse use and for controlled atmosphere storage.
Chelates	Natural chelates and synthetic chelates specifically included for that purpose in this standard are allowed. See *Lignin sulphonates.*
Cholecalciferol (vitamin D_3)	May be used outdoors and inside greenhouses for rodent control when methods described in par. 5.6.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, have failed. Not allowed inside on-farm food processing and food storage facilities.
Citric acid	Non-synthetic and synthetic sources may be used as a chelating agent and a pH adjuster.
Copper products	Includes copper hydroxide for use as a wood preservative or for disease control; copper sulphates for use as a fungicide; Bordeaux mix, copper oxychloride, fungicides or wood treatments, for fruits and vegetables. These products shall be used in a manner that prevents excessive copper accumulation in the soil. Buildup of copper in soil may prohibit future use. Use with caution. No visible residue shall be allowed on harvested crops. Basic copper sulphate, copper oxide, copper sulphate and copper oxysulphate may be used to correct documented copper deficiencies. Copper ammonia base, copper ammonium carbonate, copper nitrate and cuprous chloride are prohibited as sources of copper for plant nutrients.
Cytokinins	See *Growth regulators for plants.*
Diatomaceous earth	Only non-heated forms may be used. Make sure no synthetic pesticides or synergists are added.
Dormant oils	Allowed for use as a dormant spray on woody plants only.
Ferric phosphate (iron orthophosphate, iron phosphate)	Permitted as molluscicide. To be used in such a way as to prevent runoff into water bodies. Shall not be in contact with crops.

Common Name(s)	Origin and Usage
Fibre row covers	Shall not be incorporated into the soil or left in the field to decompose; shall be removed at the end of the growing season.
Formulants	Formulants can only be used in conjunction with substances listed in par. 4.3. Only formulants that are classified by the Pest Management Regulatory Agency (PMRA) in Regulatory Note REG2007-04 as List 4A or 4B or are non-synthetic may be used with substances in par. 4.3 that are applied directly to crops. Formulants classified as List 3 in PMRA Regulatory Note REG2007-04 may be used with passive pheromone dispensers. Formulants classified as List 1 or List 2 in PMRA Regulatory Note REG2007-04 are prohibited.
Gibberellic acid	Acceptable if made from a fermentation process. Fermentation process shall not use organisms from genetic engineering. See also *Growth regulators for plants.*
Growth regulators for plants	Natural plant hormones, such as gibberellic acid, indoleacetic acid and cytokinins, are allowed. See also *Gibberellic acid.*
Hormones	See *Growth regulators for plants.*
Hydrated lime	For plant disease control only.
Hydrogen peroxide	Hydrogen peroxide is not allowed in maple syrup production. Allowed for use as a fungicide.
Indoleacetic acid	See *Growth regulators for plants.*
Kaolin clay	
Lignin sulphonates	Lignosulphonic acid, calcium lignosulphate and sodium lignosulphate. Allowed as a chelating agent, as a formulant ingredient and as a dust suppressant. Ammonium lignosulphate is prohibited.
Lime sulphur (calcium polysulphide)	Allowed as a fungicide, an insecticide and an acaricide (mite control) on plants.
Magnesium chloride	Natural sources only.
Mulches	Organic plant residue: permitted for mulching. Where organic materials are not readily available, non-organic straw, leaves, grass clippings or hay that are not the products of genetic engineering may he used. Substances prohibited hy par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, shall not have been used on these materials for at least 60 days before harvest. Sawdust, wood chips and shavings: from natural sources or that derive from natural substances are permitted for mulching if they are from wood, trees or logs that have not been treated with paint or substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards.* Newspaper mulch: glossy paper and coloured ink are prohibited. Paper: glossy paper and coloured ink are prohibited. Plastic mulches: non-biodegradable and semi-biodegradable materials shall not be incorporated into the soil or left in field to decompose; shall be removed at the end of the growing season. Plastic mulches in perennial crops may be left for more than one season but shall be removed before the plastic decomposes. Use of polyvinyl chloride as plastic mulch or row cover is prohibited. Fully biodegradable films: permitted without removal if they do not not contain substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards.*

Common Name(s)	Origin and Usage
Nitrogen	For controlled atmosphere storage.
Oxygen	For controlled atmosphere storage.
Peracetic acid	For use in controlling fire blight bacteria and in disinfecting seed and asexually propagated planting material.
pH buffers	Shall be from a natural source, such as citric acid or vinegar. Lye and sulphuric acid are prohibited.
Pheromones and other semiochemicals	Allowed for use in pheromone traps or dispensers. Both synthetic and non-synthetic pheromones and semiochemicals may be used for pest control.
Plant extracts, oils and preparations	Allowed for use as production aids unless otherwise specifically restricted or prohibited. Allowed extractants include cocoa butter, lanolin, animal fats, alcohols and water. Allowed for disease and pest control. Extraction with synthetic solvents is prohibited except for potassium hydroxide or sodium hydroxide, provided the amount of solvent used does not exceed the amount necessary for extraction. Of the two products, potassium hydroxide is the preferred choice; the manufacturer shall prove the need to use sodium hydroxide.
Plant protectants, natural	Substances that protect plants from harsh environmental conditions such as frost and sunburn, infection, the buildup of dirt on leaf surfaces, or injury by a pest. Natural substances are allowed, including diatomaceous earth, kaolin clay, pine oil, pine resin and yucca. White wash is allowed for use on trees to protect against sunburn and southwest disease.
Plastic for row covers and solarization	Shall not he incorporated into the soil or left in the field to decompose; shall be removed at the end of the growing season. Use of polyvinyl chloride plastic is prohibited.
Potassium bicarbonate	Allowed for pest and disease control in greenhouses and other crops.
Pyrethrum	May only be combined with acceptable formulants listed in par. 4.3. See also *Botanical pesticides* for restrictions.
Quick lime	Also known as calcium oxide. Prohibited as a fertilizer or soil amendment.
Repellents	Acceptable if derived from a natural source, such as sterilized blood meal, rotten eggs, hair or predator scents, provided synthetic additives are not used.
Rotenone	Shall not be combined with unacceptable formulants. See also *Botanical pesticides* for restrictions.
Seaweed and seaweed products	Aquatic plant products are prohibited if they contain other synthetic preservatives such as formaldehyde or are fortified with prohibited plant nutrients. See also *Aquatic plant products* in par. 4.2.
Seed treatments	Microbial products, kelp, yucca, gypsum, clays, botanicals, and any substances and formulants that appear in par. 4.3 with consistent origin and usage permitted for use as treatments on organic seed.
Soaps	Soaps (including insecticidal soaps) consisting of fatty acids derived from animal or vegetable oils are allowed.
Soaps, ammonium	As a large animal repellent only; no contact with soil or edible portion of crop allowed.
Sodium bicarbonate	Allowed for pest and disease control in greenhouses and other crops.
Sodium silicate	For tree fruit and fibre processing.
Sterile insects	See *Biological organisms.*
Sugar	Organic sugar may be used as an ingredient in a crop production aid.
Sulphur (smoke bombs)	Sulphur smoke bombs used for rodent control shall be used in conjunction with other methods and only when a full pest control program is maintained but temporarily overwhelmed.

Common Name(s)	Origin and Usage
Sulphur, elemental	Allowed for foliar use only.
Summer oils	Allowed for use in organic production as suffocating or stylet oils on foliage.
Surfactants	See *Soaps*.
Transplant and potting media	Shall be composed entirely of allowed substances.
Treated seed, non-synthetic agents	Seed treated with naturally occurring biological management agents are allowed. Organisms from genetic engineering are prohibited. Seed pelletized with clay, gypsum, rhizobial bacteria or other non-synthetic coatings is allowed. Plastic polymer pelletization of seed is prohibited. See also *Seed treatments*.
Tree seals	Plant or milk-based paints may be used. Other petroleum substances may be used if there is no alternative. Shall not be combined with fungicides or other synthetic chemicals.
Vegetable oils	Spreader-stickers, surfactants and carriers. Plant oils shall not contain synthetic pesticides.
Vinegar	See *Acetic acid*.
Virus sprays	
Water	
Water, reclaimed	Reclaimed water shall be used only on non-edible parts of food crops and on crops not for human consumption. Use on edible plant parts and root crops is prohibited.
Wetting agents	Natural wetting agents, including saponins and microbial wetting agents, are allowed. See also *Soaps*.

4.4 **Weed Management** — Unless otherwise specified, the weed management substances listed below shall not contain substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, or not permitted by this standard.

Common Name(s)	Origin and Usage
Biological organisms	Living organisms that benefit plant production by reducing pest populations (e.g. viruses, bacteria, protozoa, fungi, insects, nematodes, nematode-repelling cover crops and animals). No organisms from genetic engineering.
Mulches	Organic plant residue: permitted for mulching. Where organic materials are not readily available, non-organic straw, leaves, grass clippings or hay that are not the products of genetic engineering may be used. Substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, shall not have been used on these materials for at least 60 days before harvest. Sawdust, wood chips and shavings: from natural sources or that derive from natural substances are permitted for mulching if they are from wood, trees or logs that have not been treated with paint or substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*. Newspaper mulch: glossy paper and coloured ink are prohibited. Paper: glossy paper and coloured ink are prohibited. Plastic mulches: non-biodegradable and semi-biodegradable materials shall not be incorporated into the soil or left in field to decompose; shall be removed at the end of the growing season. Plastic mulches in perennial crops may be left for more than one season but shall be removed before the plastic decomposes. Use of polyvinyl chloride as plastic mulch or row cover is prohibited. Fully biodegradable films: permitted without removal if they do not contain substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*.
Plant extracts	
Plant oils	
Vinegar (acetic acid)	Non-synthetic sources unless commercially unavailable.

5. PERMITTED SUBSTANCES LISTS FOR LIVESTOCK PRODUCTION

5.1 **Classification** — Livestock production substances are classified according to the following uses and applications:

a. **Feed, Feed Additives and Feed Supplements**

b. **Health Care Products and Production Aids** — Health care products include medications, remedies, parasiticides and other substances used to maintain or restore the well-being of an animal. Production aids include all other substances used on animals and their living areas, such as bedding and dips.

5.2 Feed, Feed Additives and Feed Supplements

Note: In Canada, livestock feed must meet the compositional and labelling standards of the Feeds Regulations, 1983. *Ingredients used in livestock feed must be approved and listed in Schedule IV or V of the* Feeds Regulations, 1983. *Some ingredients and products require registration (e.g. enzymes and milk replacers).*

Common Name(s)	Origin and Usage
Amino acids	Non-synthetic sources only. Exception granted for use of synthetic DL-methionine, DL-methionine—hydroxy analog, and DL-methionine—hydroxy analog calcium until October 1, 2010.
Antioxidants	Non-synthetic sources only. Water, alcohol, acid and base extracts that are permitted by this standard only.
Diatomaceous earth	Approved as an anti-caking agent in feed to a maximum of 2% of the total diet.
Energy feeds and forage concentrates (grains) and roughages (hay, silage, fodder, straw)	Shall be obtained from organic sources and may include silage preservation products (e.g. bacterial or enzymatic additives derived from bacteria, fungi and plants and food by-products [e.g. molasses and whey]). Note that if weather conditions are unfavourable to fermentation, lactic, propionic and formic acid may be used.
Micro-organisms and yeasts	
Milk replacer	From organic sources when commercially available. Only without antibiotics and animal fats, by-products, and for emergency use only.
Molasses	May be used as a flavouring agent; shall be organic unless commercially unavailable.
Pre-mixes	Concentrated mixture of minerals and vitamins; all ingredients shall be organically sourced, where applicable, and shall be essential for animal nutrition.
Probiotics	
Protein feeds	Shall be from organic sources.
Seaweed meal	
Trace minerals, elements (mineral products)	Non-synthetic chelated or sulphated minerals. Synthetic nutrient minerals may be used when non-synthetic sources are unavailable. Minerals may not be used to stimulate growth or production. Minerals from any source are allowed for medical use.
Vitamins	Used for enrichment or fortification of livestock feed. Synthetic vitamins may be used if non-synthetic sources are not commercially available.

5.3 Health Care Products and Production Aids

Common Name(s)	Origin and Usage
Acetylsalicylic acid	Aspirin.
Activated charcoal	Plant sources only.
Alcohol, ethyl (ethanol)	Allowed as a disinfectant and sanitizer only.
Alcohol, isopropyl	Allowed as a disinfectant only.
Antibiotics	See par. 6.7 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, for conditions on antibiotic use in livestock. See also *Antibiotics, oxytetracycline*.
Antibiotics, oxytetracycline	For emergency use for bees. The equipment shall be destroyed, in accordance with par. 7.1.14.7 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, but the bees need not be destroyed if they are taken out of organic production and treated with oxytetracycline.

Common Name(s)	Origin and Usage
Anti-inflammatories	For health care use, to reduce inflammation. Preference shall be given to natural alternatives.
Biologics, including vaccines	Organisms from genetic engineering or their products (e.g. recombinant gene technology) are not allowed.
Botanical compounds	Botanical preparations according to label specifications.
Calcium borogluconate	For milk fever. No withdrawal period required.
Chlorohexidine	For surgical procedures conducted by a veterinarian. Allowed for use as a post-milking teat dip when alternative germicidal agents and physical barriers have lost their effectiveness.
Colostral whey	Probiotic.
Colostrum	Shall be organic unless commercially unavailable.
Copper sulphate	For use as an essential nutrient (source of copper and sulphur) and for topical use (foot baths). Sulphates produced using sulphuric acid are prohibited.
Diatomaceous earth	For use in control of external parasites.
Electrolyte solutions	With no added active ingredients.
Electrolytes	Without antibiotics.
Formic acid	For apicultural use to control parasitic mites. This substance may be used after the last honey harvest of the season and shall be discontinued 30 days before the addition of honey supers.
Glucose	
Glycerin	For use as a livestock teat dip; shall be produced through the hydrolysis of fats or oils.
Homeopathic and biotherapies	
Honey	Organic honey is allowed.
Hydrogen peroxide	External use (disinfectant): pharmaceutical grade. Internal use (e.g. livestock drinking water): food grade.
Iodine	For use as a topical disinfectant. Sources include potassium iodide and elemental iodine. As a cleaning agent, shall be followed by a hot-water rinse. Non-elemental only; not to exceed 5% solution by volume (e.g. iodophors).
Iron products	May be supplied by ferric phosphate, ferric pyrophosphate, ferrous lactate, ferrous sulphate, iron carbonate, iron gluconate, iron oxide, iron phosphate, iron sulphate or reduced iron.
Lime, hydrated	Not permitted to cauterize physical alterations or deodorize animal wastes.
Local anesthetics	Use requires a withdrawal period of 90 days after administering to livestock intended for slaughter, and 7 days after administering to dairy animals. Preference shall be given to natural alternatives.
Magnesium sulphate	Mined sources only. A source of magnesium and sulphur. Sulphates produced using sulphuric acid are prohibited.
Mineral oil	For external use only.
Oxalic acid	For the control of mites in honeybee colonies.
Oxytocin	For postparturition therapeutic use only. Meat from treated animals will not lose its organic status. See par. 6.7.6 d. of CAN/CGSB 32.310, *Organic Production Systems — General Principles and Management Standards*, for mandatory withdrawal time requirement.

Common Name(s)	Origin and Usage
Parasiticides and anti-microbials	See par. 6.7 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, for conditions regarding the use of internal parasiticides.
Plant oils	To control external parasites.
Rotenone	For external parasites, rotenone shall not be combined with unacceptable formulants. See also *Botanical pesticides* in par. 4.3 for restrictions.
Selenium products	May be derived from sodium selenate or sodium selenite. See *Trace minerals, elements (mineral products).* May be used where documented deficiencies in the stock, soils or feed supplies exist.
Sulfur	For control of external parasites.
Trace minerals, elements (mineral products)	Non-synthetic chelated or sulphated minerals that are registered for use in livestock feed. Synthetic nutrient minerals may be used when non-synthetic sources are unavailable. Minerals may not be used to stimulate growth or production. Minerals from any source are allowed for medical use.
Vaccines	See *Biologics, including vaccines.*
Vitamins	Used for enrichment or fortification. Synthetic vitamins may be used if non-synthetic sources are not commercially available. Vitamins from any source are allowed for medical use.

6. PERMITTED SUBSTANCES LISTS FOR PROCESSING

6.1 **Classification** — Processing substances are classified according to the following uses and applications:

a. **Non-organic Ingredients** (NOI) are in most cases considered non-agricultural, although some of the fundamental ingredients may have originated from agricultural-based commodities. Non-organic ingredients may be used only when an acceptable alternative, non-synthetic ingredient is commercially unavailable.

   i. **Food Additives** — See the definition of Food Additive in section 3 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards.*

   ii. **Other Non-organic Ingredients** — These non-organic ingredients are not considered food additives.

b. **Substances Permitted in Products Whose Contents Are 70% or More, and Less Than 95% Organic Ingredients.**

6.2 **Other Categories of Substances** — Other categories of substances are classified according to the following uses and applications:

a. **Processing Aids** are substances or ingredients that are added to a product for a technological effect during processing. They are not present in the finished product or are present at insignificant or non-functional levels.

b. **Pest Control Substances** are used to disinfect or prevent infestation of stored commodities, prevent post-harvest decay, and control losses from insects, diseases, rodents and other organisms.

6.3 Non-organic Ingredients Classified as Food Additives

Common Name(s)	Origin and Usage
Acids	Including a) alginic, b) citric — produced by microbial fermentation of carbohydrate substances, and c) lactic.
Agar	Water, alcohol, acid and base extracts that are permitted by this standard only.
Alginates (alginic acid, sodium alginate, potassium alginate)	
Ammonium bicarbonate	For use as a leavening agent only.
Ammonium carbonate	For use as a leavening agent only.
Argon	
Ascorbic acid, non-synthetic	
Ascorbic acid, synthetic	Synthetic form is allowed in fruits and vegetables only if the natural form is not available.
Calcium carbonate	Prohibited as a colouring agent.
Calcium chloride	Milk products, fat products, fruits and vegetables, and soybean products.
Calcium citrate	
Calcium phosphates (monobasic, dibasic, and tribasic forms)	
Calcium sulphate	From mined sources only. Sulphates produced using sulphuric acid are prohibited.
Carrageenan (Irish moss)	Water, alcohol, acid and base extracts that are permitted by this standard only.
Carbon dioxide	
Citric acid	From fruit and vegetable products.
Ferrous sulphate	For iron enrichment or fortification of products when recommended or required by regulation. Sulphates produced using sulphuric acid are prohibited.
Glycerides (mono and diglycerides)	For use only in drum drying of products. Organisms from genetic engineering are excluded. Documentation is required. Shall be produced from organic sources unless not commercially available.
Glycerine	Shall be produced by hydrolysis of natural (vegetable or animal) fats and oils.
Gums	Water-extracted only (includes arabic, guar, karaya, tragacanth, locust bean and carob bean). For milk products: fat, confectionery, canned meat and egg products. For canned meat: gelatine, agar and carrageen.
Kelp and kelp products	For use only as a thickener and dietary supplement.
Lactic acid	For fermented vegetable products or in sausage casings.
Lecithin	Bleached form is allowed when unbleached form is not suitable. From organic sources only.
Magnesium chloride (nigari)	Derived from seawater, for soybean products.
Magnesium sulphate	From non-synthetic sources only. Sulphates produced using sulphuric acid are prohibited.
Malic acid	
Ozone	
Pectin (low-methoxy)	
Pectin (high-methoxy)	

Common Name(s)	Origin and Usage
Potassium acid tartrate (potassium hydrogen tartrate)	
Potassium carbonate	
Potassium chloride	
Potassium citrate	
Potassium metabisulphite	See *Sulphurous acid.*
Potassium tartrate made from tartaric acid	For cereals, cakes and confectionery. Allowed as a food additive in cider and several dairy products.
Silicon dioxide	
Sodium acid pyrophosphate	For use as a leavening agent only.
Sodium bicarbonate (baking soda)	Non-synthetic sources only.
Sodium carbonate (soda ash)	Non-synthetic sources only.
Sodium chloride	
Sodium citrate	For sausages and milk products.
Sodium hydroxide (lye or caustic soda)	
Sodium phosphates	For use in dairy products only.
Sulphurous acid	For use as a preservative only in alcoholic beverages made from grapes or other fruit; minimum use of SO_2 is recommended. The maximum allowable level of SO_2 in alcoholic beverages with less than 5% residual sugar is 100 parts per million and 30 parts per million for total sulphites and free sulphites respectively; in alcoholic beverages with 5% or more and less than 10% residual sugar, 150 parts per million and 35 parts per million respectively; and in alcoholic beverages with 10% or more residual sugar, 250 parts per million and 45 parts per million respectively. The use of sulphites from SO_2 bottled gas, as liquid SO_2, or liberated from the ignition of asbestos-free sulphur wicks is acceptable.
Tocopherols and mixed natural concentrates	Derived from vegetable oil when rosemary extracts are not a suitable alternative.
Xanthan gum	Water extracts, for fat products, fruit and vegetables, cakes and biscuits, and salads.

6.4 Non-organic Ingredients Not Classified as Food Additives

Common Name(s)	Origin and Usage
Colouring, natural	From non-synthetic sources only and shall not be produced using synthetic solvents and carrier systems or any artificial preservative.
Cornstarch	Not from sources from genetic engineering or products derived from genetic engineering, with no added chemosynthetic substance.
Dairy cultures	May not be products of recombinant DNA technology.

Common Name(s)	Origin and Usage
Enzymes	Any preparations of enzymes normally used in food processing derived from edible, non-toxic plants, non-pathogenic fungi or non-pathogenic bacteria. Animal enzymes: rennet—animal derived; catalase—bovine liver; animal lipase; pancreatin; pepsin; and trypsin. Animal-derived enzymes shall be guaranteed free of specified risk materials including the skull, brain, trigeminal ganglia (nerves attached to the brain), eyes, tonsils, spinal cord and dorsal root ganglia (nerves attached to the spinal cord) of ruminants aged 30 months or older; and the distal ileum (portion of the small intestine) of ruminants of all ages. Shall be from an organic source unless not commercially available. Egg white lysozyme. All enzymes shall be water, alcohol, acid and base extracts that are permitted by this standard only and shall not contain substances prohibited by par. 1.4.1 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*, or not permitted by this standard.
Flavours	From non-synthetic sources only; shall not be produced using synthetic solvents and carrier systems or any artificial preservative. No propylene glycol carrier or any artificial preservatives, and shall not be hexane extracted.
Micro-organisms, (processing derivatives)	Including any preparations of micro-organisms normally used in product processing, excepting micro-organisms from genetic engineering or enzymes derived from genetic engineering, with no added chemosynthetic substance.
Nitrogen	Food-grade quality only.
Oxygen	
Potassium iodide, natural	Permitted only when legally required.
Salt	See also *Sodium chloride* in par. 6.3. Only substances listed in par. 6.3 or 6.4 may be added to mined or sea salt.
Smoke flavour	See *Yeast*.
Vitamins and minerals	Minerals (including trace elements), vitamins and similar isolated ingredients shall not be used except where legally required or a dietary or nutritional deficiency can be demonstrated and shall be documented. Vitamins shall not be derived from organisms from genetic engineering.
Waxes	Non-synthetic only: a) carnauba wax and b) wood resin (processing product of resin component).
Yeast	Non-synthetic only: a) autolysate, b) bakers' (may contain lecithin, obtained without the use of bleaches and organic solvents), c) brewers', d) nutritional, and e) smoked. Non-synthetic smoke flavouring process shall be documented. Growth on petrochemical substrate and sulphite waste liquor are prohibited.

6.5 Substances Permitted in Products Whose Contents Are 70% or More, and Less Than 95% Organic Ingredients

Common Name(s)	Origin and Usage
Magnesium carbonate	As an anti-caking agent in non-standardized dry mixes (e.g. seasonings) used in meat products.
Magnesium stearate	
Potassium iodide, synthetic	
Potassium phosphate	

6.6 Processing Aids

Common Name(s)	Origin and Usage
Activated charcoal	Shall be of plant origin. Prohibited for use in the processing of maple syrup.
Alcohol, ethyl (ethanol)	
Argon	
Bentonite	
Calcium carbonate	
Calcium hydroxide (lime)	
Calcium sulphate, (gypsum)	As a carrier for cakes and biscuits, soybean products and bakers' yeast. Sulphates produced using sulphuric acid are prohibited.
Carbon dioxide	
Carrageenan (Irish moss)	Water, alcohol, acid and base extracts that are permitted by this standard only.
Casein	Shall be from organic sources unless commercially unavailable.
Cellulose	As a filtering aid (non-chlorine bleached) and for use in inedible regenerative sausage casings.
Diatomaceous earth	As a food filtering aid or as a clarifying agent only.
Ethylene	For post-harvest ripening of tropical fruit and degreening of citrus only.
Gelatine	Permitted only if guaranteed free of specified risk materials including the skull, brain, trigeminal ganglia (nerves attached to the brain), eyes, tonsils, spinal cord and dorsal root ganglia (nerves attached to the spinal cord) of cattle aged 30 months or older; and the distal ileum (portion of the small intestine) of cattle of all ages. Shall be from an organic source unless commercially unavailable.
Isinglass	As a fining agent (fish-based).
Kaolin	As a clarifying agent.
Nitrogen	Food-grade quality only.
Oxygen	
Ozone	
Perlite	For use as a filter aid in food processing only.
Potassium carbonate	
Potassium hydroxide (caustic potash)	For pH adjustment only. Prohibited for use in lye peeling of fruits and vegetables.

Common Name(s)	Origin and Usage
Silicon dioxide	
Sodium hydroxide (lye or caustic soda)	Prohibited for use in lye peeling of fruits and vegetables.
Talc	As a filtering agent.
Vegetable oil	Obtained without the use of synthetic solvents. May be used as a spray-on greasing agent only.
Waxes	Non-synthetic only: a) carnauba wax and b) wood resin (processing product of resin component).

6.7 Pest Control Substances

Common Name(s)	Origin and Usage
Ammonium carbonate	As an attractant in insect traps.
Boric acid	May be used for structural pest control (e.g. ants). No direct contact with organic food or crops is allowed.
Carbon dioxide	
Cholecalciferol (vitamin D_3)	Not allowed in organic food processing and food storage facilities.
Diatomaceous earth	
Neem oil	
Pyrethrins	Without piperonyl butoxide as a carrier. No direct contact with organic food is allowed.
Soaps, ammonium	As a large animal repellent; no contact with soil or edible portion of crop is allowed.

7. PERMITTED SUBSTANCES LISTS FOR CLEANERS, DISINFECTANTS AND SANITIZERS

7.1 **Classification** — Cleaners, disinfectants and sanitizers are used to remove dirt, filth and foreign matter from products and product-handling operations. These substances are also used to control micro-organisms that may contaminate products. They are classified as follows:

a. Food-grade cleaners, disinfectants and sanitizers that are allowed without a mandatory removal event.

b. Cleaners, disinfectants and sanitizers allowed on food-contact surfaces, equipment and in facilities provided that substances are removed from food-contact surfaces prior to organic production.

7.2 **Section 7 does not apply to maple syrup production** — The operator shall meet the specific requirements for the different stages of production as described in par. 7.2 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards.*

7.3 Food-Grade Cleaners, Disinfectants and Sanitizers That Are Allowed Without a Mandatory Removal Event

Common Name(s)	Origin and Usage
Acetic acid	Non-synthetic and synthetic sources may be used on equipment. Non-synthetic sources only may be used on food and plants.
Alcohol, ethyl (ethanol)	Non-synthetic and synthetic sources may be used on equipment.
Alcohol, isopropyl	Non-synthetic and synthetic sources may be used on equipment.
Ascorbic acid	Non-synthetic sources may be used on equipment.
Citric acid	Non-synthetic and synthetic sources may be used.
Hydrogen peroxide	
Peracetic (peroxyacetic) acid	For use in wash or rinse water for food or plants or on food-contact surfaces.
Potassium bicarbonate	On equipment.
Sodium carbonate (soda ash)	Only non-synthetic sources may be used on food or food-contact surfaces without a mandatory removal event.
Sodium bicarbonate (baking soda)	Only non-synthetic sources may be used on food or food-contact surfaces without a mandatory removal event.
Sodium hydroxide (lye or caustic soda)	
Vinegar	Organic or non-organic sources.

7.4 Cleaners, Disinfectants and Sanitizers Allowed on Food-Contact Surfaces including Equipment Provided That Substances Are Removed From Food-Contact Surfaces Prior to Organic Production

Common Name(s)	Origin and Usage
Bleach	a. Calcium hypochlorite; b. Chlorine dioxide; c. Sodium hypochlorite; d. Ozone; and e. Hydrogen peroxide. Not to exceed 10% solution by volume. Free chlorine levels for wash water in direct contact with crops or food, and in flush water from cleaning irrigation systems, that is applied to crops or fields, shall not exceed the maximum limits under the applicable regulations for safe drinking water.
Chlorine	See *Bleach*.
Detergents	Biodegradable only (whose biodegraded components are not more harmful than the original components). On equipment.
Iodine	On equipment. Non-elemental only and not to exceed 5% solution by volume (e.g. iodophors).
Lime	
Phosphoric acid	On equipment in the dairy industry only.
Potassium hydroxide (caustic potash)	

Common Name(s)	Origin and Usage
Potassium permanganate	Not to exceed 1% solution by volume.
Soaps	Soaps consisting of fatty acids derived from animal or vegetable oils are allowed.
Soap-based algicide (demossers)	On equipment.
Sodium bicarbonate (baking soda)	
Sodium borate	
Sodium carbonate (soda ash)	
Surfactants	See *Detergents*; *Soaps*.
Wetting agents	Natural wetting agents, including saponins and microbial wetting agents, are allowed. See also *Detergents, Soaps*.

8. NOTES (Informative)

8.1 Related Publications

8.1.1 Canadian Food Inspection Agency (CFIA)

Feeds Act (R.S., 1985, c. F-9)

Feeds Regulations, 1983 (SOR/83-593).

8.1.2 Health Canada

Food and Drugs Act (R.S., 1985, c. F-27)

Food and Drug Regulations (C.R.C., c. 870)

Pest Control Products Act (2002, c. 28)

Pest Control Products Regulations (SOR/2006-124).

8.2 Sources of Referenced Publications

The following addresses were valid at the date of publication.

8.2.1 The publication referred to in par. 2.1.1 may be obtained from the Canadian General Standards Board, Sales Centre, Gatineau, Canada K1A 1G6. Telephone 819-956-0425 or 1-800-665-2472. Fax 819-956-5740. E-mail ncr.cgsb-ongc@pwgsc.gc.ca. Web site www.ongc-cgsb.gc.ca.

8.2.2 The publication referred to in par. 2.1.2 may be viewed at the Canadian Council of Ministers of the Environment Web site at www.ccme.ca.

8.2.3 The publication referred to in par. 2.1.3 may be viewed at the Quebec Ministère du Développement durable, Environnement et Parcs Web site at www.mddep.gouv.qc.ca/matieres/mat_res-en/fertilisantes/critere/index.htm.

8.2.4 The publication referred to in par. 2.1.4 may be viewed at the Pest Management Regulatory Agency Web site at www.pmra-arla.gc.ca/english/pubs/reg-e.html.

8.3 Source of Related Publications

The following address was valid at the date of publication.

8.3.1 The publications referred to in par. 8.1.1 and 8.1.2 may be viewed at the Department of Justice Canada Web site at Canada.justice.gc.ca.

(This appendix does not form a mandatory part of the standard.)

ORGANIC PRODUCTION SYSTEMS
REVIEW RECORD FOR GENERIC SUBSTANCES ADDED OR AMENDED

Section 10 of CAN/CGSB-32.310, *Organic Production Systems — General Principles and Management Standards*

SECTION A — COMMENT FORM

A.1 **Substance:** ____

Common Name(s) Chemical Abstracts Service (CAS) #

A.2 **Fill out a., b. or c. by referring to Comment Form:**

a. FOR A NEW SUBSTANCE:

Proposed for addition into Table (paragraph number): ____________

____ Permitted with no restrictions **OR**

____ Permitted with limitations on origin/mode of production/usage as follows: ____________

____

Proposed organic usage: ____

____

b. FOR ADDITION OF AN EXISTING SUBSTANCE INTO A DIFFERENT TABLE:

The substance already appears in Table (paragraph number): ____________

Comment requests its addition into Table (paragraph number): ____________

Proposed organic usage: ____

____

c. FOR CHANGES TO ANNOTATIONS OF AN EXISTING SUBSTANCE:

The substance appears in Table (paragraph number): ____________

Comment requests changes to annotation: ____

____

Rationale for change to annotation: ____

____

SECTION B — SUBSTANCE SPECIFICS

B.1 Substance Description: ______________________________

____

B.2 Known Alternatives and Relative Merits: ______________________________

____

B.3 Canadian Regulatory Status: Unregulated ☐ Regulated ☐ Agency (ies) ______________________________

____

B.4 Compliance Review

B.4.1 Would use of the substance be consistent with the General Principles of Organic Production as identified in CAN/CGSB-32.310-2006, Amended October 2008, par. 10.2.1 a.? If NO, elaborate on any inconsistencies.

☐ Yes ☐ No

Comment: ______________________________

____

B.4.2 Would use of the substance be consistent with the prohibitions set out in CAN/CGSB-32.310-2006, Amended October 2008, par. 1.4.1? If NO, elaborate on any inconsistencies.

☐ Yes ☐ No

Comment: ______________________________

____

B.4.3 Is the substance found in nature?

☐ Yes ☐ No

If Yes, has it undergone ONLY the following processes during production:

a. Mechanical/physical (e.g. extraction, precipitation)

b. Enzymatic

c. Microbial (e.g. fermentation)?

☐ Yes ☐ No

If NO, is the substance produced by chemical processes or processes that chemically alter the substance?

☐ Yes ☐ No

If Yes, describe the process(es): ______________________________

____

SECTION C — CROPS

C.1 Is the substance necessary for obtaining or maintaining soil fertility, for fulfilling specific requirements of crops or for specific soil conditioning and rotational purposes that cannot be satisfied by the requirements and practices of this standard (CAN/CGSB-32.310-2006, Amended October 2008, par. 10.3.1)?

☐ Yes ☐ No

Comment: ______________________________

____

C.2 Is the substance necessary for management of diseases, insects, weeds and other pests of plants that cannot be managed by any other biological, physical or plant breeding alternative or effective management practice (CAN/CGSB-32.310-2006, Amended October 2008, par. 10.3.2)?

☐ Yes ☐ No

Comment: ______________________________

____

C.3 Is the substance of plant and animal origin and derived from crops and livestock produced in accordance with this standard (CAN/CGSB-32.310-2006, Amended October 2008, par. 10.4.1)?

☐ Yes ☐ No

If NO, is a non-synthetic form of this substance available in sufficient quality or quantity?

☐ Yes ☐ No

C.4 Is the substance produced by chemical processes or processes that chemically alter the substance?

☐ Yes ☐ No

SECTION D — LIVESTOCK

D.1 If the substance is proposed for par. 5.2, Feed, Feed Additives and Feed Supplements, is the substance necessary to correct documented essential nutrient deficiencies in the forage or feed ration given that other biological, cultural, or physical treatments are not available (CAN/CGSB-32.310-2006, Amended October 2008, par. 10.3.3.1)?

☐ Yes ☐ No

Comment: ______________________________

____

D.2 If the substance is proposed for par. 5.2, Feed, Feed Additives and Feed Supplements, is the substance necessary for ensuring and preserving product quality, given that other biological, cultural or physical treatments are not available (CAN/CGSB-32.310- 2006, Amended October 2008, par. 10.3.3.1)?

☐ Yes ☐ No

Comment: ______________________________

____

D.3 If the substance is proposed for par. 5.2, Feed, Feed Additives and Feed Supplements, is the substance obtained from organic sources or from sources occurring in nature, such as marine products or mineral origin (CAN/CGSB-32.310-2006, Amended October 2008, par. 10.4.2.1)?

☐ Yes ☐ No

Comment: ____________________

____

If NO, is a non-synthetic form of this substance available in sufficient quality or quantity?

☐ Yes ☐ No

Comment: ____________________

____

D.4 If the substance is proposed for par. 5.3, Health Care Products and Production Aids, is the substance necessary for livestock health (CAN/CGSB-32.310-2006, Amended October 2008, par. 10.3.3.2)?

☐ Yes ☐ No

Are other organic treatments not available?

☐ Yes ☐ No

Comment: ____________________

____

SECTION E — PROCESSING

E.1 Is the substance

a. necessary to correct documented essential nutrient deficiencies of the product (i.e. vitamins and minerals) OR when required by regulations?1

☐ Yes ☐ No OR

b. essential for ensuring the safety of the product?

☐ Yes ☐ No OR

c. used only when it is not feasible/practical to produce or store such products without having recourse to such ingredients and processing aids?

☐ Yes ☐ No OR

d. necessary to achieve a technological effect during processing (e.g. filtration) or an organoleptic effect in the final product (e.g. colouring and flavouring) while respecting the principle in CAN/CGSB-32.310-2006, Amended October 2008, par. 10.2.1 a. vi.?

☐ Yes ☐ No

Comment: ____________________

____

E.2 Are organic sources available in sufficient quality or quantity?

☐ Yes ☐ No

If NO, are other non-synthetic sources of these substances available in sufficient quality or quantity?

☐ Yes ☐ No

Comment: ____

____

E.3 What is the impact of the substances use and potential misuse on

a. human health through both food and non-food exposure, including acute and chronic toxicity, allergenicity and metabolites;

b. product quality, including nutrition, flavour, taste, appearance and storage, when applicable;

c. consumer perception of the nature, substance and quality of a food product?

Comment: ____

____

SECTION F — CLEANING AND SANITATION

F.1 In which area of organic production would this substance be proposed for use?

☐ Crops ☐ Livestock ☐ Processing

F.2 Is the substance necessary and appropriate for the intended use?

☐ Yes ☐ No

Comment: ____

____

F.3 Is a non-synthetic form of this substance available in sufficient quality or quantity?

☐ Yes ☐ No

Comment: ____

____

SECTION G — IMPACTS

G.1 What is the impact of the substance's manufacture and disposal after use on the environment including impacts on ecology, surface and ground water and soil and air quality including substance persistence, degradation and concentration effects?

____

____

G.2 What is the impact on equivalency and harmonization of this standard with standards and regulations of other jurisdictions?

____

____

SECTION H — REFERENCES USED

Please cite all references used in the review of this substance:____________________

____

____

SECTION I — COMPLIANCE SUMMARY

I.1 Permitted Substances Lists (PSL) sub-committee recommendations regarding substance request:

☐ Acceptance ☐ Rejection

I.2 Rationale: __________________________________

____

I.3 Substance Name as it should appear in CAN/CGSB-32.311: ____________________

I.4 Table (paragraph number) in which it should appear in CAN/CGSB-32.311:____________________

I.5 Annotation (if applicable): __________________________________

____

I.6 If accepted on an exception basis, latest date by which the substance must be reviewed again: ________________

____

____

SECTION J — REVIEWER ATTESTATION

Members of the working group reviewing this substance:

1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
	Name	Credentials	Signature	Date

This document provides a summary of the discussions undertaken by the Working Group on this substance during the period (DD/MM/YY) from ________________ to ________________.

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Bioresource Technology 98 (2007) 2824–2828

BIORESOURCE TECHNOLOGY

Fermentation of molasses by *Zymomonas mobilis*: Effects of temperature and sugar concentration on ethanol production

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Received 12 July 2004; received in revised form 9 August 2006; accepted 10 August 2006

Abstract

Fermentations utilizing strains of *Zymomonas mobilis*, in place of the traditional yeasts, have been proposed due their ethanol yields being close to theoretical. Ethanol production from sugar cane molasses was analyzed under different culture conditions using *Z. mobilis* in batch fermentation. The total reducing sugars (TRS) concentrations in the molasses, temperature, agitation and culture time effects were studied simultaneously through factorial design. The best conditions for ethanol production were 200 g L^{-1} of total reducing sugars in the molasses, temperature of 30 °C and static culture and time of fermentation of 48 h, achieving 55.8 g L^{-1}. The pH of the medium was kept constant during the experiments, showing that molasses presents a buffering effect.

Keywords: Ethanol; *Zymomonas mobilis*; Sugar cane molasses; Factorial design

1. Introduction

The depletion of fossil fuel reserves, the unstable panorama of the petrol prices and more recently, increasing environmental and political pressures (Davis et al., 2005) has increased industrial focus toward alternative fuel sources, and encouraged the search of products originated from biomass, as renewable sources of energy.

In this context, fermentative processes stand out, where microbial metabolism is used for the transformation of simple raw materials in products with high aggregate value. Among these, ethanol is one of the best examples of how fermentation can match market needs satisfactorily. Even though the fermentative process for ethanol production is well known, the production costs are still the key impediment wide use of ethanol as fuel. Therefore, the development of a fermentation process using economical carbon sources is important for the biofuel ethanol production on a commercial scale (Tanaka et al., 1999; Tao et al., 2005). Many studies have been done that focus on production improvement and decreasing its costs (Sreenath and Jeffries, 2000; Davis et al., 2005; Ruanglek et al., 2006; Mohagheghi et al., 2006).

Zymomonas mobilis, a Gram-negative bacterium, have been attracting increasing attention for fuel ethanol. It is an osmo- and ethanol-tolerant bacterium and it has shown higher specific rates of glucose uptake and ethanol production (Rogers et al., 1982, 1997) via the Entner-Doudoroff pathway under anaerobic conditions. *Z. mobilis* may have a greater potential for industrial ethanol production from raw sugar, sugarcane juice and sugarcane syrup (Lee and Huang, 2000).

Molasses is an agro-industrial by-product often used in alcohol distilleries (Jiménez et al., 2004) due to the presence of fermentative sugars, being an optimal carbon source for the microorganism metabolism. Sugar cane molasses is an abundant agro-industrial material produced in Brazil and other tropical countries and its low cost is an important

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doi:10.1016/j.biortech.2006.08.026

factor for the economical viability of substances production by fermentation.

The traditional one-at-a-time optimization strategy is relatively simple, and the individual effects of medium factors can be graphically depicted without the need of the statistical analysis. Unfortunately, it frequently fails to locate the region of optimum response in such procedures. In this case, fractional and/or full factorial design provides an efficient approach to optimization. A combination of factors generating a certain optimum response can be identified though factorial design and the use of response surface methodology (RSM) (Box et al., 1978).

The response-surface methodology is an empirical modeling system that assesses the relationship between a group of variables that can be controlled experimentally and the observed response (Sreekumar et al., 1999; Hamsaveni et al., 2001). Response surface methodology (RSM) is a useful model to study the effect of several factors influencing the responses by varying them simultaneously and carrying out a limited number of experiments (Hamsaveni et al., 2001). The aim of this work was to study the influence between four factors and their interaction to optimize the ethanol production by *Z. mobilis* ATCC 29191 in sugar cane molasses using factorial design and analysis by RSM. The selected factors were sugar concentration on molasses, temperature, agitation rate and culture time. The measured responses were ethanol and biomass.

Table 1
2^4 Factorial experimental design investigating the effect of TRS concentration in molasses, temperature, agitation rate and culture time to ethanol production by *Z. mobilis* ATCC 29191

Run	Variables in coded levels				Measured responses	
	X_1	X_2	X_3	X_4	Ethanol ($g\,L^{-1}$)	Biomass ($g\,L^{-1}$)
1	−	−	−	−	5.74	0.89
2	+	−	−	−	5.38	0.81
3	−	+	−	−	7.95	0.75
4	+	+	−	−	6.98	0.65
5	−	−	+	−	2.97	0.56
6	+	−	+	−	9.89	0.31
7	−	+	+	−	4.09	0.53
8	+	+	+	−	1.98	0.41
9	−	−	−	+	19.33	1.07
10	+	−	−	+	7.31	1.22
11	−	+	−	+	22.69	1.29
12	+	+	−	+	30.08	1.41
13	−	−	+	+	2.94	0.81
14	+	−	+	+	12.20	1.07
15	−	+	+	+	2.23	0.65
16	+	+	+	+	15.91	0.43

	Factors	Real levels	
		−1	+1
X_1	Molasses ($g\,L^{-1}$)	150	250
X_2	Temperature (°C)	25	35
X_3	Agitation rate (rpm)	0	180
X_4	Time of cultivation (h)	12	24

2. Methods

2.1. Microorganism and culture conditions

The strain used was *Z. mobilis* ATCC 29191. The strain was maintained on agar plates containing (per liter): 200 g glucose, 10 g yeast extract, 5 g peptone, 1 g $(NH_4)_2SO_4$, 2 g KH_2PO_4, 0.5 g $MgSO_4 \cdot 7H_2O$ and 0.5 g $FeSO_4$ (Merck). The culture medium was sterilized at 121 °C for 15 min. The cultures were maintained at 4 °C and renewed every five weeks.

The inoculum culture was grown composed with sucrose at 200 $g\,L^{-1}$ and the components mentioned previously. The cell concentration was standardized to 0.2 $g\,L^{-1}$, determined by turbidimetry at $\lambda = 605$ nm. The batch fermentations were carried out in duplicate in the sugar cane molasses culture medium, in the different culture conditions, according to the experimental design (Table 1).

2.2. Analytical methods

After each fermentation, the culture was centrifuged (10,0000 rpm for 15 min) and the biomass concentration was determined by measuring the turbidity of diluted sample at 605 nm using a standard curve of absorbance against dry cell mass. The total reducing sugars (TRS) were quantified according to Somogy (1945) and Nelson (1944). Ethanol was determined by Gas Chromatography (GC) Shimadzu, using a DBWAX column (30.0 × 0.25 cm) with a flux of 40 $ml\,min^{-1}$ and isopropanol as an internal standard.

2.3. Experimental design

The conditions to optimize *Z. mobilis* ethanol production by controlling fermentation variables were performed using a factorial design and analysis of the results by response surface methodology (Box et al., 1978; Barros et al., 1995). As a preliminary step for optimization, the most important factors were screened by applying the full 2^4 factorial design. The main effects for each of the factors studied were defined by the Eq. (1):

$$Ef_i = (\bar{y}_+)_i - (\bar{y}_-)_i \tag{1}$$

where Ef_i is the effect of the ith factor on the ethanol production, and $(\bar{y}_+)_i$ and $(\bar{y}_-)_i$ are the average ethanol productions values at the high (+) and low (−) levels of the factor. Interaction effects of two or more factors are also calculated using this equation. In these calculations, the ethanol production values attributed to the (+) and (−) levels were determined by multiplying the sign in the columns of design matrix for the factors involved in the interaction. The following independent variables were included X_1 = total reducing sugars (TRS), X_2 = temperature (°C), X_3 = agitation (rpm) and X_4 = culture time (h) shown in Table 1. The dependent variables were ethanol and biomass production. This preliminary analysis facilitated

Table 2
2^3 Central composite design for investigating the effects of TRS in molasses, temperature and culture time on the ethanol production by *Z. mobilis* ATCC 29191

	Factors	Real levels		
		−1	0	+1
X_1	Molasses (g L^{-1})	200	250	300
X_2	Temperature (°C)	30	35	40
X_3	Time of growth (h)	24	36	48

selecting the statistically significant factors, TRS concentration in sugar cane molasses (X_1), temperature (X_2) and growth time (X_3), therefore, two new levels for each factor were chosen according to the experimental design, shown in Table 2. The results of this factorial design evidenced that TRS concentration in sugar cane molasses (X_1) and temperature (X_2) are significant factors for ethanol production. In this case, a new full factorial design was employed to investigate the simultaneous effect of these two factors on the response. The experiments were carried out with a central point and star design, which consist in an identical planning, turning from 45° regarding to the original orientation, where the variables X_1 and X_2 were at a distance of $\sqrt{2}$ (1.414) from the central point, adding up to 11 experiments, being 3 in the central point and 4 at the star design (Table 3). All the experiments were carried out in duplicate.

The RMS used in the present study is a central composite involving two different factors. Once the experiments are performed, the coefficients of linear and polynomial models are calculated using the Eqs. (2) and (3):

$$Y = b_0 + \sum_{i=1}^{k} b_i x_i + \mathrm{e} \quad \text{linear model} \tag{2}$$

$$Y = b_0 + \sum_{i=1}^{k} b_i x_i + \sum_{i=1}^{k} b_{ij} x_i^2 + \sum_{i_{i<j}}^{k} \sum_{j}^{k} b_{ij} x_{ij} + \mathrm{e} \quad \text{quadratic model} \tag{3}$$

where, *i j*, are linear and quadratic coefficients, respectively, while *b* is the regression coefficients, *k* the number of factors studied and optimized in the experiment and *e* is random error. The significance of each coefficient was determined using a student's test.

3. Results and discussion

The first step of the statistical approach to the analysis optimization was to establish the criteria that will define the experimental factors that have a significant effect on the response variables. Therefore, to optimize the ethanol production it was first performed as a 2^4 factorial design. Four relevant factors for the fermentative process were selected in a factorial design 2^4. The variables, studied simultaneously were: TRS concentration in sugar cane molasses (150 and 250 g L^{-1}), temperature (25° and 35 °C), agitation (180 oscillations per minute and static culture) and culture time (12 and 24 h), as shown in Table 1.

The main effects of the three factors concentration in sugar cane molasses (2.72), temperature (3.27), and (8.47) are all positives, and agitation rate is negative (−6.66). The growth time (X_4) main effect is the most significant factorial design effect value for the production of ethanol. The inclusion of agitation rate reduces the average ethanol production. Therefore, the subsequent runs were performed in a static format. Higher ethanol productions, 22.69 g L^{-1} and 30.08 g L^{-1} were obtained in static culture (run 11 and 12 in Table 1). According to Lee and Huang (2000) *Z. mobilis* is able to obtain an ethanol production close to the theoretical one from glucose through Entner–Doudoroff pathway under aerobic conditions.

Based upon the results obtained in the 2^4 factorial design a 2^3 factorial design was developed using new variation levels in order to move sequentially in the direction of maximizing the ethanol production. To define the best culture conditions it was necessary to test new sugar concentrations, temperature and culture time in a 2^3 factorial

Table 3
2^2 Central composite design and star design investigating the effects of TRS in molasses and temperature on the ethanol production by *Z. mobilis* ATCC 29191

Run	Coded levels		Real levels			Measured responses			
	X_1	X_2	TRS (g L^{-1})	Temperature (°C)	Ethanol (g L^{-1})	Y_{pr}[a] (%)	$Y_{p/s}$[b] (g g^{-1})	Q_p[c] (g L^{-1} h^{-1})	Biomass (g L^{-1})
1	–	–	150	25	46.43	64.26	0.35	0.97	1.39
2	+	–	250	35	42.39	73.98	0.40	0.88	1.46
3	–	+	150	25	47.73	77.01	0.42	0.99	1.25
4	+	+	250	35	45.22	74.56	0.40	0.94	1.46
5	0	0	200	30	55.36	62.13	0.34	1.15	1.76
6	0	0	200	30	54.31	58.37	0.32	1.13	1.67
7	0	0	200	30	55.57	63.03	0.34	1.16	1.76
8	−1414	0	80	30	28.55	73.04	0.40	0.59	1.39
9	0	1414	200	37	22.83	44.66	0.24	0.47	1.65
10	1414	0	270	30	33.43	53.20	0.29	0.70	1.60
11	0	−1414	200	18	7.87	46.62	0.24	0.16	0.15

[a] Y_{pr} (%) = substrate conversion.
[b] $Y_{p/s}$ (g g^{-1}0) = yield ethanol for substrate.
[c] Q_p (g L^{-1} h^{-1}) = ethanol productivity.

analysis, with a central point. The values of the new variables are listed in Table 2.

The results of the 2^3 design showed that the condition of 200 g L^{-1} of TRS and temperature 30 °C was the most favorable, achieving 54.83 g L^{-1} after a 48-hour-culture time. The time was a decisive factor, once the ethanol production increased to more than 60% from 24 to 48 h. By comparison Bandaru et al. (2006) reported a maximum ethanol concentration (55.3 g L^{-1}) at 32.4 °C, pH of 4.93 after 17.24 h from sago starch using *Z. mobilis* MTCC 92. Davis et al. (article in press) reported similar values (54 g L^{-1}) for *Z. mobilis* ZM4 from hydrolysed waste starch stream.

In the central point, 250 g L^{-1} and 35 °C, ethanol production was an average of 31.15 g L^{-1}. The decrease in ethanol production at high sugar concentration occurred due to an increase in the osmotic pressure that is one of the essential factors for by-products synthesis such as sorbitol and levan. The molasses was an industrial sucrose-containing substrates that has been reported to contain substantial salt content (Bekers et al., 2000). At 35 °C and 300 g L^{-1} sugars concentration on molasses Cazetta et al. (2005) obtained maximum sorbitol production by *Z. mobilis* ATCC 29191.

The temperature of 40 °C was negative for fermentative process, resulting in lower productions, 4.6 g L^{-1}. Numerous studies have shown that temperatures above 37 °C are detrimental for ethanol production (Lee et al., 1981; Skotinicki et al., 1981; Lyness and Doelle, 1981; Diez and Yokoya, 1996a). Based on the results of 2^3 factorial design, it was performed as a 2^2 factorial design, with central composite design, resulting in 11 experiments (Table 3). In this stage the time was fixed in 48 h.

With the central composite design it was possible to confirm that maximum ethanol concentration occurred at the central point, 55.8 g L^{-1} on average (Fig. 1 and Table 3). These values are similar to the ones described for ethanol production from sucrose (Skotinicki et al., 1981; Lyness and Doelle, 1981; Sreekumar et al., 1999) and sago starch (Bandaru et al., 2006), which confirmed that the microorganism showed an optimal adaptation to the non-treated molasses. The ethanol productivity was a mean of 1.1 g L^{-1} h^{-1}.

A multiple regression analysis of the data was used to describe the variables under study taking into account linear, quadratic and cross product terms for each factor. The significance of the equation parameters on ethanol production was assessed by the F test.

According to the RSM methodology, it was not possible to fit the data obtained to either the linear or quadratic mathematical model, however, there was evidence of a slight curvature in the response surface. Since the average response at the center point was larger than the average response at the vertices, the surface was slightly convex.

The uncoupling between the biomass and ethanol production can be observed clearly in these experiments (Tables 1–3). Low biomass production is normally observed in *Z. mobilis*, and cell growth and fermentation are not linked (Parker et al., 1997). According to Rogers et al. (1982) approximately 2% of the carbon source is converted into biomass. This occurs due to Entner–Doudoroff pathway used by this microorganism. This pathway yields only a single mole of ATP per mole of sugar fermented, giving *Zymomonas* the lowest molar growth yield reported for a bacterium (Swings and DeLey, 1977).

The pH of the medium remained constant during the experiments, varying from 6.0 at the beginning to 5.6, on average *n* (Fig. 2). The pH has also been described as a factor that strongly interferes in the fermentative processes. However, according to Diez and Yokoya (1996b) molasses exhibits a buffering effect. This regulatory action depends of molasses chemical composition. The main stabilizer compounds of the pH are weak acids and amino acids that act in the acid range, mainly between pH 3.0 and 5.0, or phosphates, whose buffering effects occur in the range of 6.0 and 7.0. Falcão de Moraes et al. (1981) noted that *Z. mobilis* possesses hugh tolerance at pH variations from 3.5 to 7.5, and its optimum at a range of 5.0–7.0. Buzato (1984), observed no substantial oscillations on the alco-

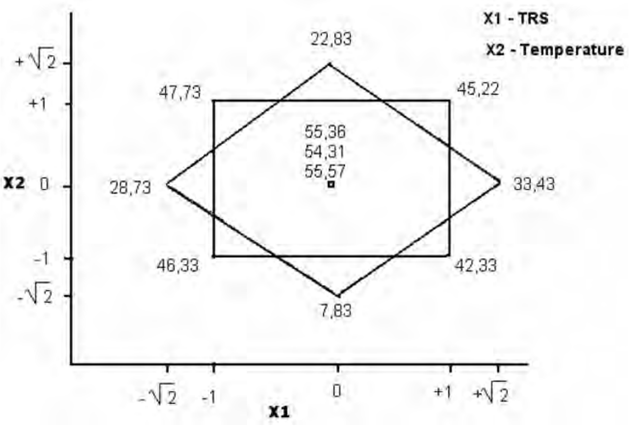

Fig. 1. Scheme showing results of 2^2 factorial analysis with star design to ethanol production by *Z. mobilis* ATCC 29191 in molasses.

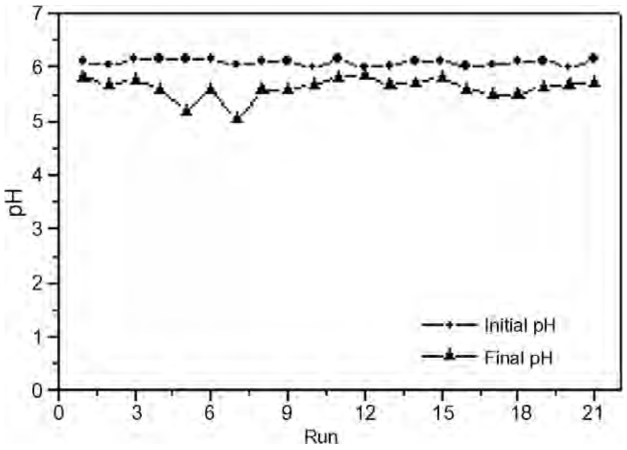

Fig. 2. Initial and final pH values on the fermentation by *Z. mobiliz* ATCC 29191.

holic yield at a pH range of 5.0–6.0, showing that there is no major influence of this factor when *Z. mobilis* is cultivated on molasses.

Acknowledgements

This project was financially supported by the CAPES-Brazil and CNPq-Brazil.

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GUIDELINES FOR THE PRODUCTION, PROCESSING, LABELLING AND MARKETING OF ORGANICALLY PRODUCED FOODS

GL 32–1999

PREFACE

The **Codex Alimentarius Commission** is an intergovernmental body with over 180 members, within the framework of the Joint Food Standards Programme established by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO), with the purpose of protecting the health of consumers and ensuring fair practices in the food trade. The Commission also promotes coordination of all food standards work undertaken by international governmental and non governmental organizations.

The Codex Alimentarius (Latin, meaning Food Law or Code) is the result of the Commission's work: a collection of internationally adopted food standards, guidelines, codes of practice and other recommendations. The texts in this publication are part of the Codex Alimentarius.

Food labelling is the primary means of communication between the producer and seller of food on one hand, and the purchaser and consumer of the other. The Codex Alimentarius standards and guidelines on food labelling are published in a specific volume: *Food Labelling – Complete Texts*. In addition to the general recommendations, the Codex Committee on Food Labelling also provides guidance for certain claims commonly found in the market in order to provide clear information to the consumer.

The Codex Committee on Food Labelling developed the *Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods* in view of the growing production and international trade in organically produced foods with a view to facilitating trade and preventing misleading claims. The *Guidelines* are intended to facilitate the harmonization of requirements for organic products at the international level, and may also provide assistance to governments wishing to establish national regulations in this area.

The *Guidelines* include general sections describing the organic production concept and the scope of the text; description and definitions; labelling and claims (including products in transition/conversion); rules of production and preparation, including criteria for the substances allowed in organic production; inspection and certification systems; and import control.

Further information on labelling texts, or any other aspect of the Codex Alimentarius Commission, may be obtained from:

The Secretary,
Codex Alimentarius Commission,
Joint FAO/WHO Food Standards Programme,
FAO, Viale delle Terme di Caracalla,
00153, Rome Italy
fax: +39(06)57.05.45.93
email: codex@fao.org
Internet address: http://www.codexalimentarius.net

Adopted 1999. Revisions 2001, 2003, 2004 and 2007. Amendments 2008 and 2009.

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GUIDELINES FOR THE PRODUCTION, PROCESSING, LABELLING AND MARKETING OF ORGANICALLY PRODUCED FOODS

GL 32–1999

FOREWORD

1. These guidelines have been prepared for the purpose of providing an agreed approach to the requirements which underpin production of, and the labelling and claims for, organically produced foods.

2. The aims of these guidelines are:
   - to protect consumers against deception and fraud in the market place and unsubstantiated product claims;
   - to protect producers of organic produce against misrepresentation of other agricultural produce as being organic;
   - to ensure that all stages of production, preparation, storage, transport and marketing are subject to inspection and comply with these guidelines;
   - to harmonize provisions for the production, certification, identification and labelling have organically grown produce;
   - to provide international guidelines for organic food control systems in order to facilitate recognition of national systems as equivalent for the purposes of imports; and
   - to maintain and enhance organic agricultural systems in each country so as to contribute to local and global preservation.

3. These guidelines are at this stage a first step into official international harmonization of the requirements for organic products in terms of production and marketing standards, inspection arrangements and labelling requirements. In this area the experience with the development of such requirements and their implementation is still very limited. Moreover, consumer perception on the organic production method may, in certain detailed but important provisions, differ from region to region in the world. Therefore, the following is recognized at this stage:
   - the guidelines are a useful instrument in assisting countries to develop national regimes regulating production, marketing and labelling of organic foods;
   - the guidelines need regular improvement and updating in order to take into account technical progress and the experience with their implementation;
   - the guidelines do not prejudice the implementation of more restrictive arrangements and more detailed rules by member countries in order to maintain consumer credibility and prevent fraudulent practices, and to apply such rules to products from other countries on the basis of equivalency to such more restrictive provisions.

4. These guidelines set out the principles of organic production at farm, preparation, storage, transport, labelling and marketing stages, and provides an indication of accepted permitted inputs for soil fertilizing and conditioning, plant pest and disease control and, food additives and processing aids. For labelling purposes, the use of terms inferring that organic production methods have been used are restricted to products derived from operators under the supervision of a certification body or authority.

5. Organic agriculture is one among the broad spectrum of methodologies which are supportive of the environment. Organic production systems are based on specific and precise standards of production which aim at achieving optimal agroecosystems which are socially, ecologically and economically sustainable. Terms such as “biological” and “ecological” are also used in an effort to describe the organic system more clearly. Requirements for organically produced foods differ from those for other agricultural products in that production procedures are an intrinsic part of the identification and labelling of, and claim for, such products.

6. “Organic” is a labelling term that denotes products that have been produced in accordance with organic production standards and certified by a duly constituted certification body or authority. Organic agriculture is based on minimizing the use of external inputs, avoiding the use of synthetic fertilizers and pesticides. Organic agriculture practices cannot ensure that products are completely free of residues, due to general environmental pollution. However, methods are used to minimize pollution of air, soil and water. Organic food handlers, processors and retailers adhere to standards to maintain the integrity of organic agriculture products. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people.

7. Organic agriculture is a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system. An organic production system is designed to:

   a) enhance biological diversity within the whole system;
   b) increase soil biological activity;
   c) maintain long-term soil fertility;
   d) recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimizing the use of non-renewable resources;
   e) rely on renewable resources in locally organized agricultural systems;
   f) promote the healthy use of soil, water and air as well as minimize all forms of pollution thereto that may result from agricultural practices;
   g) handle agricultural products with emphasis on careful processing methods in order to maintain the organic integrity and vital qualities of the product at all stages;
   h) become established on any existing farm through a period of conversion, the appropriate length of which is determined by site-specific factors such as the history of the land, and type of crops and livestock to be produced.

8. The concept of close contact between the consumer and the producer is a long established practice. Greater market demand, the increasing economic interests in production, and the increasing distance between producer and consumer has stimulated the introduction of external control and certification procedures.

9. An integral component of certification is the inspection of the organic management system. Procedures for operator certification are based primarily on a yearly description of the agricultural enterprise as prepared by the operator in cooperation with the inspection body. Likewise, at the processing level, standards are also developed against which the processing operations and plant conditions can be inspected and verified. Where the inspection process is undertaken by the certification body or authority, there must be clear separation of the inspection and certification function. In order to maintain their integrity, certification bodies or authorities which certify the procedures of the operator should be independent of economic interests with regard to the certification of operators.

10. Apart from a small portion of agricultural commodities marketed directly from the farm to consumers, most products find their way to consumers via established trade channels. To minimize deceptive practices in the market place, specific measures are necessary to ensure that trade and processing enterprises can be audited effectively. Therefore, the regulation of a process, rather than a final product, demands responsible action by all involved parties.

11. Import requirements should be based on the principles of equivalency and transparency as set out in the *Principles for Food Import and Export Inspection and Certification*.[1] In accepting imports of organic products, countries would usually assess the inspection and certification procedures and the standards applied in the exporting country.

12. Recognizing that organic production systems continue to evolve and that organic principles and standards will continue to be developed under these guidelines, the Codex Committee on Food Labelling (CCFL) shall review these guidelines on a regular basis. The CCFL shall initiate this review process by inviting member governments and international organizations to make proposals to the CCFL regarding amendments to these guidelines prior to each CCFL meeting.

SECTION 1. SCOPE

1.1 These guidelines apply to the following products which carry, or are intended to carry, descriptive labelling referring to organic production methods:

   a) unprocessed plants and plant products, livestock and livestock products to the extent that the principles of production and specific inspection rules for them are introduced in Annexes 1 and 3; and

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[1] CAC/GL 20-1995.

b) processed agricultural crop and livestock products[2] intended for human consumption derived from (a) above.

1.2 A product will be regarded as bearing indications referring to organic production methods where, in the labelling or claims, including advertising material or commercial documents, the product, or its ingredients, is described by the terms “organic”, “biodynamic”, “biological”, “ecological”, or words of similar intent including diminutives which, in the country where the product is placed on the market, suggests to the purchaser that the product or its ingredients were obtained according to organic production methods.

1.3 Paragraph 1.2 does not apply where these terms clearly have no connection with the method of production.

1.4 These guidelines apply without prejudice to other Codex Alimentarius Commission (CAC) provisions governing the production, preparation, marketing, labelling and inspection of the products specified in paragraph 1.1.

1.5 All materials and/or the products produced from genetically engineered/modified organisms (GEO/GMO) are not compatible with the principles of organic production (either the growing, manufacturing, or processing) and therefore are not accepted under these guidelines.

SECTION 2. DESCRIPTION AND DEFINITIONS

2.1 Description

Foods should only refer to organic production methods if they come from an organic farm system employing management practices which seek to nurture ecosystems which achieve sustainable productivity, and provide weed, pest and disease control through a diverse mix of mutually dependent life forms, recycling plant and animal residues, crop selection and rotation, water management, tillage and cultivation. Soil fertility is maintained and enhanced by a system which optimizes soil biological activity and the physical and mineral nature of the soil as the means to provide a balanced nutrient supply for plant and animal life as well as to conserve soil resources. Production should be sustainable with the recycling of plant nutrients as an essential part of the fertilizing strategy. Pest and disease management is attained by means of the encouragement of a balanced host/predator relationship, augmentation of beneficial insect populations, biological and cultural control and mechanical removal of pests and affected plant parts. The basis for organic livestock husbandry is the development of a harmonious relationship between land, plants and livestock, and respect for the physiological and behavioural needs of livestock. This is achieved by a combination of providing good quality organically grown feedstuffs, appropriate stocking rates, livestock husbandry systems appropriate to behavioural needs, and animal management practices that minimize stress and seek to promote animal health and welfare, prevent disease and avoid the use of chemical allopathic veterinary drugs (including antibiotics).

2.2 Definitions

For the purpose of these guidelines:

Agricultural product/product of agricultural origin means any product or commodity, raw or processed, that is marketed for human consumption (excluding water, salt and additives) or animal feed.

Audit is a systematic and functionally independent examination to determine whether activities and related results comply with planned objectives.[3]

Certification is the procedure by which official certification bodies, or officially recognized certification bodies, provide written or equivalent assurance that foods or food control systems conform to requirements. Certification of food may be, as appropriate, based on a range of inspection activities which may include continuous on-line inspection, auditing of quality assurance systems and examination of finished products.[4]

Certification body means a body which is responsible for verifying that a product sold or labelled as “organic” is produced, processed, prepared handled, and imported according to these guidelines.

Competent authority means the official government agency having jurisdiction.

Genetically engineered/modified organisms. The following provisional definition is provided for genetically/modified organisms.[5] Genetically engineered/modified organisms, and products thereof, are

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[2] Until lists of ingredients of non agricultural origin and processing aids permitted in the preparation of products of livestock origin are elaborated, competent authorities should develop their own lists.

[3] CAC/GL 20-1995.

[4] CAC/GL 20-1995.

[5] In the absence of a definition of genetically engineered/modified organisms agreed by the Codex Alimentarius Commission, this definition has been developed in order to provide initial guidance for governments in the application of these guidelines. This definition is therefore to remain under review in the light of other considerations by the Commission and its Committees. In the interim, member countries may also apply national definitions.

produced through techniques in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination.

Techniques of genetic engineering/modification include, but are not limited to: recombinant DNA, cell fusion, micro and macro injection, encapsulation, gene deletion and doubling. Genetically engineered organisms will not include organisms resulting from techniques such as conjugation, transduction and hybridization.

Ingredient means any substance, including a food additive, used in the manufacture or preparation of a food and present in the final product although possibly in a modified form.[6]

Inspection is the examination of food or systems for control of food, raw materials, processing, and distribution including in-process and finished product testing, in order to verify that they conform to requirements.[7] For organic food, inspection includes the examination of the production and processing system.

Labelling means any written, printed or graphic matter that is present on the label, accompanies the food, or is displayed near the food, including that for the purpose of promoting its sale or disposal.[8]

Livestock means any domestic or domesticated animal including bovine (including buffalo and bison), ovine, porcine, caprine, equine, poultry and bees raised for food or in the production of food.[9] The products of hunting or fishing of wild animals shall not be considered part of this definition.

Marketing means holding for sale or displaying for sale, offering for sale, selling, delivering or placing on the market in any other form.

Official accreditation is the procedure by which a government agency having jurisdiction formally recognizes the competence of an inspection and/or certification body to provide inspection and certification services. For organic production the competent authority may delegate the accreditation function to a private body.

Officially recognized inspection systems/officially recognized certification systems are systems which have been formally approved or recognized by a government agency having jurisdiction.[10]

Operator means any person who produces, prepares or imports, with a view to the subsequent marketing thereof, products as referred to in Section 1.1, or who markets such products.

Plant protection product means any substance intended for preventing, destroying, attracting, repelling, or controlling any pest or disease including unwanted species of plants or animals during the production, storage, transport, distribution and processing of food, agricultural commodities, or animal feeds.

Preparation means the operations of slaughtering, processing, preserving and packaging of agricultural products and also alterations made to the labelling concerning the presentation of the organic production method.

Production means the operations undertaken to supply agricultural products in the state in which they occur on the farm, including initial packaging and labelling of the product.

Veterinary drug means any substance applied or administered to any food-producing animal, such as meat or milk-producing animals, poultry, fish or bees, whether used for therapeutic, prophylactic or diagnostic purposes or for modification of physiological functions or behaviour.[11]

SECTION 3. LABELLING AND CLAIMS

General provisions

3.1 Organic products should be labelled in accordance with the Codex *General Standard* for the *Labelling of Prepackaged Foods.*[12]

3.2 The labelling and claims of a product specified in Section 1.1(a) may refer to organic production methods only where:

a) such indications show clearly that they relate to a method of agricultural production;
b) the product was produced in accordance with the requirements of Section 4 or imported under the requirements laid down in Section 7;
c) the product was produced or imported by an operator who is subject to the inspection measures laid down in Section 6, and
d) the labelling refers to the name and/or code number of the officially recognized inspection or certification body to which the operator who has carried out the production or the most recent processing operation is subject.

3.3 The labelling and claims of a product specified in paragraph 1.1(b) may refer to organic production methods only where:

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[6] *General Standard for the Labelling of Prepackaged Foods*, Section 4 – Labelling of Prepackaged Foods (CODEX STAN 1-1985).

[7] CAC/GL 20-1995.

[8] CODEX STAN 1-1985.

[9] Provisions for aquaculture will be elaborated at a future date.

[10] CAC/GL 20-1995.

[11] *Codex Alimentarius Commission Procedural Manual*, Definitions.

[12] CODEX STAN 1-1985.

a) such indication show clearly that they relate to a method of agricultural production and are linked with the name of the agricultural product in question, unless such indication is clearly given in the list of ingredients;
b) all the ingredients of agricultural origin of the product are, or are derived from, products obtained in accordance with the requirements of Section 4, or imported under the arrangements laid down in Section 7;
c) the product should not contain any ingredient of non-agricultural origin not listed in Annex 2, Table 3;
d) the same ingredients shall not be derived from an organic and non-organic origin;
e) the product or its ingredients have not been subjected during preparation to treatments involving the use of ionizing radiation or substances not listed in Annex 2, Table 4;
f) the product was prepared or imported by an operator subject to the regular inspection system as set out in Section 6 of these guidelines; and
g) the labelling refers to the name and/or the code number of the official or officially recognized certification body or authority to which the operator who has carried out the most recent preparation operation is subject.

3.4 By way of derogation from paragraph 3.3(b),

– certain ingredients of agricultural origin not satisfying the requirement in that paragraph may be used, within the limit of maximum level of 5% m/m of the total ingredients excluding salt and water in the final product, in the preparation of products as referred to in paragraph 1.1(b);
– where such ingredients of agricultural origin are not available, or in sufficient quantity, in accordance with the requirements of Section 4 of these guidelines;

3.5 Pending further review of the guidelines in accordance with Section 8, Member Countries can consider the following with regard to products referred to in paragraph 1.1(b) marketed in their territory:

– the development of specific labelling provisions for products containing less than 95% ingredients of agricultural ingredients;
– the calculation of the percentages in 3.4 (5%) and in 3.5 (95%) on the basis of the ingredients of agricultural origin (instead of all ingredients excluding only salt and water);
– the marketing of product with in transition/conversion labelling containing more than one ingredient of agricultural origin.

3.6 In developing labelling provisions from products containing less than 95% of organic ingredients in accordance with the paragraph above, member countries may consider the following elements in particular for products containing 95% and 70% of organic ingredients:

a) the product satisfies the requirements of paragraphs 3.3(c), (d) (e), (f) and (g);
b) the indications referring to organic production methods should only appear on the front panel as a reference to the approximate percentage of the total ingredients including additives but excluding salt and water;
c) the ingredients, appear in descending order (mass/mass) in the list of ingredients;
d) indications in the list of ingredients appear in the same colour and with an identical style and size of lettering as other indications in the list of ingredient.

Labelling of products in transition/conversion to organic

3.7 Products of farms in transition to organic production methods may only be labelled as “transition to organic” after 12 months of production using organic methods providing that:

a) the requirements referred to in paragraphs 3.2 and 3.3 are fully satisfied;
b) the indications referring to transition/conversion do not mislead the purchaser of the product regarding its difference from products obtained from farms and/or farm units which have fully completed the conversion period;
c) such indication take the form of words, such as “product under conversion to organic farming”, or similar words or phrase accepted by the competent authority of the country where the product is marketed, and must appear in a colour, size and style of lettering which is not more prominent than the sales description of the product;
d) foods composed of a single ingredient may be labelled as “transition to organic” on the principal display panel;
e) the labelling refers to the name and/or the code number of the official or officially approved certification body or authority to which the operator who has carried out the most recent preparation is subject.

Labelling of non-retail containers

3.8 The labelling of non-retail containers of product specified in paragraph 1.1 should meet the requirements set out in Annex 3, paragraph 10.

SECTION 4. RULES OF PRODUCTION AND PREPARATION

4.1 Organic production methods require that for the production of products referred to in paragraph 1.1(a):

a) at least the production requirements of Annex 1 should be satisfied;

b) in the case where (a) (above) is not effective, substances listed in Annex 2, Tables 1 and 2 or substances approved by individual countries that meet the criteria established in Section 5.1, may be used as plant protection products, fertilizers, soil conditioners, insofar as the corresponding use is not prohibited in general agriculture in the country concerned in accordance with the relevant national provisions.

4.2 Organic processing methods require that for the preparation of products referred to in paragraph 1.1(b):

a) at least the processing requirements of Annex 1 should satisfied;

b) substances listed in Annex 2, Tables 3 and 4 or substances approved by individual countries that meet the criteria established in Section 5.1 may be used as ingredients of non-agricultural origin or processing aids insofar as the corresponding use is not prohibited in the relevant national requirements concerning the preparation of food products and according to good manufacturing practice.

4.3 Organic products should be stored and transported according to the requirements of Annex 1.

4.4 By derogation of the provisions of paragraphs 4.1 (a) and 4.2 (a), the competent authority may, with regard to the provisions on livestock production at Annex 1, provide for more detailed rules as well as for derogations for implementation periods in order to permit gradual development of organic farming practices.

SECTION 5. REQUIREMENTS FOR INCLUSION OF SUBSTANCES IN ANNEX 2 AND CRITERIA FOR THE DEVELOPMENT OF LISTS OF SUBSTANCES BY COUNTRIES

5.1 At least the following criteria should be used for the purposes of amending the permitted substance lists referred to in Section 4. In using these criteria to evaluate new substances for use in organic production, countries should take into account all applicable statutory and regulatory provisions and make them available to other countries upon request.

Any proposals for the inclusion in Annex 2 of new substances must meet the following general criteria:

i) they are consistent with principles of organic production as outlined in these Guidelines;

ii) use of the substance is necessary/essential for its intended use;

iii) manufacture, use and disposal of the substance does not result in, or contribute to, harmful effects on the environment;

iv) they have the lowest negative impact on human or animal health and quality of life; and

v) approved alternatives are not available in sufficient quantity and/or quality.

The above criteria are intended to be evaluated as a whole in order to protect the integrity of organic production. In addition, the following criteria should be applied in the evaluation process:

a) if they are used for fertilization, soil conditioning purposes:
  - they are essential for obtaining or maintaining the fertility of the soil or to fulfil specific nutrition requirements of crops, or specific soil-conditioning and rotation purposes which cannot be satisfied by the practices included in Annex 1, or other products included in Table 2 of Annex 2; and
  - the ingredients will be of plant, animal, microbial, or mineral origin and may undergo the following processes: physical (e.g., mechanical, thermal), enzymatic, microbial (e.g., composting, fermentation); only when the above processes have been exhausted, chemical processes may be considered and only for the extraction of carriers and binders;[13] and
  - their use does not have a harmful impact on the balance of the soil ecosystem or the physical characteristics of the soil, or water and air quality; and
  - their use may be restricted to specific conditions, specific regions or specific commodities;

b) if they are used for the purpose of plant disease or pest and weed control:
  - they should be essential for the control of a harmful organism or a particular disease for which other biological, physical, or plant breeding alternatives and/or effective management practices are not available; and
  - their use should take into account the potential harmful impact on the environment, the ecology (in particular non-target organisms) and the health of consumers, livestock and bees; and
  - substances should be of plant, animal, microbial, or mineral origin and may undergo the following processes: physical (e.g. mechanical, thermal), enzymatic, microbial (e.g. composting, digestion);

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[13] The use of chemical processes in the context of these Criteria is an interim measure and should be reviewed in line with the provisions as set out in Section 8 of these Guidelines.

  - however, if they are products used, in exceptional circumstances, in traps and dispensers such as pheromones, which are chemically synthesized they will be considered for addition to lists if the products are not available in sufficient quantities in their natural form, provided that the conditions for their use do not directly or indirectly result in the presence of residues of the product in the edible parts;
  - their use may be restricted to specific conditions, specific regions or specific commodities;

c) if they are used as additives or processing aids in the preparation or preservation of the food :

  - these substances are used only if it has been shown that, without having recourse to them, it is impossible to:
    - produce or preserve the food, in the case of additives, or
    - produce the food, in the case of processing aids

    in the absence of other available technology that satisfies these Guidelines;
  - these substances are found in nature and may have undergone mechanical/physical processes (e.g. extraction, precipitation), biological/enzymatic processes and microbial processes (e.g. fermentation),
  - or, if these substances mentioned above are not available from such methods and technologies in sufficient quantities, then those substances that have been chemically synthesized may be considered for inclusion in exceptional circumstances;
  - their use maintains the authenticity of the product;
  - the consumer will not be deceived concerning the nature, substance and quality of the food;
  - the additives and processing aids do not detract from the overall quality of the product.

In the evaluation process of substances for inclusion on lists all stakeholders should have the opportunity to be involved.

5.2 Countries should develop or adopt a list of substances that meet the criteria outlined in Section 5.1.

The open nature of the lists

5.3 Because of the primary purpose of providing a list of substances, the lists in Annex 2 are open and subject to the inclusion of additional substances or the removal of existing ones on an ongoing basis. When a country proposes inclusion or amendment of a substance in Annex 2 it should submit a detailed description of the product and the conditions of its envisaged use to demonstrate that the requirements under Section 5.1 are satisfied. The procedure for requesting amendments to the lists is set out under Section 8 of these Guidelines.

SECTION 6. INSPECTION AND CERTIFICATION SYSTEMS[14]

6.1 Inspection and certification systems are used to verify the labelling of, and claims for, organically produced foods. Development of these systems should take into account the *Principles for Food Import and Export Inspection and Certification*[15], the *Guideline for the Design, Operation, Assessment and Accreditation of Food Import and Export Inspection and Certification Systems*.[16,17]

6.2 Competent authorities should establish an inspection system operated by one or more designated authorities and/or officially recognized inspection/certification[18] bodies to which the operators producing, preparing or importing products as referred to in paragraph 1.1 should be subject.

6.3 The officially recognized inspection and certification systems should comprise at least the application of the measures and other precautions set out in Annex 3.

6.4 For the application of the inspection system operated by the official or officially recognized certification body or authority, countries should identify a competent authority responsible for the approval and supervision of such bodies:

- the identified competent authority may delegate, while maintaining the responsibility for the decisions and actions taken, the assessment and supervision of private inspection and certification bodies to a private or public third party hereafter referred to as its “designate”. If delegated, the private or public third party should not be engaged in inspection and/or certification;
- for this purpose an importing country may recognize a third party accrediting body when the exporting country lacks an identified competent authority and a national program.

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[14] The systems conducted by certification bodies may in some countries be equivalent to those systems conducted by inspection bodies. Therefore, the term “inspection and certification” has been used wherever these systems may be synonymous.

[15] CAC/GL 20-1995.

[16] CAC/GL 26-1997.

[17] See also other agreed international standards, e.g. ISO65.

[18] In organic approval processes reference is frequently made to certification performed by either a ‘certification body’ or an ‘inspection body’. Where these functions are conducted by the same body there must be clear separation of the inspection and certification roles.

6.5 In order to attain approval as an officially recognized certification body or authority, the competent authority, or its designate, when making its assessment should take into account the following:

a) the standard inspection/certification procedures to be followed, including detailed description of the inspection measures and precautions which the body undertakes to impose on operators subject to inspection;
b) the penalties which the body intends to apply where irregularities and/or infringements are found;

c) the availability of appropriate resources in the form of qualified staff, administrative and technical facilities, inspection experience and reliability;
d) the objectivity of the body vis-à-vis the operators subject to inspection.

6.6 The competent authority or its designate should:

a) ensure that the inspections carried out on behalf of the inspection or certification body are objective;
b) verify the effectiveness of inspections;
c) take cognizance of any irregularities and/or infringements found and penalties applied;
d) withdraw approval of the certification body or authority where it fails to satisfy the requirements referred to in (a) and (b) or, no longer fulfils the criteria indicated in paragraph 6.5 or, fails to satisfy the requirements laid down in paragraphs 6.7 to 6.9.

6.7 Official and/or officially recognized certification bodies or authority referred to in paragraph 6.2 should:

a) ensure that at least the inspection measures and precautions specified in Annex 3 are applied to undertakings subject to inspection; and
b) not disclose confidential information and data obtained in their inspection or certification activities to persons other than the person responsible for the undertaking concerned and the competent authorities.

6.8 Official or officially recognized inspection and/or certification bodies or authority should:

a) give the competent authority or its designate, for audit purposes, access to their offices and facilities and, for random audit of its operators, access to the facilities of the operators, together with any information and assistance deemed necessary by the competent authority or its designate for the fulfilment of its obligations pursuant to these guidelines;
b) send to the competent authority or its designate each year a list of operators subject to inspection for the previous year and present to the said authority a concise annual report.

6.9 The designated authority and the official or officially recognized certification body or authority referred to in paragraph 6.2 should:

a) ensure that, where an irregularity is found in the implementation of Sections 3 and 4, or of the measures referred to in Annex 3, the indications provided for in paragraph 1.2 referring to the organic production method are removed from the entire lot or production run affected by the irregularity concerned;
b) where a manifest infringement, or an infringement with prolonged effects is found, prohibit the operator concerned from marketing products with indications referring to the organic production method for a period to be agreed with the competent authority or its designate.

6.10 The requirements of the *Guidelines for the Exchange of Information between Countries on Rejections of Imported Food*[19] should apply where the competent authority finds irregularities and/or infringements in the application of these guidelines.

SECTION 7. IMPORTS

7.1 Products as specified in paragraph 1.1 which are imported may be marketed only where the competent authority or designated body in the exporting country has issued a certificate of inspection stating that the lot designated in the certificate was obtained within a system of production, preparation, marketing and inspection applying at least the rules provided for in all sections and annexes of these guidelines and satisfy the decision on equivalency referred to under 7.4.

7.2 The certificate referred to in paragraph 7.1 above should accompany the goods, in the original copy, to the premises of the first consignee; thereafter the importer should keep the transactional certificate for not less than two years for inspection/audit purposes.

7.3 The authenticity of the product should be maintained after import through to the consumer. If imports of organic products are not in conformity with the requirements of these guidelines due to treatment required by

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[19] CAC/GL 25-1997.

national regulations for quarantine purposes that is not in conformity with these guidelines they loose their organic status.

7.4 An importing country may:

a) require detailed information, including reports established by independent experts mutually agreed between competent authorities of the exporting and importing countries, on the measures applied in the exporting country to enable it to make judgements and decisions on equivalency with its own rules provided that these rules of the importing country meet the requirements of these guidelines, and/or

b) arrange together with the exporting country for site visits to examine the rules of production and preparation, and the inspection/certification measures including production and preparation itself as applied in the exporting country.

c) require, in order to avoid any confusion to the consumer, that the product is labelled in accordance with the labelling requirements applied, in accordance with the provisions of section 3, in the importing country for the products concerned.

SECTION 8. ONGOING REVIEW OF THE GUIDELINES

8.1 In line with the purpose of the guidelines to provide advice to governments, member governments and international organizations are invited to make proposals to the Codex Committee on Food Labelling on an ongoing basis. Once a final document is agreed, the Codex Committee on Food Labelling shall conduct a review each 4 years of these guidelines and review each two years (or as required) the lists included in Annex 2 in order to take into account the latest developments in this area.

8.2 Proposals should be directed in the first instance to the Secretary, Codex Alimentarius Commission, Joint FAO/WHO Food Standards Programme, FAO, 00153, Rome, Italy.

ANNEX 1
PRINCIPLES OF ORGANIC PRODUCTION

A. PLANTS AND PLANT PRODUCTS

1. The principles set out in this Annex should have been applied on the parcels, farm or farm units during a conversion period of at least two years before sowing, or in the case of perennial crops other than grassland, at least three (3) years before the first harvest of products as referred to in paragraph 1.1(a) of these guidelines. The competent authority, or where delegated, the official or officially recognized certification body or authority may decide in certain cases (such as idle use for two years or more) to extend or reduce that period in the light of previous parcel use but the period must equal or exceed 12 months.

2. Whatever the length of the conversion period it may only begin once a production unit has been placed under an inspection system as required by 6.2 and once the unit has started the implementation of the production rules referred to in Section 4 of these Guidelines.

3. In cases where a whole farm is not converted at one time, it may be done progressively whereby these guidelines are applied from the start of conversion on the relevant fields. Conversion from conventional to organic production should be effected using permitted techniques as defined in these guidelines. In cases where a whole farm is not converted at the same time, the holding must be split into units as referred to in Annex 3, part A, paragraphs 3 and 11.

4. Areas in conversion as well as areas converted to organic production must not be alternated (switched back and forth) between organic and conventional production methods.

5. The fertility and biological activity of the soil should be maintained or increased, where appropriate, by:
   a) cultivation of legumes, green manures or deep-rooting plants in an appropriate multi-annual rotation programme;
   b) incorporation in the soil of organic material, composted or not, from holdings producing in accordance with these guidelines. By-products from livestock farming, such as farmyard manure, may be used if they come from livestock holdings producing in accordance with these guidelines;

   Substances, as specified in Annex 2, Table 1 may be applied only to the extent that adequate nutrition of the crop or soil conditioning are not possible by the methods set out in 5(a) and (b) above or, in the case of manures, they are not available from organic farming.
   c) for compost activation, appropriate micro-organisms or plant-based preparations may be used;
   d) biodynamic preparations from stone meal, farmyard manure or plants may also be used for the purpose covered by paragraph 5.

6. Pests, diseases and weeds should be controlled by any one, or a combination, of the following measures:
   - choice of appropriate species and varieties;
   - appropriate rotation programs;
   - mechanical cultivation;
   - protection of natural enemies of pests through provision of favourable habitat, such as hedges and nesting sites, ecological buffer zones which maintain the original vegetation to house pest predators;
   - diversified ecosystems. These will vary between geographical locations. For example, buffer zones to counteract erosion, agro-forestry, rotating crops, etc.
   - flame weeding;
   - natural enemies including release of predators and parasites;
   - biodynamic preparations from stone meal, farmyard manure or plants;
   - mulching and mowing;
   - grazing of animals;
   - mechanical controls such as traps, barriers, light and sound;
   - steam sterilization when proper rotation of soil renewal cannot take place.

7. Only in cases of imminent or serious threat to the crop and where the measures identified in 6. (above) are, or would not be effective, recourse may be had to products referred to in Annex 2.

8. Seeds and vegetative reproductive material should be from plants grown in accordance with the provisions of Section 4.1 of these guidelines for at least one generation or, in the case of perennial crops, two growing

seasons. Where an operator can demonstrate to the official or officially recognized certification body or authority that material satisfying the above requirements is not available, the certification body or authority may support:

a) in the first instance, use of untreated seeds or vegetative reproductive material, or
b) if (a) is not available, use of seeds and vegetative reproductive material treated with substances other than those included in Annex 2.

The competent authority may establish criteria to limit the application of the derogation in 8 above.

9. The collection of edible plants and parts thereof, growing naturally in natural areas, forests and agricultural areas, is considered an organic production method provided that:

– the products are from a clearly defined collection area that is subject to the inspection/certification measures set out in Section 6 of these guidelines;
– those areas have received no treatments with products other than those referred to in Annex 2 for a period of three years before the collection;
– the collection does not disturb the stability of the natural habitat or the maintenance of the species in the collection area;
– the products are from an operator managing the harvesting or gathering of the products, who is clearly identified and familiar with the collection area.

B. LIVESTOCK AND LIVESTOCK PRODUCTS

General principles

1. Where livestock for organic production are maintained, they should be an integral part of the organic farm unit and should be raised and held according to these guidelines.

2. Livestock can make an important contribution to an organic farming system by:

a) improving and maintaining the fertility of the soil;
b) managing the flora through grazing;
c) enhancing biodiversity and facilitating complementary interactions on the farm; and
d) increasing the diversity of the farming system.

3. Livestock production is a land related activity. Herbivores must have access to pasture and all other animals must have access to open-air runs; the competent authority may allow exceptions when the animals' physiological state, inclement weather conditions, and state of the land so permit, or the structure of certain `traditional` farming systems restrict access to pasture, providing the welfare of the animals can be guaranteed.

4. Stocking rates for livestock should be appropriate for the region in question taking into consideration feed production capacity, stock health, nutrient balance, and environmental impact.

5. Organic livestock management should aim to utilize natural breeding methods, minimize stress, prevent disease, progressively eliminate the use of chemical allopathic veterinary drugs (including antibiotics), reduce the feeding of animals with products of animal origin (e.g. meat meal), and maintain animal health and welfare.

Livestock sources/origin

6. The choice of breeds, strains and breeding methods shall be consistent with the principles of organic farming, taking into account in particular:

a) their adaptation to the local conditions;
b) their vitality and resistance to disease;
c) the absence of specific diseases or health problems associated with some breeds and strains (porcine stress syndrome, spontaneous abortion etc).

7. Livestock used for products satisfying Section 1.1 (a) of these guidelines must come, from birth or hatching, from production units complying with these guidelines, or have been the offspring of parents raised under the conditions set down in these guidelines. They must be raised under this system throughout their life.

~ Livestock may not be transferred between organic and non-organic units. The competent authority can establish detailed rules for the purchase of livestock from other units complying with these Guidelines.
~ Livestock existing on the livestock production unit, but not complying with these Guidelines, may be converted.

8. When an operator can demonstrate to the satisfaction of the official or officially recognized inspection/certification body that livestock satisfying the requirements indicated in the previous paragraph are not available, the official or officially recognized inspection/ certification body may allow livestock not raised according these guidelines under circumstances such as:
   a) for considerable expansion of the farm, when a breed is changed or when new livestock specialization is developed;
   b) for the renewal of a herd, e.g., high mortality of animals caused by catastrophic circumstances;
   c) males for breeding.

   The competent authority may set the specific conditions under which livestock from non-organic sources may be allowed or not allowed, taking into account that animals be brought in as young as possible as soon as they are weaned.

9. These livestock qualified by the derogations indicated in the previous paragraph must comply with the conditions set out in paragraph 12. These conversion periods must be observed if the products are to be sold as organic according to Section 3 of these guidelines.

Conversion

10. The conversion of the land intended for feeding crops or pasture must comply with the rules set out in Part A paragraphs 1, 2, and 3 of this Annex.

11. The competent authority may reduce the conversion periods or conditions established in paragraph 10 (for the land) and/or paragraph 12 (for livestock and livestock products) in the following cases:
    a) pasture, open-air runs and exercise areas used by non-herbivore species;
    b) for bovine, equine, ovine and caprine coming from extensive husbandry during an implementation period established by the competent authority or dairy herds converted for the first time;
    c) if there is simultaneous conversion of livestock and land used only for feeding within the same unit, the conversion period for both livestock, pasture and/or land used for animal feed, may be reduced to two years only in the case where the existing livestock and their offspring are fed mainly with products from the unit.

12. Once the land has reached organic status and livestock from a non-organic source is introduced, and if the products are to be sold as organic, such livestock must be reared according to these Guidelines for at least the following compliance periods:

Bovine and equine

Meat products: 12 months and at least ¾ of their life span in the organic management system;

Calves for meat production: 6 months when brought in as soon as they are weaned and less than 6 months old;

Milk products: 90 days during the implementation period established by the competent authority, after that, six months.

Ovine and caprine

Meat products: six months;

Milk products: 90 days during the implementation period established by the competent authority, after that, six months.

Porcine

Meat products: Six months.

Poultry/laying hens

Meat products: whole of life span as determined by the competent authority;

Eggs: six weeks.

Nutrition

13. All livestock systems should provide the optimum level of 100% of the diet from feedstuffs (including ‘in conversion’ feedstuffs) produced to the requirements of these guidelines.

14. For an implementation period to be set by the competent authority, livestock products will maintain their organic status providing feed, consisting of at least 85% for ruminants and 80% for non-ruminants and calculated on a dry matter basis, is from organic sources produced in compliance with these Guidelines.

15. Notwithstanding the above, where an operator can demonstrate to the satisfaction of the official or officially recognized inspection/certification body that feedstuffs satisfying the requirement outlined in paragraph 13 above are not available, as a result of, for example, unforeseen severe natural or manmade events or extreme

climatic weather conditions, the inspection/certification body may allow a restricted percentage of feedstuffs not produced according to these guidelines to be fed for a limited time, providing it does not contain genetically engineered/modified organisms or products thereof. The competent authority shall set both the maximum percentage of non-organic feed allowed and any conditions relating to this derogation.

16. Specific livestock rations should take into account:
    – the need of young mammals for natural, preferably maternal, milk;
    – that a substantial proportion of dry matter in the daily rations of herbivores needs to consist of roughage, fresh or dried fodder, or silage;
    – that polygastric animals should be not fed silage exclusively;
    – the need for cereals in the fattening phase of poultry;
    – the need for roughage, fresh or dried fodder or silage in the daily ration for pigs and poultry.

17. All livestock must have ample access to fresh water to maintain the full health and vigour of the livestock.

18. If substances are used as feedstuffs, nutritional elements, feed additives or processing aids in the preparation of feedstuffs, the competent authority shall establish a positive list/s of substances in compliance with the following criteria:

General criteria

a) substances are permitted according to national legislation on animal feeding;
b) substances are necessary/essential to maintain animal health, animal welfare and vitality; and
c) such substances:
  - contribute to an appropriate diet fulfilling the physiological and behavioural needs of the species concerned; and
  - do not contain genetically engineered/modified organisms and products thereof; and
  - are primarily of plant, mineral or animal origin.

Specific criteria for feedstuffs and nutritional elements

a) feedstuffs of plant origin from non-organic sources can only be used, under the conditions of paragraphs 14 and 15, if they are produced or prepared without the use of chemical solvents or chemical treatment;
b) feedstuffs of mineral origin, trace elements, vitamins, or provitamins can only be used if they are of natural origin. In case of shortage of these substances, or in exceptional circumstances, chemically well-defined analogic substances may be used;
c) feedstuffs of animal origin, with the exception of milk and milk products, fish, other marine animals and products derived therefrom should generally not be used or, as provided by national legislation. In any case, the feeding of mammalian material to ruminants is not permitted with the exception of milk and milk products;
d) synthetic nitrogen or non-protein nitrogen compounds shall not be used.

Specific criteria for additives and processing aids

a) binders, anti-caking agents, emulsifiers, stabilizers, thickeners, surfactants, coagulants: only natural sources are allowed;
b) antioxidants: only natural sources are allowed;
c) preservatives: only natural acids are allowed;
d) colouring agents (including pigments), flavours and appetite stimulants: only natural sources are allowed;
e) probiotics, enzymes and micro-organisms are allowed;

f) antibiotics, coccidiostatics, medicinal substances, growth promoters or any other substance intended to stimulate growth or production shall not be used in animal feeding.

19. Silage additives and processing aids may not be derived from genetically engineered/modified organisms or products thereof, and may be comprised of only:
    – sea salt;
    – coarse rock salt;
    – yeasts;
    – enzymes;
    – whey;
    – sugar; or sugar products such as molasses;
    – honey;
    – lactic, acetic, formic and propionic bacteria, or their natural acid product when the weather conditions do not allow for adequate fermentation, and with approval of the competent authority.

Health care

20. Disease prevention in organic livestock production shall be based on the following principles:

a) the choice of appropriate breeds or strains of animals as detailed in paragraph 6 above;
b) the application of animal husbandry practices appropriate to the requirements of each species, encouraging strong resistance to disease and the prevention of infections;
c) the use of good quality organic feed, together with regular exercise and access to pasture and/or open-air runs, having the effect of encouraging the natural immunological defence of the animal;
d) ensuring an appropriate density of livestock, thus avoiding overstocking and any resulting animal health problems.

21. If, despite the above preventative measures, an animal becomes sick or injured it must be treated immediately, if necessary in isolation and in suitable housing. Producers should not withhold medication where it will result in unnecessary suffering of the livestock, even if the use of such medication will cause the animal to lose its organic status.

22. The use of veterinary medicinal products in organic farming shall comply with the following principles:
a) where specific disease or health problems occur, or may occur, and no alternative permitted treatment or management practice exists, or, in cases required by law, vaccination of livestock, the use of parasiticides, or therapeutic use of veterinary drugs are permitted;

b) phytotherapeutic (excluding antibiotics), homeopathic or ayurvedic products and trace elements shall be used in preference to chemical allopathic veterinary drugs or antibiotics, provided that their therapeutic effect is effective for the species of animal and the condition for which the treatment is intended;
c) if the use of the above products is unlikely to be effective in combating illness or injury, chemical allopathic veterinary drugs or antibiotics may be used under the responsibility of a veterinarian; withholding periods should be the double of that required by legislation with, in any case, a minimum of 48 hours;
d) the use of chemical allopathic veterinary drugs or antibiotics for preventative treatments is prohibited.

23. Hormonal treatment may only be used for therapeutic reasons and under veterinary supervision.

24. Growth stimulants or substances used for the purpose of stimulating growth or production are not permitted.

Livestock husbandry, transport and slaughter

25. Maintenance of livestock should be guided by an attitude of care, responsibility and respect for living creatures.

26. Breeding methods should be in compliance with the principles of organic farming taking into account:
a) the breeds and strains suitable for raising under local conditions and under an organic system;
b) the preference for reproduction through natural methods, although artificial insemination may be used;
c) that embryo transfer techniques and the use of hormonal reproductive treatment shall not be used;
d) that breeding techniques employing genetic engineering must not be used.

27. Operations such as attaching elastic bands to the tails of sheep, tail-docking, cutting of teeth, trimming of beaks and dehorning are generally not allowed in the organic management system. Some of these operations may, however, be authorized in exceptional circumstances by the competent authority or its delegate, for reasons of safety (e.g. dehorning in young animals) or if they are intended to improve the health and welfare of the livestock. Such operations must be carried out at the most appropriate age and any suffering to the animals must be reduced to a minimum. Anaesthetic should be used where appropriate. Physical castration is allowed in order to maintain the quality of products and traditional production practices (meat-type pigs, bullocks, capons, etc) but only under these conditions.

28. The living conditions and the management of the environment should take into account the specific behavioural needs of the livestock and provide for:
- sufficient free movement and opportunity to express normal patterns of behaviour;
- company of other animals, particularly of like kind;
- the prevention of abnormal behaviour, injury and disease;
- arrangements to cover emergencies such as the outbreaks of fire, the breakdown of essential mechanical services and the disruption of supplies.

29. The transport of living stock should be managed in a calm and gentle way and in a manner which avoids stress, injury and suffering: the competent authority should establish specific conditions in order to meet these objectives and may establish maximum transport periods. In transporting livestock, the use of electric stimulation or allopathic tranquilizers is not permitted.

30. The slaughter of livestock should be undertaken in a manner which minimizes stress and suffering, and in accordance with national rules.

Housing and free-range conditions

31. Housing for livestock will not be mandatory in areas with appropriate climatic conditions to enable animals to live outdoors.

32. Housing conditions should meet the biological and behavioural needs of the livestock by providing:
- easy access to feeding and watering;
- insulation, heating, cooling and ventilation of the building to ensure that air circulation, dust level, temperature, relative air humidity and gas concentration are kept within limits which are not harmful to the livestock;
- plentiful natural ventilation and light to enter.

33. Livestock may be temporarily confined during periods of inclement weather, when their health, safety or well being could be jeopardized, or to protect plant, soil and water quality.

34. The stocking density in buildings should:
- provide for the comfort and well being of the livestock having regard for the species, the breed and the age of the livestock;
- take into account the behavioural needs of the livestock with respect to the size of the group and the sex of the livestock;
- provide them with sufficient space to stand naturally, lie down easily, turn round, groom themselves, and assume all natural postures and movements such as stretching and wing flapping.

35. Housing, pens, equipment and utensils should be properly cleaned and disinfected to prevent cross infection and the build-up of disease carrying organisms.

36. Free-range, open-air exercise areas, or open-air runs should, if necessary, provide sufficient protection against rain, wind, sun and extreme temperatures, depending on the local weather conditions and the breed concerned.

37. The outdoor stocking density of livestock kept on pasture, grassland, or other natural or semi-natural habitats, must be low enough to prevent degradation of the soil and over-grazing of vegetation.

Mammals

38. All mammals must have access to pasture or an open-air exercise area or run which may be partially covered, and they must be able to use those areas whenever the physiological condition of the animal, the weather conditions and the state of the ground permit.

39. The competent authority may grant exceptions for :
- the access of bulls to pasture or, in case of cows to an open-air exercise area or run during the winter period;
- the final fattening phase.

40. Livestock housing must have smooth, but not slippery floors. The floor must not be entirely of slatted or grid construction.

41. The housing must be provided with a comfortable, clean and dry laying/rest area of sufficient size, consisting of a solid construction. Ample dry bedding strewn with litter material must be provided in the rest area.

42. The housing of calves in individual boxes and the tethering of livestock are not permitted without the approval of the competent authority.

43. Sows must be kept in groups, except in the last stages of pregnancy and during the suckling period. Piglets may not be kept on flat decks or in piglet cages. Exercise areas must permit dunging and rooting by the animals.

44. The keeping of rabbits in cages is not permitted.

Poultry

45. Poultry must be reared in open-range conditions and have free access to open-air run whenever the weather conditions permit. The keeping of poultry in cages is not permitted.

46. Water fowl must have access to a stream, pond or lake whenever the weather conditions permit.

47. Housing for all poultry should provide an area of solid construction covered with litter material such as straw, wood shavings, sand or turf. A sufficiently large part of the floor area must be available to laying hens for the collection of droppings, Perches/higher sleeping areas of a size and number commensurate with the species and size of the group and of the birds and exit/entry holes of an adequate size must be provided.

48. In the case of laying hens, when natural day length is prolonged by artificial light, the competent authority shall prescribe maximum hours respective to species, geographical considerations and general health of the animals.

49. For health reasons, between each batch of poultry reared buildings should be emptied, and runs left empty to allow the vegetation to grow back.

Manure management

50. Manure management practices used to maintain any area in which livestock are housed, penned or pastured should be implemented in a manner that:
    a) minimizes soil and water degradation;
    b) does not significantly contribute to contamination of water by nitrates and pathogenic bacteria;
    c) optimizes recycling of nutrients; and
    d) does not include burning or any practice inconsistent with organic practices.

51. All manure storage and handling facilities, including composting facilities should be designed, constructed and operated to prevent contamination of ground and/or surface water.

52. Manure application rates should be at levels that do not contribute to ground and/or surface water contamination. The competent authority may establish maximum application rates for manure or stocking densities. The timing of application and application methods should not increase the potential for run-off into ponds, rivers and streams.

Record keeping and identification

53. The operator should maintain detailed and up-to-date records as set out in Annex 3, paras 7–15.

Species specific requirements

Beekeeping and bee products

General principles

54. Bee keeping is an important activity that contributes to the enhancement of the environment, agriculture and forestry production through the pollination action of bees.

55. The treatment and management of hives should respect the principles of organic farming.

56. Collection areas must be large enough to provide adequate and sufficient nutrition and access to water.

57. The sources of natural nectar, honeydew and pollen shall consist essentially of organically produced plants and/or spontaneous (wild) vegetation.

58. The health of bees should be based on prevention such as adequate selection of breeds, favourable environment, balanced diet and appropriate husbandry practices.

59. The hives shall consist basically of natural materials presenting no risk of contamination to the environment or the bee products.

60. When bees are placed in wild areas, consideration should be given to the indigenous insect population.

Siting of hives

61. Hives for beekeeping shall be placed in areas where cultivated and/or spontaneous vegetation comply with the rules of production as set out in Section 4 of these Guidelines.

62. The official certification body or authority shall approve the areas which ensure appropriate sources of honeydew, nectar and pollen based on information provided by the operators and/or through the process of inspection.

63. The official certification body or authority may designate a specific radius from the hive within which the bees have access to adequate and sufficient nutrition that meets the requirements of these Guidelines.

64. The certification body or authority must identify zones where hives, that meet these requirements, should not be placed due to potential sources of contamination with prohibited substances, genetically modified organisms or environmental contaminants.

Feed

65. At the end of the production season hives must be left with reserves of honey and pollen sufficiently abundant for the colony to survive the dormancy period.

66. The feeding of colonies can be undertaken to overcome temporary feed shortages due to climatic or other exceptional circumstances. In such cases, organically produced honey or sugars should be used if available. However the certification body or authority may permit the use of non-organically produced honey or sugars. Time-limits should be set for such derogations. Feeding should be carried out only between the last honey harvest and the start of the next nectar or honeydew flow period.

Conversion period

67. Bee products can be sold as organically produced when these Guidelines have been complied with for at least one year. During the conversion period the wax must be replaced by organically produced wax. In cases where all the wax cannot be replaced during a one-year period, the certification body or authority may extend the conversion period. By way of derogation when organically produced beeswax is not available, wax from sources not complying with these Guidelines may be authorized by the certification body or authority, provided it comes from the cap or from areas where no prohibited materials have been used.

68. Where no prohibited products have been previously used in the hive, replacement of wax is not necessary.

Origin of bees

69. Bee colonies can be converted to organic production. Introduced bees should come from organic production units when available.

70. In the choice of breeds, account must be taken of the capacity of bees to adapt to local conditions, their vitality and their resistance to disease.

Health of the bees

71. The health of bee colonies should be maintained by good agricultural practice, with emphasis on disease prevention through breed selection and hive management. This includes:
a) the use of hardy breeds that adapt well to the local conditions;
b) renewal of queen bees if necessary;
c) regular cleaning and disinfecting of equipment;
d) regular renewal of beeswax;
e) availability in hives of sufficient pollen and honey;
f) systematic inspection of hives to detect any anomalies;
g) systematic control of male broods in the hive;
h) moving diseased hives to isolated areas, if necessary; or
i) destruction of contaminated hives and materials.

72. For pest and disease control the following are allowed:
- lactic, oxalic, acetic acid
- formic acid
- sulphur
- natural etheric oils (e.g. menthol, eucalyptol, camphor)
- *Bacillus thuringiensis*
- steam and direct flame.

73. Where preventative measures fail, veterinary medicinal products may be used provided that:
a) preference is given to phytotherapeutic and homeopathic treatment, and
b) if allopathic chemically synthesized medicinal products are used, the bee products must not be sold as organic. Treated hives must be placed in isolation and undergo a conversion period of one year. All the wax must be replaced with wax which is in accordance with these Guidelines, and
c) every veterinary treatment must be clearly documented.

74. The practice of destroying the male brood is permitted only to contain infestation with *Varroa jacobsoni*.

Management

75. The foundation comb shall be made from organically produced wax.

76. The destruction of bees in the combs as a method of harvesting of bee products is prohibited.

77. Mutilations, such as clipping of the wings of queen bees, are prohibited.

78. The use of chemical synthetic repellents is prohibited during honey extraction operations.

79. Smoking should be kept to a minimum. Acceptable smoking materials should be natural or from materials that meet the requirements of these Guidelines.

80. It is recommended that temperatures are maintained as low as possible during the extraction and processing of products derived from beekeeping.

Record keeping

81. The operator should maintain detailed and up-to-date records as set out in Annex 3, paragraph 7. Maps should be maintained depicting the location of all hives.

C. HANDLING, STORAGE, TRANSPORTATION, PROCESSING AND PACKAGING

82. The integrity of the organic product must be maintained throughout the processing phase. This is achieved by the use of techniques appropriate to the specifics of the ingredients with careful processing methods limiting refining and the use of additives and processing aids. Ionizing radiation should not be used on organic products for the purpose of pest control, food preservation, elimination of pathogens or sanitation. Ethylene may be used for ripening of kiwifruit and bananas.

Pest management

83. For pest management and control the following measures, in order of preference, should be used:

a) Preventative methods, such as disruption and elimination of habitat and access to facilities by pest organisms, should be the primary methodology of pest management;

b) If preventative methods are inadequate, the first choice for pest control should be mechanical/physical and biological methods;

c) If mechanical/physical and biological methods are inadequate for pest control, pesticidal substances appearing in Annex 2 table 2 (or other substances allowed for use by a competent authority in accordance with Section 5.2) may be used provided that they are accepted for use in handling, storage, transportation or processing facilities by the competent authority and so that contact with organic products is prevented.

84. Pests should be avoided by good manufacturing practice. Pest control measures within storage areas or transport containers may include physical barriers or other treatments such as sound, ultra-sound, light, ultra-violet light, traps (pheromone traps and static

bait traps) controlled temperature, controlled atmosphere (carbon dioxide, oxygen, nitrogen), and diatomaceous earth.

85. Use of pesticides not listed in Annex 2 for post harvest or quarantine purposes should not be permitted on products prepared in accordance with these guidelines and would cause organically produced foods to lose their organic status.

Processing and manufacturing

86. Processing methods should be mechanical, physical or biological (such as fermentation and smoking) and minimize the use of non-agricultural ingredients and additives as listed in Annex 2, Tables 3 and 4.

Packaging

87. Packaging materials should preferably be chosen from bio-degradable, recycled or recyclable sources.

Storage and transport

88. Product integrity should be maintained during any storage and transportation and handling by use of the following precautions:

a) Organic products must be protected at all times from co-mingling with non-organic products; and

b) Organic products must be protected at all times from contact with materials and substances not permitted for use in organic farming and handling.

89. Where only part of the unit is certified, other product not covered by these guidelines should be stored and handled separately and both types of products should be clearly identified.

90. Bulk stores for organic product should be separate from conventional product stores and clearly labelled to that effect.

91. Storage areas and transport containers for organic product should be cleaned using methods and materials permitted in organic production. Measures should be taken to prevent possible contamination from any pesticide or other treatment not listed in Annex 2 before using a storage area or container that is not dedicated solely to organic products.

ANNEX 2

PERMITTED SUBSTANCES FOR THE PRODUCTION OF ORGANIC FOODS

PRECAUTIONS

1. Any substances used in an organic system for soil fertilization and conditioning, pest and disease control, for the health of livestock and quality of the animal products, or for preparation, preservation and storage of the food product should comply with the relevant national regulations.

2. Conditions for use of certain substances contained in the following lists may be specified by the certification body or authority, e.g. volume, frequency of application, specific purpose, etc.

3. Where substances are required for primary production they should be used with care and with the knowledge that even permitted substances may be subject to misuse and may alter the ecosystem of the soil or farm.

4. The following lists do not attempt to be all inclusive or exclusive, or a finite regulatory tool but rather provide advice to governments on internationally agreed inputs. A system of review criteria as detailed in Section 5 of these Guidelines for products to be considered by national governments should be the primary determinant for acceptability or rejection of substances.

TABLE 1
SUBSTANCES FOR USE IN SOIL FERTILIZING AND CONDITIONING

Substances	Description; compositional requirements; conditions of use
Farmyard and poultry manure	Need recognized by certification body or authority if not sourced from organic production systems. “Factory” farming[20] sources not permitted.
Slurry or urine	If not from organic sources, need recognized by inspection body. Preferably after controlled fermentation and/or appropriate dilution. “Factory” farming sources not permitted.
Composted animal excrements, including poultry	Need recognized by the certification body or authority
Manure and composted farmyard manure	“Factory” farming sources not permitted.
Dried farmyard manure and dehydrated poultry manure	Need recognized by the certification body or authority. “Factory” farming sources not permitted.
Guano	Need recognized by the certification body or authority.
Straw	Need recognized by the certification body or authority.
Compost and spent mushroom and Vermiculite substrate	Need recognized by the certification body or authority. The initial composition of the substrate must be limited to the products on this list
Sorted, composted or fermented home refuse	Need recognized by the certification body or authority.
Compost from plant residues	
Processed animal products from slaughterhouses & fish industries	Need recognized by the certification body or authority.
By-products of food & textile industries not treated with synthetic additives.	Need recognized by the certification body or authority.
Seaweeds and seaweed products	Need recognized by the certification body or authority.
Sawdust, bark and wood waste	Need recognized by the certification body or authority, wood not chemically treated after felling.
Wood ash and wood charcoal	Need recognized by the certification body or authority, from wood not chemically treated after felling.

Substances	Description; compositional requirements; conditions of use
Natural phosphate rock.	Need recognized by the certification body or authority. Cadmium should not exceed 90mg/kg P_20_5
Basic slag	Need recognized by the certification body or authority.
Rock potash, mined potassium salts (e.g. kainite, sylvinite)	Less than 60% chlorine
Sulphate of potash (e.g. patenkali)	Obtained by physical procedures but not enriched by chemical processes to increase its solubility. Need recognized by the certification body or authority.
Calcium carbonate of natural origin (e.g. chalk, marl, maerl, limestone, phosphate chalk)	
Magnesium rock	
Calcareous magnesium rock	
Epsom salt (magnesium-sulphate)	
Gypsum (calcium sulphate)	Only from natural sources/origin.
Stillage and stillage extract	Ammonium stillage excluded
Sodium chloride	Only mined salt
Aluminium calcium phosphate	Cadmium should not exceed 90mg/kg P_20_5
Trace elements (e.g. boron, copper, iron, manganese, molybdenum, zinc)	Need recognized by the certification body or authority.
Sulphur	Need recognized by the certification body or authority.
Stone meal	
Clay (e.g. bentonite, perlite, zeolite)	
Naturally occurring biological organisms (e.g. worms)	
Vermiculite	
Peat	Excluding synthetic additives; permitted for seed, potting module composts. Other use as recognized by certification body or authority. Not permitted as a soil conditioner.
Humus from earthworms and insects	
Chloride of lime	Need recognized by the certification body or authority.
Human excrements	Need recognized by the certification body or authority. The source is separated from household and industrial wastes that pose a risk of chemical contamination. It is treated sufficiently to eliminate risks from pests, parasites, pathogenic micro-organisms, and is not applied to crops intended for human consumption or to the edible parts of plants.
By-products of the sugar industry (e.g. Vinasse)	Need recognized by the certification body or authority.
By-products from oil palm, coconut and cocoa (including empty fruit bunch, palm oil mill effluent (pome), cocoa peat and empty cocoa pods)	Need recognized by the certification body or authority.
By-products of industries processing ingredients from organic agriculture	Need recognized by the certification body or authority.
Calcium chloride solution	Leaf treatment in case of proven calcium deficiency.

TABLE 2

SUBSTANCES FOR PLANT PEST AND DISEASE CONTROL

Substance	Description; compositional requirements; conditions for use
I. PLANT AND ANIMAL	
Preparations on basis of pyrethrins extracted from *Chrysanthemum cinerariaefolium*, containing possibly a synergist	Need recognized by the certification body or authority. Exclusion of Piperonyl butoxide after 2005 as a synergist.
Preparations of Rotenone from *Derris elliptica, Lonchocarpus, Thephrosia* spp.	Need recognized by the certification body or authority. The substance should be used in such a way as to prevent its flowing into waterways.
Preparations from *Quassia amara*	Need recognized by the certification body or authority.
Preparations from *Ryania speciosa*	Need recognized by the certification body or authority.
Commercial preparations/ products of Neem (Azadirachtin) from *Azadirachta indica*	Need recognized by the certification body or authority.
Propolis	Need recognized by the certification body or authority.
Plant and animal oils	
Seaweed, seaweed meal, seaweed extracts, sea salts and salty water	Need recognized by the certification body or authority. Not chemically treated.
Gelatine	
Lecithin	Need recognized by the certification body or authority.
Casein	
Natural acids (e.g. vinegar)	Need recognized by the certification body or authority.
Fermented product from Aspergillus	
Extract from mushroom (Shiitake fungus)	Need recognized by certification body or authority
Extract from Chlorella	
Chitin nematicides	Natural origin
Natural plant preparations, excluding tobacco	Need recognized by certification body or authority.
Tobacco tea (except pure nicotine)	Need recognized by certification body or authority.
Sabadilla	
Beeswax	
II. MINERAL	
Copper in the form of copper hydroxide, copper oxychloride, (tribasic) copper sulphate, cuprous oxide, Bordeaux mixture and Burgundy mixture	Need, prescription and application rates recognized by certification body or authority. As a fungicide on condition that the substance be used in such a way as to minimize copper accumulation in the soil.
Sulphur	Need recognized by certification body or authority.
Mineral powders (stone meal, silicates)	
Diatomaceous earth	Need recognized by certification body or authority.

Substance	Description; compositional requirements; conditions for use
Silicates, clay (bentonite)	
Sodium silicate	
Sodium bicarbonate	
Potassium permanganate	Need recognized by certification body or authority.
Iron phosphates	As molluscicide.
Paraffin oil	Need recognized by certification body or authority.
III. MICRO-ORGANISMS USED FOR BIOLOGICAL PEST CONTROLS	
Micro-organisms (bacteria, viruses, fungi) e.g. *Bacillus thuringiensis*, Granulosis virus,etc.	Need recognized by certification body or authority.
IV. OTHER	
Carbon dioxide and nitrogen gas	Need recognized by certification body or authority.
Potassium soap (soft soap)	
Ethyl alcohol	Need recognized by certification body or authority.
Homeopathic and Ayurvedic preparations	
Herbal and biodynamic preparations	
Sterilized insect males	Need recognized by certification body or authority.
Rodenticides	Products for pest control in livestock buildings and installations. Need recognized by certification body or authority.
V. TRAPS	
Pheromone preparations	
Preparations on the basis of metaldehyde containing a repellent to higher animal species and as far as applied in traps.	Need recognized by certification body or authority.
Mineral oils	Need recognized by the certification body or authority.
Mechanical control devices such as e.g., crop protection nets, spiral barriers, glue-coated plastic traps, sticky bands.	

TABLE 3

INGREDIENTS OF NON-AGRICULTURAL ORIGIN REFERRED TO IN SECTION 3 OF THESE GUIDELINES

3.1 Additives permitted for use under specified conditions in certain organic food categories or individual food items

The following table provides a list of those food additives including carriers which are allowed for use in organic food production. The functional uses and food categories and individual food items for each food additive in the following table are governed by the provisions in Tables 1–3 of the *General Standard for Food Additives* and other standards which have been adopted by the Codex Alimentarius Commission.

The table is an indicative list for the purpose of processing organic food only. Countries may develop a list of substances for national purposes that satisfy the requirements as recommended in Section 5.2 of these Guidelines.

Food additives in this Table can be used to perform the function indicated in the specified food products.

INS no.	Additive name	Functional use allowed in organic production	Permitted for use in food categories	
			Food of plant origin	Food of animal origin
170i	Calcium Carbonate	All	Permitted, although exclusions of the GSFA still apply.	01.0 Dairy products and analogues, excluding products of food category 02.0
220	Sulphur Dioxide	All	14.2.2 Cider and perry14.2.3 Grape wines14.2.4 Wines (other than grapes)	14.2.5 Mead
270	Lactic Acid (L- D- and DL-)	All	04.2.2.7 Fermented vegetable (including mushrooms and fungi, roots and tubers, pulses and legumes and aloe vera), and seaweed products, excluding fermented soybean products of food category 12.10	01.0 Dairy products and analogues, excluding products of food category 02.008.4 Edible casings (e.g. sausage casings)
290	Carbon Dioxide	All	Permitted, although exclusions of the GSFA still apply.	Permitted, although exclusions of the GSFA still apply.
296	Malic Acid (DL-)	All	Permitted, although exclusions of the GSFA still apply.	Not permitted.
300	Ascorbic Acid	All	Provided insufficient natural sources are available.Permitted, although exclusions of the GSFA still apply.	Provided insufficient natural sources are available.08.2 Processed meat, poultry, and game products in whole pieces or cuts08.3 Processed comminuted meat, poultry, and game products08.4 Edible casings (e.g., sausage casings)
307	Tocopherols (mixed natural concentrates)	All	Permitted, although exclusions of the GSFA still apply.	All mixed products allowed under the General Standard for Food Additives and Standards adopted by the Codex Alimentarius Commission
322	Lecithins (obtained without bleaches and organic solvents.)	All	Permitted, although exclusions of the GSFA still apply.	01.0 Dairy products and analogues, excluding products of food category 02.002.0 Fats and oils, and fat emulsions12.6.1 Emulsified sauces (e.g. mayonnaise, salad dressing)13.1 Infant formulae and follow-on formulae13.2 Complementary foods for infants and young children
327	Calcium Lactate	All	Not permitted.	01.0 Dairy products and analogues, excluding products of food category 02.0
330	Citric Acid	All	04.0 Fruits and vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweeds, and nuts and seeds	As a coagulation agent for specific cheese products and for cooked eggs01.6 Cheese and analogues02.1 Fats and oils essentially free from water 10.0 Egg and egg products
331i	Sodium Dihydrogen Citrate	All	Not permitted.	01.1.1.2 Butter milk (plain) (Stabilizer only) 01.1.2 Dairy-based drinks, flavoured and/or fermented (e.g., chocolate milk, cocoa, eggnog, drinking yoghurt, whey-based drinks)01.2.1.2 Fermented milks (plain), heat-treated after fermentation (Stabilizer only)01.2.2

INS no.	Additive name	Functional use allowed in organic production	Permitted for use in food categories	
			Food of plant origin	Food of animal origin
				Renneted milk (Stabilizer only) 01.3 Condensed milk and analogues (plain) (Stabilizer only)01.4 Cream (plain) and the like (Stabilizer only)01.5.1 Milk powder and cream powder (plain) (Stabilizer only)01.6.1 Unripened cheese (Stabilizer only)01.6.4 Processed cheese (Emulsifier only)01.8.2 Dried whey and whey products, excluding whey cheeses08.3 Processed comminuted meat, poultry, and game products, restricted to sausagesTo be used in pasteurization of egg whites only in the following:10.2 Egg Products
332i	Potassium Dihydrogen Citrate	All	Not permitted.	Permitted, although exclusions of the GSFA still apply.
333	Calcium Citrates	All	Permitted, although exclusions of the GSFA still apply.	01.0 Dairy products and analogues, excluding products of food category 02.0
334	Tartaric Acid	All	Permitted, although exclusions of the GSFA still apply.	Not permitted.
335i 335ii	Monosodium TartrateDisodium Tartrate	All	05.0 Confectionery07.2.1 Cakes	Not permitted.
336i 336ii	Monopotassium TartrateDipotassium Tartrate	All	05.0 Confectionery06.2 Flours and starches 07.2.1 Cakes	Not permitted.
341i	Monocalcium Orthophosphate	All	06.2.1 Flours	Not permitted.
400	Alginic Acid	All	Permitted, although exclusions of the GSFA still apply.	01.0 Dairy products and analogues, excluding products of food category 02.0
401	Sodium Alginate	All	Permitted, although exclusions of the GSFA still apply.	01.0 Dairy products and analogues, excluding products of food category 02.0 All mixed products allowed under the *General Standard for Food Additives* and Standards adopted by the Codex Alimentarius Commission
402	Potassium Alginate	All	Permitted, although exclusions of the GSFA still apply.	01.0 Dairy products and analogues, excluding products of food category 02.0 All mixed products allowed under the *General Standard for Food Additives* and Standards adopted by the Codex Alimentarius Commission
406	Agar	All	Permitted, although exclusions of the GSFA still apply.	Permitted, although exclusions of the GSFA still apply.
407	Carrageenan	All	Permitted, although exclusions of the GSFA still apply.	01.0 Dairy products and analogues, excluding products of food category 02.0
410	Carob Bean Gum	All	Permitted, although exclusions of the GSFA still apply	01.1 Milk and dairy-based drinks01.2 Fermented and renneted milk products (plain), excluding food category 01.1.2 (dairy-based drinks) 01.3 Condensed milk and analogues (plain)01.4 Cream (plain) and the like01.5 Milk powder and cream powder and powder analogues (plain)
410	Carob Bean Gum*(cont'd)*	All	Permitted, although exclusions of the GSFA still apply.	01.6 Cheese and analogues01.7 Dairy-based desserts (e.g. pudding, fruit or flavoured yoghurt)01.8.1 Liquid whey and whey products, excluding whey cheeses08.1.2 Fresh meat, poultry and game, comminuted 08.2 Processed meat, poultry, game products in whole pieces or cuts08.3 Processed comminuted meat, poultry, and game products08.4 Edible casings (e.g. sausage casings)

INS no.	Additive name	Functional use allowed in organic production	Permitted for use in food categories	
			Food of plant origin	Food of animal origin
412	Guar Gum	All	Permitted, although exclusions of the GSFA still apply.	01.0 Dairy products and analogues, excluding products of food category 02.08.2.2 Heat-treated processed meat, poultry, and game products in whole pieces or cuts8.3.2 Heat-treated processed comminuted meat, poultry, and game products10.2 Egg products
413	Tragacanth Gum	All	Permitted, although exclusions of the GSFA still apply.	Permitted, although exclusions of the GSFA still apply.
414	Gum Arabic	All	02.0 Fats and oils, and fat emulsions05.0 Confectionery	01.0 Dairy products and analogues, excluding products of food category 02.002.0 Fats and oils, and fat emulsions05.0 Confectionery
415	Xanthan Gum	All	02.0 Fats and oils, and fat emulsions04.0 Fruits and vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweeds, and nuts and seeds07.0 Bakery wares12.7 Salads (e.g. macaroni salad, potato salad)	Not permitted.
416	Karaya Gum	All	Permitted, although exclusions of the GSFA still apply.	Not permitted.
422	Glycerol	All	Obtained from plant origin; used as a carrier for plant extracts04.1.1.1 Untreated fresh fruit04.1.1.2 Surface-treated fresh fruit04.1.2 Processed fruit04.2.1.2 Surface-treated fresh vegetables, (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweeds and nuts and seeds04.2.2.2 Dried vegetables, (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweeds, and nuts and seeds04.2.2.3 Vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), and seaweeds in vinegar, oil, brine, or soy sauce04.2.2.4 Canned or bottled (pasteurized) or retort pouch vegetables (includingmushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), and seaweeds04.2.2.5 Vegetable, (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweed, and nut and seed purees and spreads (e.g., peanut butter)04.2.2.6 Vegetable, (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweed, and nut and seed pulps and preparations (e.g., vegetable desserts and sauces, candied vegetables) other than food category 04.2.2.504.2.2.7 Fermented vegetable (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera) and seaweed products, excluding fermented soybean products of food category 12.1012.2 Herbs, spices, seasonings, and condiments (e.g., seasoning for instant noodles)	Not permitted.
440	Pectins (non-amidated)	All	Permitted, although exclusions of the GSFA still apply.	01.0 Dairy products and analogues, excluding products of food category 02.0
500ii 500iii	Sodium hydrogen carbonateSodium Sesquicarbonate	All	05.0 Confectionery07.0 Bakery Wares	01.0 Dairy products and analogues, excluding products of food category 02.0
501i	Potassium Carbonate	All	05.0 Confectionery06.0 Cereals and cereal products, derived from cereal grains, from roots and tubers, pulses and legumes, excluding bakery wares of food category 07.007.2 Fine Bakery wares (sweet, salty, savoury) and mixes	Not permitted.

INS no.	Additive name	Functional use allowed in organic production	Permitted for use in food categories	
			Food of plant origin	Food of animal origin
503i 503ii	Ammonium carbonateAmmonium Hydrogen Carbonate	Acidity RegulatorRaising Agent	Permitted, although exclusions of the GSFA still apply.	Not permitted.
504i504ii	Magnesium CarbonateMagnesium Hydrogen Carbonate	All	Permitted, although exclusions of the GSFA still apply.	Not permitted.
508	Potassium Chloride	All	04.0 Fruits and vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweeds, and nuts and seeds12.4 Mustards12.6.2 Non-emulsified sauces (e.g. ketchup, cheese sauces, cream sauces, brown gravy)	Not permitted.
509	Calcium chloride	All	04.0 Fruits and vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweeds, and nuts and seeds06.8 Soybean products (excluding soybean products of food category 12.9 and fermented soybean products of food category 12.10)12.9.1 Soybean protein products12.10 Fermented soybean products	01.0 Dairy products and analogues, excluding products of food category 02.008.2 Processed meat, poultry, and game products in whole pieces or cuts08.3 Processed comminuted meat, poultry and game products08.4 Edible casings (e.g. sausage casings)
511	Magnesium chloride	All	06.8 Soybean products (excluding soybean products of food category 12.9 and fermented soybean products of food category 12.10)12.9.1 Soybean protein products12.10 Fermented soybean products	Not permitted.
516	Calcium sulphate	All	06.8 Soybean products (excluding soybean products of food category 12.9 and fermented soybean products of food category 12.10)07.2.1 Cakes, cookies and pies (e.g. fruit-filled or custard type)12.8 Yeast and like products12.9.1 Soybean protein products12.10 Fermented soybean products	Not permitted.
524	Sodium Hydroxide	All	06.0 Cereals and cereal products, derived from cereal grains, from roots and tubers, pulses and legumes, excluding bakery wares of food category 07.007.1.1.1 yeast-leavened breads and specialty breads	Not permitted.
551	Silicon Dioxide (Amorphous)	All	12.2 Herbs, spices, seasonings, and condiments (e.g. seasonings for instant noodles)	Not permitted.
941	Nitrogen	All	Permitted, although exclusions of the GSFA still apply	Permitted, although exclusions of the GSFA still apply

3.2 Flavourings

Substances and products labelled as natural flavouring substances or natural flavouring preparations are defined in the *General Requirements for Natural Flavourings* (CAC/GL 29-1987).

3.3 Water and salts

Drinking water.

Salts (with sodium chloride or potassium chloride as basic components generally used in food processing).

3.4 Preparations of micro-organisms and enzymes

Any preparation of micro-organisms and enzymes normally used in food processing, with the exception of micro-organisms genetically engineered/modified or enzymes derived from genetic engineering.

3.5 Minerals (including trace elements), vitamins, essential fatty and amino acids, and other nitrogen compounds

Only approved in so far as their use is legally required in the food products in which they are incorporated.

Table 4

PROCESSING AIDS WHICH MAY BE USED FOR THE PREPARATION OF PRODUCTS OF AGRICULTURAL ORIGIN REFERRED TO IN SECTION 3 OF THESE GUIDELINES

Substance	Specific conditions
FOR PLANT PRODUCTS	
Water	
Calcium chloride	coagulation agent
Calcium carbonate	
Calcium hydroxide	
Calcium sulphate	coagulation agent
Magnesium chloride (or nigari)	coagulation agent
Potassium carbonate	drying of grape raisins
Carbon dioxide	
Nitrogen	
Ethanol	solvent
Tannic acid	filtration aid
Egg white albumin	
Casein	
Gelatine	
Isinglass	
Vegetable oils	greasing or releasing agent
Silicon dioxide	as gel or collodial solution
Activated carbon	
Talc	
Bentonite	
Kaolin	
Diatomaceous earth	
Perlite	
Hazelnut shells	
Beeswax	releasing agent

Substance	Specific conditions
Carnauba wax	releasing agent
Sulphuric acid	pH adjustment of extraction water in sugar production
Sodium hydroxide	pH adjustment in sugar production
Tartaric acid and salts	
Sodium carbonate	sugar production
Preparations of bark components	
Potassium hydroxide	pH adjustment for sugar processing
Citric acid	pH adjustment

Preparations of micro-organisms and enzymes

Any preparations of micro-organisms and enzymes normally used as processing aids in food processing, with the exception of genetically engineered/modified organisms and enzymes derived from genetically engineered/modified organisms.

For livestock and bee products

The following is a provisional list for the purposes of processing livestock and bee products only. Countries may develop a list of substances for national purposes that satisfy the requirements of these Guidelines as recommended in Section 5.2.

INS	Name	Specific conditions
	Calcium carbonates	
	Calcium chloride	Firming, coagulation agent in cheese making.
	Kaolin	Extraction of propolis.
	Lactic acid	Milk products: coagulation agent, pH regulation of salt bath for cheese.
	Sodium carbonate	Milk products: neutralizing substance.
	Water	

ANNEX 3

MINIMUM INSPECTION REQUIREMENTS AND PRECAUTIONARY MEASURES UNDER THE INSPECTION OR CERTIFICATION SYSTEM

1. Inspection measures are necessary across the whole of the food chain to verify product labelled according to Section 3 of these guidelines conforms to internationally agreed practices. The official or officially recognized certification body or authority and the competent authority should establish policies and procedures in accordance with these guidelines.

2. Access by the inspection body to all written and/or documentary records and to the establishment under the inspection scheme is essential. The operator under an inspection should also give access to the competent or designated authority and provide any necessary information for third party audit purposes.

A. PRODUCTION UNITS

3. Production according to these guidelines should take place in a unit where the land parcels, production areas, farm buildings and storage facilities for crop and livestock are clearly separate from those of any other unit which does not produce according to these guidelines; preparation and/or packaging workshops may form part of the unit, where its activity is limited to preparation and packaging of its own agricultural produce.

4. When the inspection arrangements are first implemented, the operator and the official or officially recognized certification body or authority should draw up and sign a document which includes:
   a) a full description of the unit and/or collection areas, showing the storage and production premises and land parcels and, where applicable, premises where certain preparation and/or packaging operations take place;
   b) and, in the case of collection of wild plants, the guarantees given by third parties, if appropriate, which the producer can provide to ensure that the provisions of Annex 1, para 10 are satisfied;
   c) all the practical measures to be taken at the level of the unit to ensure compliance with these guidelines;
   d) the date of the last application on the land parcels and/or collection areas concerned of products the use of which is not compatible with Section 4 of these guidelines;
   e) an undertaking by the operator to carry out operations in accordance with Sections 3 and 4 and to accept, in event of infringements, implementation of the measures as referred to in Section 6, paragraph 9 of these guidelines.

5. Each year, before the date indicated by the certification body or authority, the operator should notify the official or officially recognized certification body or authority of its schedule of production of crop products and livestock, giving a breakdown by land parcel/herd, flock or hive.

6. Written and/or documentary accounts should be kept which enable the official or officially recognized certification body or authority to trace the origin, nature and quantities of all raw materials bought, and the use of such materials; in addition, written and/or documentary accounts should be kept of the nature, quantities and consignees of all agricultural products sold. Quantities sold directly to the final consumer should preferably be accounted for on a daily basis. When the unit itself processes agricultural products, its accounts must contain the information required in B2, third dash point of this Annex.

7. All livestock should be identified individually or, in the case of small mammals or poultry, by herd or flock or in the case of bees by hive. Written and/or documentary accounts should be kept to enable tracking of livestock and bee colonies within the system at all times and to provide adequate traceback for audit purpose. The operator should maintain detailed and up-to-date records of:
   a) breeding and/or origins of livestock;
   b) registration of any purchases;
   c) the health plan to be used in the prevention and management of disease, injury and reproductive problems;
   d) all treatments and medicines administered for any purpose, including quarantine periods and identification of treated animals or hives;
   e) feed provided and the source of the feedstuffs;
   f) stock movements within the unit and hive movements within designated forage areas as identified on maps;

g) transportation, slaughter and/or sales.
h) extraction, processing and storing of all bee products.

8. Storage, on the unit, of input substances, other than those whose use is with paragraph 4.1(b) of these guidelines is prohibited.

9. The official or officially recognized certification body or authority should ensure that a full physical inspection is undertaken, at least once a year, of the unit. Samples for testing of products not listed in these guidelines may be taken where their use is suspected. An inspection report should be drawn up after each visit. Additional occasional unannounced visits should also be undertaken according to need or at random.

10. The operator should give the certification body or authority, for inspection purposes, access to the storage and production premises and to the parcels of land, as well as to the accounts and relevant supporting documents. The operator should also provide the inspection body with any information deemed necessary for the purposes of the inspection.

11. Products referred to in Section 1 of these guidelines which are not in their packaging for the end consumer should be transported in a manner which should prevent contamination or substitution of the content with substances or product not compatible with these guidelines and the following information, without prejudice to any other indications required by law:
– the name and address of the person responsible for the production or preparation of the product;
– the name of the product; and
– that the product is of organic status.

12. Where an operator runs several production units in the same area (parallel cropping), units in the area producing crop, crop products not covered by Section 1 should also be subject to the inspection arrangements as regards the dash points of paragraph 4 and paragraphs 6 and 8 above. Plants of indistinguishable varieties as those produced at the unit referred to in paragraph 3 above should not be produced at these units:
– If derogations are allowed by the competent authority, the authority must specify the types of production and circumstances for which derogations are granted and the supplementary inspection requirements, such as unannounced site visits; extra inspections during harvest; additional documentary requirements; assessment of an operation’s ability to prevent co-mingling, etc., which are to be implemented.
– Pending further review of these guidelines in accordance with Section 8, member countries can accept parallel cropping of the same variety, even if it is not distinguishable, subject to adequate inspection measures being applied.

13. In organic livestock production, all livestock on one and the same production unit must be reared in accordance with the rules laid down in these Guidelines. However, livestock not reared in accordance with these Guidelines may be present on the organic holding provided that they are separated clearly from livestock produced in accordance with these Guidelines. The competent authority can prescribe more restrictive measures, such as different species.

14. The competent authority may accept that animals reared in accordance with the provisions of these Guidelines may be grazed on common land, provided that:
a) this land has not been treated with products other than those allowed in accordance with Section 4.1 (a) and (b) of these Guidelines, for at least three years;
b) a clear segregation between the animals reared in accordance with the provisions of these Guidelines, and the other animals can be organized.

15. For livestock production, the competent authority should ensure, without prejudice to the other provisions in this Annex, that the inspections related to all stages of production and preparation up to the sale to the consumer ensure, as far as technically possible, the traceability of livestock and livestock products from the livestock production unit through processing and any other preparation until final packaging and/or labelling.

B. PREPARATION AND PACKAGING UNITS

1. The producer and/or operator and should provide:
– a full description of the unit, showing the facilities used for the preparation, packaging and storage of agricultural products before and after the operations concerning them;
– all the practical measures to be taken at the level of the unit to ensure compliance these guidelines.

This description and the measures concerned should be signed by the responsible person of the unit and the certification body.

The report should include an undertaking by the operator to perform the operations in such a way as to comply with Section 4 of these guidelines and to accept, in the event of infringements, the implementation of measures as referred to in paragraph 6.9 of these guidelines and be countersigned by both parties.

2. Written accounts should be kept enabling the certification body or authority to trace:
   - the origin, nature and quantities of agricultural products as referred to in Section 1 of these guidelines which have been delivered to the unit;
   - the nature, quantities and consignees of products as referred to in Section 1 of these guidelines which have left the unit;
   - any other information such as the origin, nature and quantities of ingredients, additives and manufacturing aids delivered to the unit and the composition of processed products, that is required by the certification body or authority for the purposes of proper inspection of the operations.

3. Where products not referred to in Section 1 of these guidelines are also processed, packaged or stored in the unit concerned:
   - the unit should have separate areas within the premises for the storage of products as referred to in Section 1 of these guidelines, before and after the operations;
   - operations should be carried out continuously until the complete run has been dealt with, separated by place or time from similar operations performed on products not covered by Section 1 of these guidelines;
   - if such operations are not carried out frequently, they should be announced in advance, with a deadline agreed on with the certification body or authority;
   - every measure should be taken to ensure identification of lots and to avoid mixtures with products not obtained in accordance with the requirements of these guidelines.

4. The official or officially recognized certification body or authority should ensure that a full physical inspection, at least once a year, of the unit. Samples for testing of products not listed in these guidelines may be taken where their use is suspected. An inspection report must be drawn up after each visit countersigned by the person responsible for the unit inspected. Additional occasional unannounced visits should also be undertaken according to need or at random.

5. The operator should give the official or officially recognized certification body or authority or authority, for inspection purposes, access to the unit and to written accounts and relevant supporting documents. The operator should also provide the inspection body with any information necessary for the purposes of inspection.

6. The requirements in respect to the transport as laid down in paragraph A.10 of this Annex are applicable.

7. On receipt of a product referred to in Section 1 of these Guidelines, the operator shall check:
   - the closing of the packaging or contained where it is required;
   - the presence of the indications referred to in A.10 of this Annex. The result of this verification shall be explicitly mentioned in the accounts referred to in point B.2. When there is any doubt that the product cannot be verified according to the production system provided for in Section 6 of this Guidelines, it must be placed on the market without indication referring to the organic production method.

C. IMPORTS

Importing countries should establish appropriate inspection requirements for the inspection of importers and of imported organic products.

MOLASSES - GENERAL CONSIDERATIONS

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This Article Was Excerpted From

MOLASSES IN ANIMAL NUTRITION

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INTRODUCTION

Initially the term molasses referred specifically to the final effluent obtained in the preparation of sucrose by repeated evaporation, crystallization and centrifugation of juices from sugar cane and from sugar beets. Today, several types of molasses are recognized and in general, any liquid feed ingredient that contains in excess of 43% sugars is termed molasses. Literature relating to the early history, production and processing of molasses is presented by Madsen (1953) and Anonymous (1959) for sugar beets; by Meade and Chem (1977) and Anonymous (1970) for sugar cane and by Hendrickson and Kesterson (1965) for citrus molasses.

The use of molasses in livestock and poultry feeds dates back into the nineteenth century and has been the subject of several excellent review articles (Scott, 1953; Cleasby, 1963; Van Niekerk, 1980; Waldroup, 1981). In North America, one of the earliest documented reports showing the value of cane molasses in cattle feeding was published by Gulley and Carson (1890), for swine by Lindsey et al., (1907) and for poultry by Graham (1906). The extent to which molasses has been used in animal feeds varies from a small amount used to eliminate dust and feed wastage to serving as the major source of dietary energy.

TYPES OF MOLASSES

The Association of American Feed Control officials (AAFCO, 1982) describes the following types of molasses.

Cane Molasses is a by-product of the manufacture or refining of sucrose from sugar cane. It must not contain less than 46% total sugars expressed as invert. If its moisture content exceeds 27%, its density determined by double dilution must not be less than 79.5^0 Brix. IFN 4-13-251 Sugar cane molasses.

Beet Molasses is a by-product of the manufacture of sucrose from sugar beets. It must contain not less than 48% total sugars expressed as invert and its density determined by double dilution must not be less than 79.5^0 Brix. IFN 4-30-289 Beet sugar molasses.

Citrus Molasses is the partially dehydrated juices obtained from the manufacture of dried citrus pulp. It must contain not less than 45% total sugars expressed as invert and its density determined by double dilution must not be less than 71.0^0 Brix. IFN 4-01-241 Citrus syrup.

Hemicellulose Extract is a by-product of the manufacture of pressed wood. It is the concentrated soluble material obtained from the treatment of wood at elevated temperature and pressure without use of acids, alkalis, or salts. It contains pentose and hexose sugars, and has a total carbohydrate content of not less than 55%. IFN 4-08-030 Hemicellulose extract.

Starch Molasses is a by-product of dextrose manufacture from starch derived from corn or grain sorghums where the starch is hydrolyzed by enzymes and/or acid. It must contain not less than 43% reducing sugars expressed as dextrose and not less than 50% total sugars expressed as dextrose. It shall contain not less than 73% total solids. IFN 4-08-037 Maize sorghum grain starch molasses.

Recent production estimates for the various types of molasses show that of the total United States supply, 60% was cane molasses, 32% was beet molasses, 7% was starch molasses and 1% citrus molasses (Anonymous 1981). As is indicated by these percentages, the production of citrus molasses, starch molasses and hemicellulose extract is quite limited and normally usage is localized near the areas of production.

PRODUCTION AND TRADE STATISTICS

The total production of molasses for 1981-82 is approximately 35 million metric tons (Anonymous 1982b). The U.S. production of all types of molasses as compared to world production is shown in Table 1 (Anonymous 1982a, 1982b)

Table 1. Molasses Production in the U.S. As Compared to World Production

Year	U.S.	World
	--------------Million metric tons	---------------
1978-79	2.02	32.3
1979-80	1.93	29.7
1980-81	2.06	30.9
1981-81	2.12	34.8
1982-83 (est.)	2.08	34.4

The U.S. production of cane molasses comes from Florida, Louisiana, Texas, Hawaii and Puerto Rico. The major consuming areas of the world for molasses are the United States, Canada, Europe and the Far East. The size of this market is about 10-11 million tons, of which 4-5 million tons are produced within the market.

The production of molasses by region is shown in Table 2. Several changes have occurred in recent years causing increases or decreases in several of the regions (Anonymous 1982a, 1982b).

In 1981, total market supplies of molasses available in the United States were approximately 2.8 million metric tons. The percentages of the total United States molasses supply used by various groups were as follows: mixed feeds and direct feeding, 81%; yeast and citric acid, 14%; pharmaceutics, 4%; distilled spirits, 1%; (Anonymous 1982a and 1982b). A further breakdown of the feed utilization percentage shows that of the total used for feed, approximately 65% goes to liquid and feedlot use and 35% is used for dry feed. Baker (1979) reporting on world usage indicated that the animal feed industry was also the principal marketing area in the United Kingdom (75%) and Denmark (95%), whereas in the European Economic Community in general, usage of molasses fell to 58%. Although these utilization percentages have remained relatively constant over the past decade, future use patterns are dependent upon many factors. These include the world supply of sugar, cost of molasses relative to cost of grain, technological advancements in utilization of alcohol

Table 2. Molasses Production in Specific Regions

Country	1978-79	1980-81	1982-83
	------------------Million metric tons---------------------		
North America	3.40	3.21	3.38
Caribbean	2.14	1.79	1.84
Central America	0.60	0.72	0.82
South America	7.13	7.26	7.86
European Community	2.99	3.19	3.59
Other Western Europe	0.68	0.62	0.72
Eastern Europe	2.13	1.83	2.02
U.S.S.R.	3.31	2.67	2.67
Africa	1.82	1.88	2.11
Middle East	0.69	0.38	0.60
Other Asia	6.68	6.44	7.93
Oceanic	0.66	0.82	0.86

as power and changes in processing techniques. An added usage of molasses in recent years is the production of alcohol. The most successful program is in Brazil where, by 1985, alcohol production from molasses is expected to contribute about 2% of their total energy needs (Baker, 1981).

As a result, Brazil has reduced its molasses exports from about a million tons to the present figure of 635,000 tons. This trend may continue in areas where it is difficult or very expensive to move molasses to ports. In the major consuming areas it appears unlikely that molasses will be used in large quantities as a substrate for the production of power alcohol.

The greatest increase in imported cane molasses (Table 3) in recent years has occurred in Western Europe (Baker, 1981). The grain farmer in this region is protected with very high supports, and molasses always has a favorable relationship to grain prices at almost any level (Kosseff, 1980).

Table 3. Imported Cane Molasses Usage

Location	1973	1978	1981
	------------------Million metric tons---------------------		
North America	2.55	2.10	1.38
Western Europe	1.50	2.60	2.68
Far East	1.33	1.35	1.05

COMPOSITION

The average composition and selected nutrient content of the various types of molasses is presented in Tables 4, 5 and 6. As is often found with many industrial by-products, the chemical composition of molasses shows wide variation. Its composition is influenced by factors such as soil type, ambient temperature, moisture, season of production, variety, production practices at a particular processing plant, and by storage variables. Consequently, considerable variation may be found in nutrient content, flavor, color, viscosity and total sugar content. The composition data presented in Tables 4, 5 and 6 reflect these differences since these figures were compiled from analysis presented in several publications (Wornick, 1969; Anonymous, 1970; Hendrickson and Kesterson, 1971; NRC, 1971; Curtin, 1973 and NRC, 1979).

Brix

The molasses trade commonly use the term Brix as an indicator of specific gravity and as illustrated in Table 4, represents an approximation of total solids content. Brix is a term originally initiated for pure sucrose solutions to indicate the percentage of sucrose in solution on a weight basis. However, in addition to sucrose, molasses contains glucose, fructose, raffinose and numerous non-sugar organic materials. Consequently, a Brix value for molasses will often differ dramatically

Table 4. Composition and Nutrient Content of Molasses Products Hemicellulose

Item	Cane	Beet	Citrus	Extract	Starch
Brix	79.5	79.5	71.0	65.0	78.0
Total Solids (%)	75.0	77.0	65.0	65.0	73.0
Specific Gravity	1.41	0.41	1.36	1.32	1.40
Total Sugars (%)	46.0	48.0	45.0	55.0	50.0
Crude Protein (%)	3.0	6.0	4.0	0.5	0.4
Nitrogen Free Extract (%)	63.0	62.0	55.0	55.0	65.0
Total Fat (%)	0.0	0.0	0.2	0.5	0.0
Total Fiber (%)	0.0	0.0	0.0	0.5	0.0
Ash (%)	8.1	8.7	6.0	5.0	6.0
Calcium, (%)	0.8	0.2	1.3	0.8	0.1
Phosphorus, (%)	0.08	0.03	0.15	0.05	0.2
Potassium, (%)	2.4	4.7	0.1	0.04	0.02
Sodium, (%)	0.2	1.0	0.3	---	2.5
Chlorine, (%)	1.4	0.9	0.07	---	3.0
Sulfur, (%)	0.5	0.5	0.17	---	0.05
Energy (kcal/kg)					
Swine (ME)	2343	2320	2264	2231	---
Poultry (ME_N)	1962	1962	---	---	---

from actual sugar or total solid content. In fact, Baker (1979) stated that, "With an impure sucrose solution such as molasses, Brix does not represent anything except a number denoting specific gravity and this cannot be related to either sucrose or dry matter content." Regardless, in the United States, Brix is used in the official definition of beet, citrus, starch and cane molasses (AAFCO, 1982).

Sugars

All types of molasses contain relatively large amounts of total sugars or carbohydrates and these compounds constitute the majority of the feeding value of molasses. Sugar mills can control the amount of sucrose extracted and because of this, the sugar content of molasses produced in different countries will vary according to the production technology employed. According to Baker (1981), changes in the design of centrifuges used to separate sugar and syrup constitute one of the major advancements in the cane sugar industry. Continuous centrifugation now results in more sugar extracted with a corresponding decrease in the amount of sugar left in molasses. In the beet processing industry, the Steffen process has been the most efficient and widely used method of reducing the sugar content of beet molasses. More recently, the use of ion exchange resins (Quetin process) extracts more sugar from the beet which decreases the sugar content of molasses about 4%. Another recent development in the separation of sugar from beet and cane molasses is the Finnsugar-Pfeifer and Langen process. The use of this process to date has been mainly restricted to Europe.

Protein

As is presented in Table 4, none of the molasses types contain significant levels of crude protein (N x 6.25). Also, the nitrogenous materials which are present consist mainly of non-protein nitrogen compounds which include amides, albuminoids, amino acids and other simple nitrogenous compounds. These two factors, minimal quantity and quality of protein, would indicate the molasses protein is of limited nutritional value for non-ruminants. The effect of soil type on nutrient content is well illustrated by a Florida report showing that molasses produced from cane grown on organic soils contained 7-10% protein as compared to 3% for molasses from mineral soils (Chapman et al., 1965). However, Combs and Wallace (1973) reported that substituting this molasses protein for corn protein in swine diets resulted in significant decreases in rate and efficiency of gain.

Minerals

In general, the mineral content of molasses has not been considered when formulating diets for swine and poultry. Factors contributing to this situation include: the lack of bioavailability data for the various mineral elements and the wide range of values reported to exist within the various molasses types. However, in comparison to the commonly used sources of dietary energy, mainly cereal grains, the calcium content of cane and citrus molasses is high, whereas the phosphorus content is low. Cane and beet molasses are comparatively high in potassium, magnesium, sodium, chlorine and sulfur. Additional comparisons between types of molasses show that in general, cane molasses is higher than beet molasses in calcium, phosphorus and chlorine, whereas beet molasses is higher in potassium and sodium.

The trace mineral content of cane, beet and citrus molasses is presented in Table 5. Cane and citrus molasses contain higher amounts of copper, iron and manganese than beet molasses. Within a molasses type, the trace mineral variability can be quite high. Curtin (1973) reported that cane molasses contained an average of 297 mg/kg iron with a range of 145-640 mg/kg and that beet molasses contained an average of 65 mg/kg zinc with a range of 4 to 264 mg/kg. Similar ranges also were presented for copper and manganese.

Table 5. Trace Minerals in Molasses

Mineral	Cane	Beet	Citrus
Copper, mg/kg	36	13	30
Iron, mg/kg	249	117	400
Manganese, mg/kg	35	10	20
Zinc, mg/kg	13	40	---

Vitamins

The approximate B-vitamin content of cane, beet and citrus molasses is shown in Table 6. Curtin (1973) reported that processing procedures concentrated the heat and alkali-stable vitamins in the final molasses and that pantothenic acid appeared to be sensitive to some of the processes used in sugar production. In addition to the vitamins presented in Table 6, Baker (1979) reported that cane molasses contained approximately 6,000 mg/kg inositol, 800 mg/kg niacin and 5 mg/kg pyridoxine. In comparison to commonly used grains, the biotin content is quite high in both cane and beet molasses. However, data presented by Curtin (1973) and Olbrich (1963) indicated that the vitamin content of molasses was subject to wide variations. These variations coupled with their relatively low content in molasses tends to diminish their nutritional significance.

Table 6. Vitamins in Molasses

Vitamin	Cane	Beet	Citrus
Biotin, mg/kg	0.36	0.46	---
Choline, mg/kg	745.0	716.0	---
Pantothenic Acid, mg/kg	21.0	7.0	10.0
Riboflavin, mg/kg	1.8	1.4	11.0
Thiamine, mg/kg	0.9	---	---

Energy

As mentioned previously, sugars and soluble carbohydrates account for the major portion of the feeding value of molasses. The metabolizable energy content of the various types of molasses is presented in Table 4. A comparison of these values with commonly used energy feeds in swine and poultry diets is shown in Table 7. Averaging the energy values for barley, corn, oats and wheat shows that for swine, molasses contains only 77% of the energy found in these grains and that with poultry, the figure decreases to 68%. However, in certain countries of the world, molasses is the only inexpensive and available energy source that can be used in livestock and poultry production.

In addition to energy, molasses products also provide other advantages in rations, particularly for ruminants, which are difficult to evaluate on a numerical basis. These advantages include:

1. Increases the palatability of many types of rations.

2. Energy in form of simple sugars is easily digestible.

3. Molasses at times appears to exert a tonic effect.

4. In many feeds it eliminates dust.

Table 7. Comparison of the Metabolizable Energy Content of Molasses with Other Energy Feeds

Feedstuff	IFN	Swine ME (kcal/kg)	Poultry ME (kcal/kg)
Cane Molasses	4-04-696	2343	1962
Beet Molasses	4-00-669	2320	1962
Barley	4-00-549	2870	2640
Corn	4-02-935	3325	3430
Oats	4-03-309	2668	2550
Wheat	4-05-268	3220	2800

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Applied and Environmental Microbiology, Jan. 2008, p. 333–335 Vol. 74, No. 1
0099-2240/08/$08.00+0 doi:10.1128/AEM.01595-07

Utilization of Molasses Sugar for Lactic Acid Production by *Lactobacillus delbrueckii* subsp. *delbrueckii* Mutant Uc-3 in Batch Fermentation[▽]

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Received 13 July 2007/Accepted 25 October 2007

Efficient lactic acid production from cane sugar molasses by *Lactobacillus delbrueckii* mutant Uc-3 in batch fermentation process is demonstrated. Lactic acid fermentation using molasses was not significantly affected by yeast extract concentrations. The final lactic acid concentration increased with increases of molasses sugar concentrations up to 190 g/liter. The maximum lactic acid concentration of 166 g/liter was obtained at a molasses sugar concentration of 190 g/liter with a productivity of 4.15 g/liter/h. Such a high concentration of lactic acid with high productivity from molasses has not been reported previously, and hence mutant Uc-3 could be a potential candidate for economical production of lactic acid from molasses at a commercial scale.

Lactic acid can be used as a preservative, acidulant, and flavor in food, textile, and pharmaceutical industries. It could become a commodity chemical for the production of lactate esters, propylene glycol, propylene oxide, acrylic acid, 2,3-pentanedione, propanoic acidacetaldehyde, and dilactide (3, 15). It has also been increasing in importance as a feedstock for manufacture of polylactic acid (PLA), which could be a good substitute for synthetic plastic derived from petroleum feedstock. Approximately 90% of the total lactic acid produced worldwide is by bacterial fermentation (20). The chemical synthesis of lactic acid always leads to racemic mixture, which is major disadvantage. Fermentative production of lactic acid offers great advantage in producing optically pure L- or D-lactic and also DL-lactic acid, depending on the strain selected for fermentation. The optical purity of lactic acid is crucial factor in the physical properties of PLA, and it is L(+)-lactic acid that can be polymerized to a high-crystal PLA suited to commercial uses such as fibers and films (14).

Most studies within production of lactic acid have focused on the use of pure substrates such as glucose (9, 12) or lactose (5) for the production of lactic acid. The use of natural substrates like starch (4, 10, 11, 18) and cellulose (2, 6, 16) is economically unfavorable because they are very expensive and also require pretreatment in order to release fermentable sugars. The manufacturing cost of lactic acid can be significantly reduced if waste products such as whey or molasses containing fermentable sugars could be used for the production of lactic acid. India is one of the largest countries producing more than 20 million tons of cane sugar from sugar cane. During this process, a large amount of molasses is generated as the by-product, which contains 40 to 60% sucrose, which can be converted to lactic acid by the use of microorganisms.

In this paper, we describe the efficient conversion of molasses sugar by a mutant strain, *Lactobacillus delbrueckii* Uc-3, for lactic acid production. The mutant was isolated by UV mutagenesis followed by selection on the basis of a bigger zone of acid formation on sucrose-based medium (7). The mutant is reported to utilize glucose preferentially from high concentrations of hydrolyzed cane sugar resulting in coproduction of lactic acid and fructose (13). Recently, we have reported the complete utilization of bagasse-derived cellulose to lactic acid with an 80% yield using this strain (2), which was attributed to the presence of cellobiose and cellotriose enzymes present in the mutant strain (1).

For the evaluation of lactic acid production from cane molasses, experiments were performed in 250-ml, screw-cap flasks at 42°C with shaking at 150 rpm. The flask contained 100 ml production medium consisting of hydrolyzed 10 g cane molasses sugar, 4.0 g $CaCO_3$, and 0.5 g yeast extract. The cane molasses was obtained from Godavari Sugar Mills Limited, Sameerwadi, India. The molasses contained sucrose (31%), glucose (9.5%), fructose (10%), and nitrogen (0.95%). The cane molasses sugar was hydrolyzed by adding 1 ml of 20% H_2SO_4 in 100 ml of molasses solution. The acidified molasses solution was heated in a boiling water bath for 20 min. The cane molasses contained 46 to 48% reducing sugar. The pH of the medium was adjusted to 6.5 with 4.0 M KOH prior to sterilization. The flasks were inoculated (5% inoculum) with culture grown in hydrolyzed, sucrose-based medium (7). The culture samples harvested after suitable time intervals were centrifuged at 2,000 × *g* for 20 min to separate the cells. The supernatant was analyzed for sugar and lactic acid and for determination of the pH of fermented broth. Lactic acid was analyzed by high-pressure liquid chromatography with UV or refractive index detectors using an Aminex HPX-87H column, and sugar was analyzed by the dinitrosalicylic acid method as reported earlier (7). The dry cell weight was determined by a calibration curve related with optical density at 660 nm to dry weight (g/liter). One unit of optical density corresponded to 0.76 g/liter of dry cell weight.

The parent strain *Lactobacillus delbrueckii* NCIM 2365 and mutant Uc-3 were evaluated initially for lactic acid production in molasses-based fermentation medium using 102 g/liter of

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[▽] Published ahead of print on 2 November 2007.

TABLE 1. Lactic acid production by parent and mutant strains in cane molasses sugar[a]

Yeast extract concn (g/liter)	Result for:					
	Parent strain			Mutant Uc-3		
	Dry cell wt (g/liter)	Lactic acid concn (g/liter)	Productivity (g/liter/h)	Dry cell wt (g/liter)	Lactic acid concn (g/liter)	Productivity (g/liter/h)
0	4.5 ± 0.3	8.0 ± 0.7	0.33 ± 0.05	5.8 ± 0.6	43.6 ± 3.5	1.80 ± 0.1
2.5	5.0 ± 0.4	14.0 ± 1.2	0.58 ± 0.06	9.2 ± 0.8	74.0 ± 5.0	3.08 ± 0.2
5	5.7 ± 0.3	16.4 ± 1.1	0.68 ± 0.04	8.7 ± 0.6	73.0 ± 3.7	3.04 ± 0.1
10	5.8 ± 0.3	16.8 ± 1.1	0.70 ± 0.04	9.8 ± 0.7	73.2 ± 4.0	3.05 ± 0.2

[a] The cultures were grown anaerobically at 42°C with shaking (150 rpm). The concentration of molasses sugar was 102 g/liter. The samples were removed after 24 h of fermentation and analyzed for growth and lactic acid. The values are averages of three independent experiments.

cane molasses sugar and various concentrations of yeast extract. The mutant Uc-3 produced 4.5 times more lactic acid than the parent strain within 24 h using 102 g/liter of molasses sugar (Table 1). Lactic acid bacteria are generally fastidious organisms requiring complex nutrients such as amino acids and vitamins for cell growth. Yeast extract is the most commonly used nitrogen source which provides vitamin B complex content in addition to organic nitrogen to lactic acid bacteria (19). It was found that 2.5 g/liter yeast extract was sufficient to obtain maximum lactic acid with high productivity. The requirement of a smaller amount of yeast extract as a nitrogen source could be attributed to the presence of enough nitrogen in molasses. Further experiments were performed using 5 g/liter of yeast extract because we used higher molasses sugar concentrations. In order to investigate the influence of molasses concentration on lactic acid production, *Lactobacillus delbrueckii* mutant Uc-3 was grown using 110 to 500 g/liter of molasses (equivalent to 51 to 240 g/liter of total sugar). As shown in Table 2, the final lactic acid concentration increased with increases in the initial molasses sugar concentration up to 190 g/liter. A sharp decrease in lactic acid production was observed at 240 g/liter of molasses sugar concentration. This could be probably due to substrate inhibition, a phenomenon observed in traditional batch fermentation. Maximum lactic acid production (166 g/liter) was obtained within 40 h of fermentation with an initial molasses sugar concentration of 190 g/liter. At all molasses sugar concentrations, the lactic acid yields were 0.88 to 0.96 g/g based on the total sugar consumed and the highest yield (0.96 g/g) and productivity (4.3 g/liter/h) were obtained at 148 g/liter of molasses sugar concentration.

TABLE 2. Effect of initial hydrolyzed molasses sugar concentration on fermentation time required, lactic acid production, dry cell weight, and lactic acid productivity of mutant Uc-3[a]

Molasses sugar concn (g/liter)	Lactic acid concn in g/liter (time of analysis [h])[b]	Dry cell wt (g/liter)	Lactic acid yield (g/g)	Productivity (g/liter/h)
51	40.0 ± 2.4 (16)	7.42 ± 0.4	0.88	2.50 ± 0.2
102	84.6 ± 3.8 (30)	8.75 ± 0.3	0.94	2.82 ± 0.1
123	105.0 ± 6.5 (30)	14.0 ± 0.9	0.95	3.50 ± 0.2
148	129.0 ± 7.0 (30)	14.0 ± 0.8	0.96	4.30 ± 0.2
190	166.0 ± 7.5 (40)	15.1 ± 0.8	0.95	4.15 ± 0.2
240	88.2 ± 5.0 (48)	2.70 ± 0.2	0.94	1.83 ± 0.1

[a] The values are averages of three independent experiments.

[b] The values in parentheses indicate the time points (in hours) when the samples were analyzed.

The profile of growth (optical density), pH, lactic acid production, and molasses sugar utilization is shown in Fig. 1. The maximum amount of lactic acid (166 g/liter) was produced from 190 g/liter of molasses sugar within 40 h of fermentation, with an increase in optical density from 1.5 to 21.6 and a decrease in pH from 6.0 to 5.3. The decrease in pH of the fermentation is not significant, probably due to buffering action of molasses. We observed a drastic pH drop from 6.8 to 4.5 of the fermented broth when sucrose-based production medium was used for lactic acid production (7). Hence, molasses-based production medium could be an advantage for maintaining the pH of the fermentation medium above 5.3, at which fermentation rates are faster. This could be one of the reasons for the high lactic acid productivity observed in molasses-based medium.

Table 3 summarizes the results obtained from this work and from other literature previously reported on lactic acid concentration, lactic acid yield, and productivity in batch fermentation of molasses. Recently, Wee et al. (17) reported that a maximum lactic acid concentration of 134.9 g/liter was obtained at a molasses concentration of 333 g/liter (equivalent to 170 g/liter of total sugar) with productivity of 1.5 g/liter/h using *Enterococcus faecalis*. The high productivity of 4.3 was obtained at lower molasses concentrations. However, their requirement for yeast extract was very high (15 g/liter) to obtain the highest productivity of lactic acid. The *Lactobacillus*

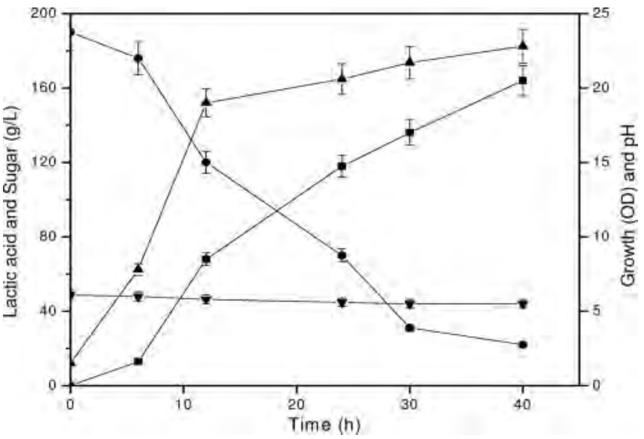

FIG. 1. Profile of lactic acid production, growth, pH, and sugar utilization during fermentation by *Lactobacillus delbrueckii* mutant Uc-3 using a molasses sugar concentration of 190 g/liter. OD, optical density. ●, molasses sugar; ■, lactic acid; ▲, growth; ▼, pH.

TABLE 3. Comparison of different lactic acid-overproducing strains grown on molasses in batch fermentation

Strain used (yeast extract concn [g/liter])	Lactic acid concn (g/liter)	Molasses sugar concn (g/liter)	Lactic acid yield (g/g)	Fermentation time (h)	Productivity (g/liter/h)	Reference
Lactobacillus delbrueckii NCIMB 8130 (50)	90.0	100	0.98	24	3.8	8
Enterococcus faecalis RKY1 (15)	95.7	102	0.95	24	4.0	17
	127.0	136	0.95	60	2.1	17
	134.9	170	0.93	90	1.5	17
Lactobacillus delbrueckii Uc-3 (5)	129.0	148	0.96	30	4.3	This work
	166.0	190	0.95	40	4.15	This work

delbrueckii mutant Uc-3 used in this study could produce 166 g/liter of lactic acid from 400 g/liter of molasses (equivalent to 190 g/liter of total sugar). It is noteworthy that we required a very small amount of yeast extract (5 g/liter) to obtain high lactic acid productivity even at a high molasses concentration. Therefore, the mutant Uc-3 proved to be an efficient strain with very high productivity for production of lactic acid from a high concentration of molasses.

In conclusion, the *Lactobacillus delbrueckii* mutant Uc-3 proved to be a promising strain for the production of lactic acid from molasses. The requirement for yeast extract is brought down to minimum because molasses contains enough of the nitrogen source necessary to grow such fastidious organisms. Also the buffering capacity of the molasses could be an advantage in maintaining the pH of the medium above pH 5.3 during fermentation. Molasses was also proven to be an economically feasible raw material for industrial production of lactic acid since it is fortified with enough nutrients necessary for growth of lactic acid bacteria.

We acknowledge financial support from the NMITLI Division of the Council of Scientific and Industrial Research, New Delhi, India.

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(Acts adopted under the EC Treaty/Euratom Treaty whose publication is obligatory)

REGULATIONS

COMMISSION REGULATION (EC) No 889/2008

of 5 September 2008

laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Community,

Having regard to Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91 ([1]), and in particular Article 9(4), the second paragraph of Article 11 Articles 12(3), 14(2), 16(3)(c), 17(2) and 18(5), the second subparagraph of Article 19(3), Articles 21(2), 22(1), 24(3), 25(3), 26, 28(6), 29(3) and 38(a), (b), (c) and (e), and Article 40 thereof,

Whereas:

(1) Regulation (EC) No 834/2007, and in particular Titles III, IV and V thereof, lay down basic requirements with regard to production, labelling and control of organic products in the plant and livestock sector. Detailed rules for the implementation of those requirements should be laid down.

(2) The evolution of new detailed production rules on certain animal species, organic aquaculture, seaweed and yeasts used as food or feed on community level will require more time and therefore should be elaborated in a subsequent procedure. It is therefore appropriate to exclude those products from the scope of this Regulation. However, as regards certain livestock species, aquaculture products and seaweed, the Community rules provided for production, controls and labelling should apply *mutatis mutandis* to those products, in accordance with Article 42 of Regulation (EC) No 834/2007.

(3) Certain definitions should be laid down in order to avoid ambiguities and to guarantee the uniform application of the organic production rules.

(4) Organic plant production is based on nourishing the plants primarily through the soil ecosystem. Therefore hydroponic cultivation, where plants grow with their roots in an inert medium feed with soluble minerals and nutrients, should not be allowed.

(5) Organic plant production involves varied cultivation practices and limited use of fertilisers and conditioners of low solubility, therefore these practices should be specified. In particular, conditions for the use of certain non-synthetic products should be laid down.

(6) The use of pesticides, which may have detrimental effects on the environment or result in the presence of residues in agricultural products, should be significantly restricted. Preference should be given to the application of preventive measures in pest, disease and weed control. In addition, conditions for the use of certain plant protection products should be laid down.

(7) For the purpose of organic farming, the use of certain plant protection products, fertilisers, soil conditioners, as well as certain non-organic feed materials, feed additives and feed processing aids and certain products used for cleaning and disinfection was allowed under Council Regulation (EEC) No 2092/91 ([2]) under well-defined conditions. For the sake of ensuring the continuity of organic farming the products and substances in question should, in accordance with the provisions laid down in Article 16(3)(c) of Regulation (EC) No 834/2007, continue to be allowed. Moreover, for the sake of clarity, it is appropriate to list in the Annexes to this Regulation the products and substances which had been allowed under Regulation (EEC) No 2092/91. Other products and substances may be added to these lists in the future under a different legal basis, namely Article 16(1) of Regulation (EC) No 834/2007. It is therefore appropriate to identify the distinct status of each category of products and substances by means of a symbol in the list.

([1]) OJ L 189, 20.7.2007, p. 1.

([2]) OJ L198, 22.7.1991, p. 1.

(8) The holistic approach of organic farming requires a livestock production related to the land, where the produced manure is used to nourish the crop production. Since livestock farming always implies the management of agricultural land, provision should be made to prohibit landless livestock production. In organic livestock production the choice of breeds should take account of their capacity to adapt to local conditions, their vitality and their resistance to disease and a wide biological diversity should be encouraged.

(9) Under certain circumstances operators may face difficulties in obtaining organic breeding animals from a reduced gene pool, which would hamper the development of the sector. Therefore the possibility of bringing a limited number of non-organic animals onto a farm for breeding purposes should be provided for.

(10) Organic stock farming should ensure that specific behavioural needs of animals are met. In this regard, housing for all species of livestock should satisfy the needs of the animals concerned as regards ventilation, light, space and comfort and sufficient area should accordingly be provided to permit ample freedom of movement for each animal and to develop the animal's natural social behaviour. Specific housing conditions and husbandry practices with regard to certain animals, including bees, should be laid down. These specific housing conditions should serve a high level of animal welfare, which is a priority in organic livestock farming and therefore may go beyond Community welfare standards which apply to farming in general. Organic husbandry practices should prevent poultry from being reared too quickly. Therefore specific provisions to avoid intensive rearing methods should be laid down. In particular poultry shall either be reared until they reach a minimum age or else shall come from slow-growing poultry strains, so that in either case there is no incentive to use intensive rearing methods.

(11) In most cases, livestock should have permanent access to open air areas for grazing, weather conditions permitting, and such open air areas should in principle be organised under an appropriate system of rotation.

(12) In order to avoid environmental pollution of natural resources such as soil and water by nutrients, an upper limit for the use of manure per hectare and for keeping livestock per hectare should be set. This limit should be related to the nitrogen content of the manure.

(13) Mutilations which lead to stress, harm, disease or the suffering of animals should be banned. However, specific operations essential to certain types of production and for the sake of security for animals and human beings may be permitted under restricted conditions.

(14) Livestock should be fed on grass, fodder and feedingstuffs produced in accordance with the rules of organic farming, preferably coming from the own holding, by taking into account their physiological needs. In addition, in order to provide for the basic nutritional requirements of livestock, certain minerals, trace elements and vitamins may need to be used under well-defined conditions.

(15) Since the existing regional differences in the possibility for organic ruminants to obtain the necessary essential vitamins A, D and E through their feed rations, as regards climate and available sources of feed, are expected to persist, the use of such vitamins for ruminants should be allowed.

(16) Animal-health management should mainly be based on prevention of disease. In addition specific cleaning and disinfection measures should be applied.

(17) The preventive use of chemically-synthesised allopathic medicinal products is not permitted in organic farming. However, in the event of a sickness or injury of an animal requiring an immediate treatment, the use of chemically-synthesised allopathic medicinal products should be limited to a strict minimum. Furthermore, in order to guarantee the integrity of organic production for consumers it should be possible to take restrictive measures such as doubling the withdrawal period after use of chemically synthesised allopathic medicinal products.

(18) Specific rules for disease prevention and veterinary treatment in beekeeping should be laid down.

(19) Provision should be made to require operators producing feed or food to take account of appropriate procedures based on a systematic identification of critical processing steps in order to ensure that the produced processed products comply with the organic production rules.

(20) Certain non-organic products and substances are needed in order to ensure the production of certain processed organic food and feed. The harmonization of wine processing rules on Community level will require more time. Therefore the mentioned products should be excluded for wine processing until, in a subsequent procedure, specific rules are laid down.

(21) For the purpose of processing organic food, the use of certain ingredients of non-agricultural origin, certain food processing aid and certain non-organic ingredients of agricultural origin was allowed under Regulation (EEC) No 2092/91 under well-defined conditions. For the sake of ensuring the continuity of organic farming the products and substances in question should, in accordance with the provisions laid down in Article 21(2) of Regulation (EC) No 834/2007, continue to be allowed. Moreover, for the

sake of clarity, it is appropriate to list in the Annexes to this Regulation the products and substances which had been allowed under Regulation (EEC) No 2092/91. Other products and substances may be added to these lists in the future under a different legal basis, namely Article 21(2) of Regulation (EC) No 834/2007. It is therefore appropriate to identify the distinct status of each category of products and substances by means of a symbol in the list.

(22) Under certain conditions organic products and non-organic products can be collected and transported simultaneously. In order to duly separate organic from non-organic products during handling and to avoid any commingling specific provisions should be laid down.

(23) The conversion to the organic production method requires certain periods of adaptation of all means in use. Depending on the previous farm production, specific time periods for the various production sectors should be laid down.

(24) In accordance with Article 22 of Regulation (EC) No 834/2007, specific conditions for the application of exceptions provided for in that Article should be laid down. It is appropriate to set out such conditions with regard to the non availability of organic animals, feed, beeswax, seeds and seed potatoes and organic ingredients as well as to specific problems related to the livestock management and in the case of catastrophic circumstances.

(25) Geographical and structural differences in agriculture and climatic constraints may hamper the development of organic production in certain regions and therefore call for exceptions for certain practices as regards the characteristics of livestock buildings and installations. Therefore tethering of animals should, under well-defined conditions, be allowed in holdings which, due to their geographical location and structural constraints, in particular with regard to mountainous areas, are of small size, and only where it is not possible to keep the cattle in groups appropriate to their behavioural needs.

(26) For the purpose of ensuring the development of an incipient organic livestock sector, several temporary derogations as regards tethering of animals, housing conditions for animals and stocking densities were granted under Regulation (EEC) No 2092/91. These derogations should, on a transitional basis, be maintained until their expiry date, in order not to disrupt the organic livestock sector.

(27) Considering the importance of pollination of the organic beekeeping sector it should be possible to grant exceptions permitting the parallel production of organic and non-organic beekeeping unit on the same farm.

(28) Under certain circumstances, farmers may experience difficulty in securing supplies of organically reared livestock and organic feedingstuffs and therefore authorisation should be granted for a limited number of non-organically produced farm input to be used in restricted quantities.

(29) Major efforts have been undertaken by producers involved in organic production for the development of the production of organic seeds and vegetative materials in order to establish a broad choice of plant varieties of plant species for which organic seeds and vegetative propagating material is available. However, currently for many species there is still not enough organic seed and vegetative propagating material available and, in those cases, the use of non-organic seed and vegetative propagating material should be allowed.

(30) In order to help operators to find organic seed and seed potatoes, each Member State should ensure that a database is set up that contains the varieties of which organic seed and seed potatoes are available on the market.

(31) The management of adult bovine animals may endanger the keeper and other persons handling the animals. Therefore provision should be made to allow for exceptions to be granted during the final fattening phase of mammals, in particular with regard to bovine animals.

(32) Catastrophic circumstances or widespread animal or plant diseases may have serious effects on the organic production in the regions concerned. Appropriate measures need to be taken to ensure the maintenance of farming or even the reestablishment of farming. Therefore the supply of non-organic animals, or non-organic feed should be made possible for a limited period in the affected areas.

(33) In accordance with Articles 24(3) and 25(3) of Regulation (EC) No 834/2007, specific criteria as regards the presentation, composition, size and design of the Community logo, as well as the presentation and composition of the code number of the control authority or control body and of the indication of the place where the agricultural product has been farmed should be laid down.

(34) In accordance with Article 26 of Regulation (EC) No 834/2007, specific requirements for the labelling of organic feed should be laid down taking into account the varieties and composition of feed and the horizontal labelling provisions applicable to feed.

(35) In addition to the control system based on the Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules ([3]) specific control measures should be laid down. In particular, detailed requirements with regard to all stages of production, preparation and distribution related to organic products.

(36) Notifications of information by the Member States to the Commission must enable it to use the information sent directly and as effectively as possible for the management of statistical information and referential data. To achieve this objective, all information to be made available or to be communicated between the Member States and the Commission should be sent electronically or in digital form.

(37) Exchanges of information and documents between the Commission and the Member States, and the provision and notification of information from the Member States to the Commission are generally carried out electronically or in digital form. In order to improve the way such exchanges of information under organic production rules are dealt with and to extend their use, it is necessary to adapt the existing computer systems or set up new ones. Provision should be made for this to be done by the Commission and implemented after informing the Member States via the Committee on organic production.

(38) The conditions under which information is processed by these computer systems and the form and content of documents which have to be communicated under Regulation (EC) No 834/2007 have to be adjusted frequently in line with changes to the applicable rules or management requirements. Uniform presentation of the documents to be sent in by the Member States is also necessary. To achieve these objectives and to simplify procedures and ensure that the computer systems concerned can be made operational immediately, the form and content of the documents should be laid down on the basis of models or questionnaires, which should be adapted and updated by the Commission after informing the Committee on organic production.

(39) Transitional measures should be laid down, for certain provisions established under Regulation (EEC) No 2092/91, in order not to jeopardize the continuity of the organic production.

(40) Commission Regulation (EEC) No 207/93 of 29 January 1993 defining the content of Annex VI to Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs and laying down detailed rules for implementing the provisions of Article 5(4) thereto ([4]) Commission Regulation (EC) No 1452/2003 of 14 August 2003 maintaining the derogation provided for in Article 6 (3)(a) of Council Regulation (EEC) No 2092/91 with regard to certain species of seed and vegetative propagating material and laying down procedural rules and criteria relating to that derogation ([5]) and Commission Regulation (EC) No 223/2003 of 5 February 2003 on labelling requirements related to the organic production method for feedingstuffs, compound feedingstuffs and feed materials and amending Council Regulation (EEC) No 2092/91 ([6]) should be repealed and replaced by a new Regulation.

(41) Regulation (EEC) No 2092/91 is repealed by Regulation (EC) No 834/2007 with effect from 1 January 2009. However, many of its provisions should, with some adaptation, continue to apply and should therefore be adopted in the framework of this Regulation. For the sake of clarity it is appropriate to set out the correlation between those provisions of Regulation (EEC) No 2092/91 and the provisions of this Regulation.

(42) The measures provided for in this Regulation are in accordance with the opinion of the regulatory Committee on organic production,

HAS ADOPTED THIS REGULATION:

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[3] OJ L 165, 30.4.2004, p. 1. Corrected by OJ L 191, 28.5.2004, p. 1.

[4] OJ L 25, 2.2.1993, p. 5.

[5] OJ L 206, 15.8.2003, p. 17.

[6] OJ L 31, 6.2.2003, p. 3.

Content

TITLE I

INTRODUCTORY PROVISIONS

Article 1

Subject matter and scope

1. This Regulation lays down specific rules on organic production, labelling and control in respect of products referred to in Article 1(2) of Regulation (EC) No 834/2007.

2. This Regulation shall not apply to the following products:

(a) products originating from aquaculture;

(b) seaweed;

(c) livestock species other than those referred to in Article 7;

(d) yeasts used as food or feed.

However, Title II, Title III and Title IV shall apply *mutatis mutandis* to products referred to in points (a), (b) and (c) of the first subparagraph until detailed production rules for those products are laid down on the basis of Regulation (EC) No 834/2007.

Article 2

Definitions

In addition to the definitions laid down in Article 2 of Regulation (EC) No 834/2007, the following definitions shall apply for the purposes of this Regulation:

(a) 'non-organic': means not coming from or not related to a production in accordance to Regulation (EC) No 834/2007 and this Regulation;

(b) 'veterinary medicinal products': means products as defined in Article 1(2) of Directive 2001/82/EC of the European Parliament and of the Council (7) concerning the Community code relating to veterinary medicinal products

(c) 'importer': means the natural or legal person within the community who presents a consignment for release for free circulation into the Community, either in person, or through a representative;

(d) 'first consignee' means the natural or legal person to whom the imported consignment is delivered and who will receive it for further preparation and/or marketing;

(e) 'holding' means all the production units operated under a single management for the purpose of producing agricultural products;

(f) 'production unit' meaning all assets to be used for a production sector such as production premises, land parcels, pasturages, open air areas, livestock buildings, the premises for the storage of crops, crop products, livestock products, raw materials and any other input relevant for this specific production sector;

(g) 'hydroponic production' means the method of growing plants with their roots in a mineral nutrient solution only or in an inert medium, such as perlite, gravel or mineral wool to which a nutrient solution is added;

(h) 'veterinary treatment' means all courses of a curative or preventive treatment against one occurrence of a specific disease;

(i) 'in-conversion feedingstuffs' means feedingstuffs produced during the conversion period to organic production, with the exclusion of those harvested in the 12 months following the beginning of the conversion as referred to in Article 17(1)(a) of Regulation (EC) No 834/2007.

TITLE II

RULES ON PRODUCTION, PROCESSING, PACKAGING, TRANSPORT AND STORAGE OF ORGANIC PRODUCTS

CHAPTER 1

Plant Production

Article 3

Soil management and fertilisation

1. Where the nutritional needs of plants cannot be met by measures provided for in Article 12(1)(a), (b) and (c) of Regulation (EC) No 834/2007, only fertilisers and soil conditioners referred to in Annex I to this Regulation may be used in organic production and only to the extent necessary. Operators shall keep documentary evidence of the need to use the product.

2. The total amount of livestock manure, as defined in Council Directive 91/676/EEC (8) concerning the protection of waters against pollution caused by nitrates from agricultural sources, applied on the holding may not exceed 170 kg of nitrogen per year/hectare of agricultural area used. This limit shall only apply to the use of farmyard manure, dried farmyard manure and dehydrated poultry manure, composted animal excrements, including poultry manure, composted farmyard manure and liquid animal excrements.

3. Organic-production holdings may establish written cooperation agreements exclusively with other holdings and enterprises which comply with the organic production rules, with the intention of spreading surplus manure from organic production. The maximum limit as referred to in paragraph 2, shall be calculated on the basis of all of the organic-production units involved in such cooperation.

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(7) OJ L 311, 28.11.2001, p. 1.

(8) OJ L 375, 31.12.1991, p. 1.

4. Appropriate preparations of micro-organisms may be used to improve the overall condition of the soil or the availability of nutrients in the soil or in the crops.

5. For compost activation appropriate plant-based preparations or preparations of micro-organisms may be used.

Article 4

Prohibition of hydroponic production

Hydroponic production is prohibited.

Article 5

Pest, disease and weed management

1. Where plants cannot be adequately protected from pests and diseases by measures provided for in Article 12 (1)(a), (b), (c) and (g) of Regulation (EC) No 834/2007, only products referred to in Annex II to this Regulation may be used in organic production. Operators shall keep documentary evidence of the need to use the product.

2. For products used in traps and dispensers, except pheromone dispensers, the traps and/or dispensers, shall prevent the substances from being released into the environment and prevent contact between the substances and the crops being cultivated. The traps shall be collected after use and disposed off safely.

Article 6

Specific rules on mushroom production

For production of mushrooms, substrates may be used, if they are composed only of the following components:

(a) farmyard manure and animal excrements:

  (i) either from holdings producing according to the organic production method;

  (ii) or referred to in Annex I, only when the product referred to in point (i) is not available; and when they do not exceed 25 % of the weight of total components of the substrate, excluding the covering material and any added water, before composting;

(b) products of agricultural origin, other than those referred to in point (a), from holdings producing according to organic production method;

(c) peat not chemically treated;

(d) wood, not treated with chemical products after felling;

(e) mineral products referred to in Annex I, water and soil.

CHAPTER 2

Livestock production

Article 7

Scope

This Chapter lays down detailed production rules for the following species: bovine including *bubalus* and bison, equidae, porcine, ovine, caprine, poultry (species as mentioned in Annex III) and bees.

Section 1

Origin of animals

Article 8

Origin of organic animals

1. In the choice of breeds or strains, account shall be taken of the capacity of animals to adapt to local conditions, their vitality and their resistance to disease. In addition, breeds or strains of animals shall be selected to avoid specific diseases or health problems associated with some breeds or strains used in intensive production, such as porcine stress syndrome, PSE Syndrome (pale-soft-exudative), sudden death, spontaneous abortion and difficult births requiring caesarean operations. Preference is to be given to indigenous breeds and strains.

2. For bees, preference shall be given to the use of *Apis mellifera* and their local ecotypes.

Article 9

Origin of non-organic animals

1. In accordance with Article 14(1)(a)(ii) of Regulation (EC) No 834/2007, non-organic animals may be brought onto a holding for breeding purposes, only when organic animals are not available in sufficient number and subject to the conditions provided for in paragraphs 2 to 5 of this Article.

2. Non-organic young mammals, when a herd or flock is constituted for the first time, shall be reared in accordance with the organic production rules immediately after they are weaned. Moreover, the following restrictions shall apply at the date on which the animals enter the herd:

(a) buffalo, calves and foals shall be less than six months old;

(b) lambs and kids shall be less than 60 days old;

(c) piglets shall weigh less than 35 kg.

3. Non-organic adult male and nulliparous female mammals, for the renewal of a herd or flock, shall be reared subsequently in accordance with the organic production rules. Moreover, the number of female mammals is subject to the following restrictions per year:

(a) up to a maximum of 10 % of adult equine or bovine, including *bubalus* and bison species, livestock and 20 % of the adult porcine, ovine and caprine livestock, as female animals;

(b) for units with less than 10 equine or bovine animals, or with less than five porcine, ovine or caprine animals any renewal as mentioned above shall be limited to a maximum of one animal per year.

This provision of this paragraph will be reviewed in 2012 with a view to phase it out.

4. The percentages referred to in paragraph 3 may be increased up to 40 %, subject to prior authorisation by the competent authority, in the following special cases:

(a) when a major extension to the farm is undertaken;

(b) when a breed is changed;

(c) when a new livestock specialisation is initiated;

(d) when breeds are in danger of being lost to farming as laid down in Annex IV to Commission Regulation (EC) No 1974/2006 ([9]) and in that case animals of those breeds must not necessarily be nulliparous.

5. For the renovation of apiaries, 10 % per year of the queen bees and swarms may be replaced by non-organic queen bees and swarms in the organic production unit provided that the queen bees and swarms are placed in hives with combs or comb foundations coming from organic production units.

Section 2

Livestock housing and husbandry practices

Article 10

Rules pertaining to housing conditions

1. Insulation, heating and ventilation of the building shall ensure that air circulation, dust level, temperature, relative air humidity and gas concentration, are kept within limits which are not harmful to the animals. The building shall permit plentiful natural ventilation and light to enter.

2. Housing for livestock shall not be mandatory in areas with appropriate climatic conditions to enable animals to live outdoors.

3. The stocking density in buildings shall provide for the comfort, the well being and the species-specific needs of the animals which, in particular, shall depend on the species, the breed and the age of the animals. It shall also take account of the behavioural needs of the animals, which depend in particular on the size of the group and the animals' sex. The density shall ensure the animals' welfare by providing them with sufficient space to stand naturally, lie down easily, turn round, groom themselves, assume all natural postures and make all natural movements such as stretching and wing flapping.

4. The minimum surface for indoor and outdoor areas, and other characteristics of housing for different species and categories of animals, are laid down in Annex III.

Article 11

Specific housing conditions and husbandry practices for mammals

1. Livestock housing shall have smooth, but not slippery floors. At least half of the indoor surface area as specified in Annex III shall be solid, that is, not of slatted or of grid construction.

2. The housing shall be provided with a comfortable, clean and dry laying/rest area of sufficient size, consisting of a solid construction which is not slatted. Ample dry bedding strewn with litter material shall be provided in the rest area. The litter shall comprise straw or other suitable natural material. The litter may be improved and enriched with any mineral product listed in Annex I.

3. Notwithstanding Article 3(3) of Council Directive 91/629/EEC ([10]) the housing of calves in individual boxes shall be forbidden after the age of one week.

4. Notwithstanding Article 3(8) of Council Directive 91/630/EEC ([11]) sows shall be kept in groups, except in the last stages of pregnancy and during the suckling period.

5. Piglets shall not be kept on flat decks or in piglet cages.

6. Exercise areas shall permit dunging and rooting by porcine animals. For the purposes of rooting different substrates can be used.

([9]) OJ L 368, 23.12.2006, p. 15.

([10]) OJ L 340, 11.12.1991, p. 28.

([11]) OJ L 340, 11.12.1991, p. 33.

Article 12

Specific housing conditions and husbandry practices for poultry

1. Poultry shall not be kept in cages.

2. Water fowl shall have access to a stream, pond, lake or a pool whenever the weather and hygienic conditions permit in order to respect their species-specific needs and animal welfare requirements.

3. Buildings for all poultry shall meet the following conditions:

(a) at least one third of the floor area shall be solid, that is, not of slatted or of grid construction, and covered with a litter material such as straw, wood shavings, sand or turf;

(b) in poultry houses for laying hens, a sufficiently large part of the floor area available to the hens shall be available for the collection of bird droppings;

(c) they shall have perches of a size and number commensurate with the size of the group and of the birds as laid down in Annex III.

(d) they shall have exit/entry pop-holes of a size adequate for the birds, and these pop-holes shall have a combined length of at least 4 m per 100 m^2 area of the house available to the birds;

(e) each poultry house shall not contain more than:

  (i) 4 800 chickens,

  (ii) 3 000 laying hens,

  (iii) 5 200 guinea fowl,

  (iv) 4 000 female Muscovy or Peking ducks or 3 200 male Muscovy or Peking ducks or other ducks,

  (v) 2 500 capons, geese or turkeys;

(f) the total usable area of poultry houses for meat production on any single unit, shall not exceed 1 600 m^2;

(g) poultry houses shall be constructed in a manner allowing all birds easy access to open air area.

4. Natural light may be supplemented by artificial means to provide a maximum of 16 hours light per day with a continuous nocturnal rest period without artificial light of at least eight hours.

5. To prevent the use of intensive rearing methods, poultry shall either be reared until they reach a minimum age or else shall come from slow-growing poultry strains. Where slow-growing poultry strains are not used by the operator the following minimum age at slaughter shall be:

(a) 81 days for chickens,

(b) 150 days for capons,

(c) 49 days for Peking ducks,

(d) 70 days for female Muscovy ducks,

(e) 84 days for male Muscovy ducks,

(f) 92 days for Mallard ducks,

(g) 94 days for guinea fowl,

(h) 140 days for male turkeys and roasting geese and

(i) 100 days for female turkeys.

The competent authority shall define the criteria of slow-growing strains or draw up a list thereof and provide this information to operators, other Member States and the Commission.

Article 13

Specific requirements and housing conditions in beekeeping

1. The siting of the apiaries shall be such that, within a radius of 3 km from the apiary site, nectar and pollen sources consist essentially of organically produced crops and/or spontaneous vegetation and/or crops treated with low environmental impact methods equivalent to those as described in Article 36 of Council Regulation (EC) No 1698/2005 ([12]) or in Article 22 of Council Regulation 1257/1999 ([13]) which cannot affect the qualification of beekeeping production as being organic. The above mentioned requirements do not apply where flowering is not taking place, or the hives are dormant.

2. The Member States may designate regions or areas where beekeeping complying with organic production rules is not practicable.

3. The hives shall be made basically of natural materials presenting no risk of contamination to the environment or the apiculture products.

([12]) OJ L 277, 21.10.2005, p. 1.

([13]) OJ L 160, 26.6.1999, p. 80.

4. The bees wax for new foundations shall come from organic production units.

5. Without prejudice to Article 25, only natural products such as propolis, wax and plant oils can be used in the hives.

6. The use of chemical synthetic repellents is prohibited during honey extractions operations.

7. The use of brood combs is prohibited for honey extraction.

Article 14

Access to open air areas

1. Open air areas may be partially covered.

2. In accordance with Article 14(1)(b)(iii) of Regulation (EC) No 834/2007 herbivores shall have access to pasturage for grazing whenever conditions allow.

3. In cases where herbivores have access to pasturage during the grazing period and where the winter-housing system gives freedom of movement to the animals, the obligation to provide open air areas during the winter months may be waived.

4. Notwithstanding paragraph 2, bulls over one year old shall have access to pasturage or an open air area.

5. Poultry shall have access to an open air area for at least one third of their life.

6. Open air areas for poultry shall be mainly covered with vegetation and be provided with protective facilities and permit fowl to have easy access to adequate numbers of drinking and feeding troughs.

7. Where poultry are kept indoors due to restrictions or obligations imposed on the basis of Community legislation, they shall permanently have access to sufficient quantities of roughage and suitable material in order to meet their ethological needs.

Article 15

Stocking density

1. The total stocking density shall be such as not to exceed the limit of 170 kg of nitrogen per year and hectare of agricultural area as referred to in Article 3(2).

2. To determine the appropriate density of livestock referred to above, the competent authority shall set out the livestock units equivalent to the above limit, taking as a guideline, the figures laid down in Annex IV or the relevant national provisions adopted pursuant to Directive 91/676/EEC.

Article 16

Prohibition of landless livestock production

Landless livestock production, by which the operator of the livestock does not manage agricultural land and/or has not established a written cooperation agreement with another operator according to Article 3(3), is prohibited.

Article 17

Simultaneous production of organic and non-organic livestock

1. Non organic livestock may be present on the holding provided they are reared on units where the buildings and parcels are separated clearly from the units producing in accordance with the organic production rules and a different species is involved.

2. Non-organic livestock may use organic pasturage for a limited period of time each year, provided that such animals come from a farming system as defined in paragraph 3(b) and that organic animals are not present at the same time on that pasture.

3. Organic animals may be grazed on common land, providing that:

(a) the land has not been treated with products not authorised for organic production for at least three years;

(b) any non-organic animals which use the land concerned are derived from a farming system equivalent to those as described in Article 36 of Regulation (EC) No 1698/2005 or in Article 22 of Regulation 1257/1999;

(c) any livestock products from organic animals, whilst using this land, shall not be regarded as being from organic-production, unless adequate segregation from non-organic animals can be proved.

4. During the period of transhumance animals may graze on non-organic land when they are being moved on foot from one grazing area to another. The uptake of non-organic feed, in the form of grass and other vegetation on which the animals graze, during this period shall not exceed 10 % of the total feed ration per year. This figure shall be calculated as a percentage of the dry matter of feedingstuffs from agricultural origin.

5. Operators shall keep documentary evidence of the use of provisions referred to in this Article.

Article 18

Management of animals

1. Operations such as attaching elastic bands to the tails of sheep, tail-docking, cutting of teeth, trimming of beaks and dehorning shall not be carried out routinely in organic farming. However, some of these operations may be authorised by the competent authority for reasons of safety or if they are intended to improve the health, welfare or hygiene of the livestock on a case-by-case basis.

Any suffering to the animals shall be reduced to a minimum by applying adequate anaesthesia and/or analgesia and by carrying out the operation only at the most appropriate age by qualified personnel.

2. Physical castration is allowed in order to maintain the quality of products and traditional production practices but only under the conditions set out in the second subparagraph of paragraph 1.

3. Mutilation such as clipping the wings of queen bees is prohibited.

4. Loading and unloading of animals shall be carried out without the use of any type of electrical stimulation to coerce the animals. The use of allopathic tranquillisers, prior to or during transport, is prohibited.

Section 3

Feed

Article 19

Feed from own holding or from other organic holdings

1. In the case of herbivores, except during the period each year when the animals are under transhumance subject to Article 17 (4), at least 50 % of the feed shall come from the farm unit itself or in case this is not feasible, be produced in cooperation with other organic farms primarily in the same region.

2. In the case of bees, at the end of the production season hives shall be left with sufficient reserves of honey and pollen to survive the winter.

3. The feeding of bee colonies shall only be permitted where the survival of the hives is endangered due to climatic conditions and only between the last honey harvest and 15 days before the start of the next nectar or honeydew flow period. Feeding shall be with organic honey, organic sugar syrup, or organic sugar.

Article 20

Feed meeting animals' nutritional requirements

1. All young mammals shall be fed on maternal milk in preference to natural milk, for a minimum period of three months for bovines including *bubalus* and bison species and equidae, 45 days for sheep and goats and 40 days for pigs.

2. Rearing systems for herbivores are to be based on maximum use of grazing pasturage according to the availability of pastures in the different periods of the year. At least 60 % of the dry matter in daily rations of herbivores shall consist of roughage, fresh or dried fodder, or silage. A reduction to 50 % for animals in dairy production for a maximum period of three months in early lactation is allowed.

3. Roughage, fresh or dried fodder, or silage shall be added to the daily ration for pigs and poultry.

4. The keeping of livestock in conditions, or on a diet, which may encourage anaemia, is prohibited.

5. Fattening practices shall be reversible at any stage of the rearing process. Force-feeding is forbidden.

Article 21

In-conversion feed

1. Up to 30 % of the feed formula of rations on average may comprise in-conversion feedingstuffs. When the in-conversion feedingstuffs come from a unit of the holding itself, this percentage may be increased to 60 %.

2. Up to 20 % of the total average amount of feedingstuffs fed to the livestock may originate from the grazing or harvesting of permanent pastures or perennial forage parcels in their first year of conversion, provided that they are part of the holding itself and have not been part of an organic production unit of that holding in the last five years. When both in-conversion feedingstuffs and feedingstuffs from parcels in their first year of conversion are being used, the total combined percentage of such feedingstuffs shall not exceed the maximum percentages fixed in paragraph 1.

3. The figures in paragraph 1 and 2 shall be calculated annually as a percentage of the dry matter of feedingstuffs of plant origin.

Article 22

Products and substances referred to in Article 14(1)(d)(iv) of Regulation (EC) No 834/2007

1. Non-organic feed materials of plant and animal origin may be used in organic production subject to the restrictions laid down in Article 43 and only if they are listed in Annex V and the restrictions laid down therein are complied with.

2. Organic feed materials of animal origin, and feed materials of mineral origin may be used in organic production and only if they are listed in Annex V and the restrictions laid down therein are complied with.

3. Products and by-products from fisheries may be used in organic production only if they are listed in Annex V and the restrictions laid down therein are complied with.

4. Feed additives, certain products used in animal nutrition and processing aids may be used in organic production only if they are listed in Annex VI and the restrictions laid down therein are complied with.

Section 4

Disease prevention and veterinary treatment

Article 23

Disease prevention

1. The use of chemically synthesised allopathic veterinary medicinal products or antibiotics for preventive treatment is prohibited, without prejudice to Article 24(3).

2. The use of substances to promote growth or production (including antibiotics, coccidiostatics and other artificial aids for growth promotion purposes) and the use of hormones or similar substances to control reproduction or for other purposes (e.g. induction or synchronisation of oestrus), is prohibited.

3. Where livestock is obtained from non-organic units, special measures such as screening tests or quarantine periods may apply, depending on local circumstances.

4. Housing, pens, equipment and utensils shall be properly cleaned and disinfected to prevent cross-infection and the build-up of disease carrying organisms. Faeces, urine and uneaten or spilt feed shall be removed as often as necessary to minimise smell and to avoid attracting insects or rodents.

For the purpose of Article 14(1)(f) of Regulation (EC) No 834/2007, only products listed in Annex VII may be used for cleaning and disinfection of livestock buildings installations and utensils. Rodenticides (to be used only in traps), and the products listed in Annex II, can be used for the elimination of insects and other pests in buildings and other installations where livestock is kept.

5. Buildings shall be emptied of livestock between each batch of poultry reared. The buildings and fittings shall be cleaned and disinfected during this time. In addition, when the rearing of each batch of poultry has been completed, runs shall be left empty to allow vegetation to grow back. Member States shall establish the period for which runs must be empty. The operator shall keep documentary evidence of the application of this period. These requirements shall not apply where poultry is not reared in batches, is not kept in runs and is free to roam, throughout the day.

Article 24

Veterinary treatment

1. Where despite preventive measures to ensure animal health as laid down in Article 14(1)(e)(i) of Regulation (EC) No 834/2007 animals become sick or injured they shall be treated immediately, if necessary in isolation and in suitable housing.

2. Phytotherapeutic, homoepathic products, trace elements and products listed in Annex V, part 3 and in Annex VI, part 1.1. shall be used in preference to chemically-synthesized allopathic veterinary treatment or antibiotics, provided that their therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended.

3. If the use of measures referred to in paragraph 1 and 2 is not effective in combating illness or injury, and if treatment is essential to avoid suffering or distress of the animal, chemically-synthesised allopathic veterinary medicinal products or antibiotics may be used under the responsibility of a veterinarian.

4. With the exception of vaccinations, treatments for parasites and compulsory eradication schemes where an animal or group of animals receive more than three courses of treatments with chemically-synthesised allopathic veterinary medicinal products or antibiotics within 12 months, or more than one course of treatment if their productive lifecycle is less than one year, the livestock concerned, or produce derived from them, may not be sold as organic products, and the livestock shall undergo the conversion periods laid down in Article 38(1).

Records of documented evidence of the occurrence of such circumstances shall be kept for the control body or control authority.

5. The withdrawal period between the last administration of an allopathic veterinary medicinal product to an animal under normal conditions of use, and the production of organically produced foodstuffs from such animals, is to be twice the legal withdrawal period as referred to in Article 11 of Directive 2001/82/EC or, in a case in which this period is not specified, 48 hours.

Article 25

Specific rules on disease prevention and veterinary treatment in beekeeping

1. For the purposes of protecting frames, hives and combs, in particular from pests, only rodenticides (to be used only in traps), and appropriate products listed in Annex II, are permitted.

2. Physical treatments for disinfection of apiaries such as steam or direct flame are permitted.

3. The practice of destroying the male brood is permitted only to isolate the infestation of *Varroa destructor*.

4. If despite all preventive measures, the colonies become sick or infested, they shall be treated immediately and, if necessary, the colonies can be placed in isolation apiaries.

5. Veterinary medicinal products may be used in organic beekeeping in so far as the corresponding use is authorised in the Member State in accordance with the relevant Community provisions or national provisions in conformity with Community law.

6. Formic acid, lactic acid, acetic acid and oxalic acid as well as menthol, thymol, eucalyptol or camphor may be used in cases of infestation with *Varroa destructor*.

7. If a treatment is applied with chemically synthesised allopathic products, during such a period, the colonies treated shall be placed in isolation apiaries and all the wax shall be replaced with wax coming from organic beekeeping. Subsequently, the conversion period of one year laid down in Article 38(3) will apply to those colonies.

8. The requirements laid down in paragraph 7 shall not apply to products listed in paragraph 6.

CHAPTER 3

Processed products

Article 26

Rules for the production of processed feed and food

1. Additives, processing aids and other substances and ingredients used for processing food or feed and any processing practice applied, such as smoking, shall respect the principles of good manufacturing practice.

2. Operators producing processed feed or food shall establish and update appropriate procedures based on a systematic identification of critical processing steps.

3. The application of the procedures referred to in paragraph 2 shall guarantee at all times that the produced processed products comply with the organic production rules.

4. Operators shall comply with and implement the procedures referred to in paragraph 2. In particular, operators shall:

(a) take precautionary measures to avoid the risk of contamination by unauthorised substances or products;

(b) implement suitable cleaning measures, monitor their effectiveness and record these operations;

(c) guarantee that non-organic products are not placed on the market with an indication referring to the organic production method.

5. Further to the provisions laid down in paragraphs 2 and 4, when non-organic products are also prepared or stored in the preparation unit concerned, the operator shall:

(a) carry out the operations continuously until the complete run has been dealt with, separated by place or time from similar operations performed on non-organic products;

(b) store organic products, before and after the operations, separate by place or time from non-organic products;

(c) inform the control authority or control body thereof and keep available an updated register of all operations and quantities processed;

(d) take the necessary measures to ensure identification of lots and to avoid mixtures or exchanges with non-organic products;

(e) carry out operations on organic products only after suitable cleaning of the production equipment.

Article 27

Use of certain products and substances in processing of food

1. For the purpose of Article 19(2)(b) of Regulation (EC) No 834/2007, only the following substances can be used in the processing of organic food, with the exception of wine:

(a) substances listed in Annex VIII to this Regulation;

(b) preparations of micro-organisms and enzymes normally used in food processing;

(c) substances, and products as defined in Articles 1(2)(b)(i) and 1(2)(c) of Council Directive 88/388/EEC ([14]) labelled as natural flavouring substances or natural flavouring preparations, according to Articles 9(1)(d) and (2) of that Directive.

(d) colours for stamping meat and eggshells in accordance with, respectively, Article 2(8) and Article 2(9) of European Parliament and Council Directive 94/36/EC ([15]);

(e) drinking water and salt (with sodium chloride or potassium chloride as basic components) generally used in food processing;

(f) minerals (trace elements included), vitamins, aminoacids, and micronutrients, only authorised as far their use is legally required in the foodstuffs in which they are incorporated.

2. For the purpose of the calculation referred to in Article 23 (4)(a)(ii) of Regulation (EC) No 834/2007,

(a) food additives listed in Annex VIII and marked with an asterisk in the column of the additive code number, shall be calculated as ingredients of agricultural origin;

(b) preparations and substances referred to in paragraph (1)(b), (c),(d),(e) and (f) of this Article and substances not marked with an asterisk in the column of the additive code number shall not be calculated as ingredients of agricultural origin.

3. The use of the following substances listed in Annex VIII shall be re-examined before 31 December 2010:

(a) Sodium nitrite and potassium nitrate in Section A with a view to withdrawing these additives;

(b) Sulphur dioxide and potassium metabisulphite in Section A;

(c) Hydrochloric acid in Section B for the processing of Gouda, Edam and Maasdammer cheeses, Boerenkaas, Friese, and Leidse Nagelkaas.

The re-examination referred to in point (a) shall take account of the efforts made by Member States to find safe alternatives to nitrites/nitrates and in establishing educational programmes in alternative processing methods and hygiene for organic meat processors/manufacturers.

Article 28

Use of certain non-organic ingredients of agricultural origin in processing food

For the purpose of Article 19(2)(c) of Regulation (EC) No 834/2007, non-organic agricultural ingredients listed in Annex IX to this Regulation can be used in the processing of organic food.

Article 29

Authorisation of non-organic food ingredients of agricultural origin by Member State

1. Where an ingredient of agricultural origin is not included in Annex IX to this Regulation, that ingredient may only be used under the following conditions:

(a) the operator has notified to the competent authority of the Member State all the requisite evidence showing that the ingredient concerned is not produced in sufficient quantity in the Community in accordance with the organic production rules or cannot be imported from third countries;

(b) the competent authority of the Member State has provisionally authorised, the use for a maximum period of 12 months after having verified that the operator has undertaken the necessary contacts with suppliers in the Community to ensure himself of the unavailability of the ingredients concerned with the required quality requirements;

(c) no decision has been taken, in accordance with the provisions of paragraphs 3 or 4 that a granted authorisation with regard to the ingredient concerned shall be withdrawn.

The Member State may prolong the authorisation provided for in point (b) a maximum of three times for 12 months each.

2. Where an authorisation as referred to in paragraph 1 has been granted, the Member State shall immediately notify to the other Member States and to the Commission, the following information:

(a) the date of the authorisation and in case of a prolonged authorisation, the date of the first authorisation;

(b) the name, address, telephone, and where relevant, fax and e-mail of the holder of the authorisation; the name and address of the contact point of the authority which granted the authorisation;

(c) the name and, where necessary, the precise description and quality requirements of the ingredient of agricultural origin concerned;

([14]) OJ L 184, 15.7.1988, p. 61.

([15]) OJ L 237, 10.9.1994, p. 13.

(d) the type of products for the preparation of which the requested ingredient is necessary;

(e) the quantities that are required and the justification for those quantities;

(f) the reasons for, and expected period of, the shortage;

(g) the date on which the Member State sends this notification to the other Member States and the Commission. The Commission and/or Member States may make this information available to the public.

3. Where a Member State submits comments to the Commission and to the Member State which granted the authorisation, which show that supplies are available during the period of the shortage, the Member State shall consider withdrawal of the authorisation or reducing the envisaged period of validity, and shall inform the Commission and the other Member States of the measures it has taken or will take, within 15 working days from the date of receipt of the information.

4. At the request of a Member State or at the Commission's initiative, the matter shall be submitted for examination to the Committee set up in accordance with Article 37 of Regulation (EC) No 834/2007. It may be decided, in accordance with the procedure laid down in paragraph 2 of that Article, that a previously granted authorisation shall be withdrawn or its period of validity amended, or where appropriate, that the ingredient concerned shall be included in Annex IX to this Regulation.

5. In case of an extension as referred to in the second subparagraph of paragraph 1, the procedures of paragraphs 2 and 3 shall apply.

CHAPTER 4

Collection, packaging, transport and storage of products

Article 30

Collection of products and transport to preparation units

Operators may carry out simultaneous collection of organic and non-organic products, only where appropriate measures are taken to prevent any possible mixture or exchange with non-organic products and to ensure the identification of the organic products. The operator shall keep the information relating to collection days, hours, circuit and date and time of reception of the products available to the control body or control authority.

Article 31

Packaging and transport of products to other operators or units

1. Operators shall ensure that organic products are transported to other units, including wholesalers and retailers, only in appropriate packaging, containers or vehicles closed in such a manner that substitution of the content cannot be achieved without manipulation or damage of the seal and provided with a label stating, without prejudice to any other indications required by law:

(a) the name and address of the operator and, where different, of the owner or seller of the product;

(b) the name of the product or a description of the compound feedingstuff accompanied by a reference to the organic production method;

(c) the name and/or the code number of the control body or authority to which the operator is subject; and

(d) where relevant, the lot identification mark according to a marking system either approved at national level or agreed with the control body or authority and which permits to link the lot with the accounts referred to in Article 66.

The information referred to in points (a) to (d) of the first subparagraph may also be presented on an accompanying document, if such a document can be undeniably linked with the packaging, container or vehicular transport of the product. This accompanying document shall include information on the supplier and/or the transporter.

2. The closing of packaging, containers or vehicles shall not be required where:

(a) transportation is direct between an operator and another operator who are both subject to the organic control system, and

(b) the products are accompanied by a document giving the information required under paragraph 1, and

(c) both the expediting and the receiving operators shall keep documentary records of such transport operations available for the control body or control authority of such transport operations.

Article 32

Special rules for transporting feed to other production/preparation units or storage premises

In addition to the provisions of Article 31, when transporting feed to other production or preparation units or storage premises, operators shall ensure that the following conditions are met:

(a) during transport, organically-produced feed, in-conversion feed, and non-organic feed shall be effectively physically separated;

(b) the vehicles and/or containers which have transported non-organic products are used to transport organic products provided that:

  (i) suitable cleaning measures, the effectiveness of which has been checked, have been carried out before commencing the transport of organic products; operators shall record these operations,

  (ii) all appropriate measures are implemented, depending on the risks evaluated in accordance with Article 88 (3) and, where necessary, operators shall guarantee that non-organic products cannot be placed on the market with an indication referring to organic production,

  (iii) the operator shall keep documentary records of such transport operations available for the control body or control authority;

(c) the transport of finished organic feed shall be separated physically or in time from the transport of other finished products;

(d) during transport, the quantity of products at the start and each individual quantity delivered in the course of a delivery round shall be recorded.

Article 33

Reception of products from other units and other operators

On receipt of an organic product, the operator shall check the closing of the packaging or container where it is required and the presence of the indications provided to in Article 31.

The operator shall crosscheck the information on the label referred to in Article 31 with the information on the accompanying documents. The result of these verifications shall be explicitly mentioned in the documentary accounts referred to in Article 66.

Article 34

Special rules for the reception of products from a third country

Organic products shall be imported from a third country in appropriate packaging or containers, closed in a manner preventing substitution of the content and provided with identification of the exporter and with any other marks and numbers serving to identify the lot and with the certificate of control for import from third countries as appropriate.

On receipt of an organic product, imported from a third country, the first consignee shall check the closing of the packaging or container and, in the case of products imported in accordance with Article 33 of Regulation (EC) No 834/2007, shall check that the certificate mentioned in that Article covers the type of product contained in the consignment. The result of this verification shall be explicitly mentioned in the documentary accounts referred to in Article 66 of this Regulation.

Article 35

Storage of products

1. For the storage of products, areas shall be managed in such a way as to ensure identification of lots and to avoid any mixing with or contamination by products and/or substances not in compliance with the organic production rules. Organic products shall be clearly identifiable at all times.

2. In case of organic plant and livestock production units, storage of input products other than those authorised under this Regulation is prohibited in the production unit.

3. The storage of allopathic veterinary medicinal products and antibiotics is permitted on holdings provided that they have been prescribed by a veterinarian in connection with treatment as referred to in Article 14(1)(e)(ii) of Regulation (EC) No 834/2007, that they are stored in a supervised location and that they are entered in the livestock record as referred to in Article 76 of this Regulation.

4. In case where operators handle both non-organic products and organic products and the latter are stored in storage facilities in which also other agricultural products or foodstuffs are stored:

(a) the organic products shall be kept separate from the other agricultural products and/or foodstuffs;

(b) every measure shall be taken to ensure identification of consignments and to avoid mixtures or exchanges with non-organic products;

(c) suitable cleaning measures, the effectiveness of which has been checked, have been carried out before the storage of organic products; operators shall record these operations.

CHAPTER 5

Conversion rules

Article 36

Plant and plant products

1. For plants and plant products to be considered organic, the production rules as referred to in Articles 9, 10, 11 and 12 of Regulation (EC) No 834/2007 and Chapter 1 of this Regulation and where applicable the exceptional production rules in

Chapter 6 of this Regulation must have been applied on the parcels during a conversion period of at least two years before sowing, or, in the case of grassland or perennial forage, at least two years before its use as feed from organic farming, or, in the case of perennial crops other than forage, at least three years before the first harvest of organic products.

2. The competent authority may decide to recognise retroactively as being part of the conversion period any previous period in which:

(a) the land parcels were subject of measures defined in a programme implemented pursuant to Regulations (EC) No 1257/99, (EC) No 1698/2005, or in another official programme, provided that the measures concerned ensure that products not authorised for organic production have not been used on those parcels, or

(b) the parcels were natural or agricultural areas which were not treated with products not authorised for organic production.

The period referred to in point (b) of the first subparagraph can be taken into consideration retroactively only where satisfactory proof has been furnished to the competent authority allowing it to satisfy itself that the conditions were met for a period of at least three years.

3. The competent authority may decide, in certain cases, where the land had been contaminated with products not authorised for organic production, to extend the conversion period beyond the period referred to in paragraph 1.

4. In the case of parcels which have already been converted to or were in the process of conversion to organic farming, and which are treated with a product not authorised for organic production, the Member State may shorten the conversion period referred to in paragraph 1 in the following two cases:

(a) parcels treated with a product not authorised for organic production as part of a compulsory disease or pest control measure imposed by the competent authority of the Member State;

(b) parcels treated with a product not authorised for organic production as part of scientific tests approved by the competent authority of the Member State.

In the cases provided for in points (a) and (b) of the first subparagraph, the length of the conversion period shall be fixed taking into account of the following factors:

(a) the process of degradation of the product concerned shall guarantee, at the end of the conversion period, an insignificant level of residues in the soil and, in the case of a perennial crop, in the plant;

(b) the harvest following the treatment may not be sold with reference to organic production methods.

The Member State concerned shall inform the other Member States and the Commission of its decision to require compulsory measures.

Article 37

Specific conversion rules for land associated with organic livestock production

1. The conversion rules as referred to in Article 36 of this Regulation shall apply to the whole area of the production unit on which animal feed is produced.

2. Notwithstanding the provisions in paragraph 1, the conversion period may be reduced to one year for pasturages and open air areas used by non-herbivore species. This period may be reduced to six months where the land concerned has not during the last year, received treatments with products not authorised for organic production.

Article 38

Livestock and livestock products

1. Where non-organic livestock has been brought onto a holding in accordance with Article 14(1)(a)(ii) of Regulation (EC) No 834/2007 and Article 9 and/or Article 42 of this Regulation and if livestock products are to be sold as organic products, the production rules as referred to in Articles 9, 10, 11 and 14 of Regulation (EC) No 834/2007 and in Chapter 2 of Title II and where applicable in Article 42 of this Regulation must have been applied for at least:

(a) 12 months in the case of equidae and bovines, including *bubalus* and bison species, for meat production, and in any case at least three quarters of their lifetime;

(b) six months in the case of small ruminants and pigs and animals for milk production;

(c) 10 weeks for poultry for meat production, brought in before they are three days old;

(d) six weeks in the case of poultry for egg production.

2. Where non-organic animals exist on a holding at the beginning of the conversion period in accordance with Article 14 (1)(a)(iii) of Regulation (EC) No 834/2007 their products may be deemed organic if there is simultaneous conversion of the complete production unit, including livestock, pasturage and/or any land used for animal feed. The total combined conversion

period for both existing animals and their offspring, pasturage and/or any land used for animal feed, may be reduced to 24 months, if the animals are mainly fed with products from the production unit.

3. Beekeeping products can be sold with references to the organic production method only when the organic production rules have been complied with for at least one year.

4. The conversion period for apiaries does not apply in the case of application of Article 9(5) of this Regulation.

5. During the conversion period the wax shall be replaced with wax coming from organic beekeeping.

CHAPTER 6

Exceptional production rules

Section 1

Exceptional production rules related to climatic, geographical or structural constraints in accordance with Article 22(2)(a) of Regulation (EC) No 834/2007

Article 39

Tethering of animals

Where the conditions laid down in Article 22(2)(a) of Regulation (EC) No 834/2007 apply, competent authorities may authorise cattle in small holdings to be tethered if it is not possible to keep the cattle in groups appropriate to their behaviour requirements, provided they have access to pastures during the grazing period according to Article 14(2), and at least twice a week access to open air areas when grazing is not possible.

Article 40

Parallel production

1. Where the conditions laid down in Article 22(2)(a) of Regulation (EC) No 834/2007 apply, a producer may run organic and non-organic production units in the same area:

(a) in the case of the production of perennial crops, which require a cultivation period of at least three years, where varieties cannot be easily differentiated, provided the following conditions are met:

   (i) the production in question forms part of a conversion plan in respect of which the producer gives a firm undertaking and which provides for the beginning of the conversion of the last part of the area concerned to organic production in the shortest possible period which may not in any event exceed a maximum of five years;

   (ii) appropriate measures have been taken to ensure the permanent separation of the products obtained from each unit concerned;

   (iii) the control authority or control body is notified of the harvest of each of the products concerned at least 48 hours in advance;

   (iv) upon completion of the harvest, the producer informs the control authority or control body of the exact quantities harvested on the units concerned and of the measures applied to separate the products;

   (v) the conversion plan and the control measures referred to in Chapter 1 and 2 of Title IV have been approved by the competent authority; this approval shall be confirmed each year after the start of the conversion plan;

(b) in the case of areas intended for agricultural research or formal education agreed by the Member States' competent authorities and provided the conditions set out in point (a)(ii)(iii)(iv) and the relevant part of point (v) are met;

(c) in the case of production of seed, vegetative propagating material and transplants and provided the conditions set out in point (a)(ii)(iii)(iv) and the relevant part of point (v) are met;

(d) in the case of grassland exclusively used for grazing.

2. The competent authority may authorise holdings carrying out agricultural research or formal education to rear organic and non-organic livestock of the same species, where the following conditions are met:

(a) appropriate measures, notified in advance to the control authority or control body, have been taken in order to guarantee the permanent separation between livestock, livestock products, manure and feedingstuffs of each of the units;

(b) the producer informs the control authority or control body in advance of any delivery or selling of the livestock or livestock products;

(c) the operator informs the control authority or control body of the exact quantities produced in the units together with all characteristics permitting the identification of the products and confirms that the measures taken to separate the products have been applied.

Article 41

Management of beekeeping units for the purpose of pollination

Where the conditions laid down in Article 22(2)(a) of Regulation (EC) No 834/2007 apply, for the purpose of pollination actions an operator may run organic and non-organic beekeeping units on the same holding, provided that all the requirements of the organic production rules are fulfilled, with the exception of the provisions for the siting of the apiaries. In that case the product cannot be sold as organic.

The operator shall keep documentary evidence of the use of this provision.

Section 2

Exceptional production rules related to non-availability of organic farm inputs in accordance with Article 22(2)(b) of Regulation (EC) No 834/2007

Article 42

Use of non-organic animals

Where the conditions laid down in Article 22(2)(b) of Regulation (EC) No 834/2007 apply, and with prior authorisation of the competent authority,

(a) when a flock is constituted for the first time, renewed or reconstituted and organically reared poultry are not available in sufficient numbers, non-organically reared poultry may be brought into an organic poultry production unit, provided that the pullets for the production of eggs and poultry for meat production are less than three days old;

(b) non-organically reared pullets for egg production of not more than 18 weeks may be brought into an organic livestock unit until 31 December 2011, when organically reared pullets are not available and provided that the relevant provisions laid down in Section 3 and 4 of Chapter 2 are complied with.

Article 43

Use of non-organic feed of agricultural origin

Where the conditions laid down in Article 22(2)(b) of Regulation (EC) No 834/2007 apply, the use of a limited proportion of non-organic feed of plant and animal origin is allowed where farmers are unable to obtain feed exclusively from organic production. The maximum percentage of non-organic feed authorised per period of 12 months for species other than herbivores shall be:

(a) 10 % during the period from 1 January 2009 to 31 December 2009;

(b) 5 % during the period from 1 January 2010 to 31 December 2011.

The figures shall be calculated annually as a percentage of the dry matter of feed from agricultural origin. The maximum percentage authorised of non-organic feed in the daily ration shall be 25 % calculated as a percentage of the dry matter.

The operator shall keep documentary evidence of the need for the use of this provision.

Article 44

Use of non-organic beeswax

In the case of new installations or during the conversion period, non-organic beeswax may be used only

(a) where beeswax from organic beekeeping is not available on the market;

(b) where it is proven free of contamination by substances not authorised for organic production; and

(c) provided that it comes from the cap.

Article 45

Use of seed or vegetative propagating material not obtained by the organic production method

1. Where the conditions laid down in Article 22(2)(b) of Regulation (EC) No 834/2007 apply,

(a) seed and vegetative propagating material from a production unit in conversion to organic farming may be used,

(b) where point (a) is not applicable, Member States may authorise the use of non-organic seed or vegetative propagating material if not available from organic production. However, for the use of non-organic seed and seed potatoes the following paragraphs (2) to (9) apply.

2. Non-organic seed and seed potatoes may be used, provided that the seed or seed potatoes are not treated with plant protection products, other than those authorised for treatment of seed in accordance with Article 5(1), unless chemical treatment is prescribed in accordance with Council Directive 2000/29/EC (16) for phytosanitary purposes by the competent authority of the Member State for all varieties of a given species in the area where the seed or seed potatoes are to be used.

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(16) OJ L 169, 10.7.2000, p. 1.

3. Species for which it is established that organically produced seed or seed potatoes are available in sufficient quantities and for a significant number of varieties in all parts of the Community are set out in Annex X.

The species listed in Annex X may not be subject of authorisations pursuant to paragraph 1(b), unless these are justified by one of the purposes referred to in paragraph 5(d).

4. Member States may delegate the responsibility for granting the authorisation referred to in paragraph 1(b) to another public administration under their supervision or to the control authorities or control bodies referred to in Article 27 of Regulation (EC) No 834/2007.

5. Authorisation to use seed or seed potatoes not obtained by the organic production method may only be granted in the following cases:

(a) where no variety of the species which the user wants to obtain is registered in the database referred to in Article 48;

(b) where no supplier, meaning an operator who markets seed or seed potatoes to other operators, is able to deliver the seed or seed potatoes before sowing or planting in situations where the user has ordered the seed or seed potatoes in reasonable time;

(c) where the variety which the user wants to obtain is not registered in the database referred to in Article 48, and the user is able to demonstrate that none of the registered alternatives of the same species are appropriate and that the authorisation therefore is significant for his production;

(d) where it is justified for use in research, test in small-scale field trials or for variety conservation purposes agreed by the competent authority of the Member State.

6. The authorisation shall be granted before the sowing of the crop.

7. The authorisation shall be granted only to individual users for one season at a time and the authority or body responsible for the authorisations shall register the quantities of seed or seed potatoes authorised.

8. By way of derogation from paragraph 7, the competent authority of the Member State may grant to all users a general authorisation:

(a) for a given species when and in so far as the condition laid down in paragraph 5(a) is fulfilled;

(b) for a given variety when and in so far as the conditions laid down in paragraph 5(c) are fulfilled.

The authorisations referred to in the first subparagraph shall be clearly indicated in the database referred to in Article 48.

9. Authorisation may only be granted during periods for which the database is updated in accordance with Article 49(3).

Section 3

Exceptional production rules related to specific management problems in organic livestock in accordance with Article 22(2)(d) of Regulation (EC) No 834/2007

Article 46

Specific management problems in organic livestock

The final fattening phase of adult bovines for meat production may take place indoors, provided that this indoors period does not exceed one fifth of their lifetime and in any case for a maximum period of three months.

Section 4

Exceptional production rules related to catastrophic circumstances in accordance with Article 22(2)(f) of Regulation (EC) No 834/2007

Article 47

Catastrophic circumstances

The competent authority may authorise on a temporary basis:

(a) in the case of high mortality of animals caused by health or catastrophic circumstances, the renewal or reconstitution of the herd or flock with non-organic animals, when organically reared animals are not available;

(b) in case of high mortality of bees caused by health or catastrophic circumstances, the reconstitution of the apiaries with non-organic bees, when organic apiaries are not available;

(c) the use of non-organic feedingstuffs for a limited period and in relation to a specific area by individual operators, when forage production is lost or when restrictions are imposed, in particular as a result of exceptional meteorological conditions, the outbreak of infectious diseases, the contamination with toxic substances, or as a consequence of fires;

(d) the feeding of bees with organic honey, organic sugar or organic sugar syrup in case of long lasting exceptional weather conditions or catastrophic circumstances, which hamper the nectar or honeydew production.

Upon approval by the competent authority, the individual operators shall keep documentary evidence of the use of the above exceptions. Member States shall inform each other and the Commission on the exceptions they have granted under point (c) of the first subparagraph within 1 month from its approval.

CHAPTER 7

Seed data base

Article 48

Database

1. Each Member State shall ensure that a computerised database is established for the listing of the varieties for which seed or seed potatoes obtained by the organic production method are available on its territory.

2. The database shall be managed either by the competent authority of the Member State or by an authority or body designated for this purpose by the Member State, hereinafter referred to as 'manager of the database'. Member States may also designate an authority or a private body in another country.

3. Each Member State shall inform the Commission and the other Member States of the authority or private body designated to manage the database.

Article 49

Registration

1. Varieties for which seed or seed potatoes produced by the organic production method are available shall be registered in the database referred to in Article 48 at the request of the supplier.

2. Any variety which has not been registered in the database shall be considered as unavailable with regard to Article 45(5).

3. Each Member State shall decide in which period of the year the database has to be regularly updated for each species or group of species cultivated on its territory. The database shall hold information with regard to that decision.

Article 50

Conditions for registration

1. For registration, the supplier shall:

(a) demonstrate that he or the last operator, in cases where the supplier is only dealing with pre-packaged seed or seed potatoes, has been subject to the control system referred to in Article 27 of Regulation (EC) No 834/2007;

(b) demonstrate that the seed or seed potatoes to be placed on the market comply with the general requirements applicable to seed and seed potatoes;

(c) make available all the information required under Article 51 of this Regulation, and undertake to update this information at the request of the manager of the database or whenever such updating is necessary to ensure that the information remains reliable.

2. The manager of the database may, with the approval by the competent authority of the Member State, refuse a supplier's application for registration or delete a previously accepted registration if the supplier does not comply with the requirements set out in paragraph 1.

Article 51

Registered information

1. For each registered variety and for each supplier, the database referred to in Article 48 shall contain at least the following information:

(a) the scientific name of the species and the variety denomination;

(b) the name and contact details of the supplier or his representative;

(c) the area where the supplier can deliver the seed or seed potatoes to the user in the usual time needed for the delivery;

(d) the country or region in which the variety is tested and approved for the purpose of the common catalogues of varieties of agricultural plant species and vegetable species as defined in Council Directives 2002/53/EC on the common catalogue of varieties of agricultural plant species (17) and 2002/55/EC on the marketing of vegetable seed (18);

(e) the date from which the seed or seed potatoes will be available;

(f) the name and/or code number of the control authority or control body in charge of the control of the operator as referred to in Article 27 of Regulation (EC) No 834/2007.

2. The supplier shall immediately inform the manager of the database if any of the registered varieties are no longer available. The amendments shall be recorded in the database.

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(17) OJ L 193, 20.7.2002, p. 1.

(18) OJ L 193, 20.7.2002, p. 33.

3. Besides the information specified in paragraph 1, the database shall contain a list of the species listed in Annex X.

Article 52

Access to information

1. The information in the database referred to in Article 48 shall be available through the Internet, free of cost, to the users of seed or seed potatoes and to the public. Member States may decide that any user who has notified its activity in accordance with Article 28(1)(a) of Regulation (EC) No 834/2007 may obtain, on request, an extract of data concerning one or several groups of species from the database manager.

2. The Member States shall ensure that all users referred to in paragraph 1 are informed, at least once a year, about the system and how to obtain the information in the database.

Article 53

Registration fee

Each registration may be subject to the levying of a fee, which shall represent the cost of inserting and maintaining the information in the database referred to in Article 48. The competent authority of the Member State shall approve the amount of the fee charged by the manager of the database.

Article 54

Annual report

1. The authorities or bodies designated to grant authorisations in accordance with Article 45 shall register all authorisations, and shall make this information available in a report to the competent authority of the Member State and to the manager of the database.

The report shall contain, for each species concerned by an authorisation according to Article 45(5), the following information:

(a) the scientific name of the species and the variety denomination;

(b) the justification for the authorisation indicated by a reference to Article 45(5)(a), (b), (c) or (d);

(c) the total number of authorisations;

(d) the total quantity of seed or seed potatoes involved;

(e) the chemical treatment for phytosanitary purposes, as referred to in Article 45(2).

2. For authorisations according to Article 45(8) the report shall contain the information referred to in point (a) of the second subparagraph of paragraph 1 of this Article and the period for which the authorisations were in force.

Article 55

Summary report

The competent authority of the Member State shall, before 31 March each year, collect the reports and send a summary report covering all authorisations of the Member State from the previous calendar year to the Commission and to the other Member States. The report shall cover the information specified in Article 54. The information shall be published in the database referred to in Article 48. The competent authority may delegate the task of collecting the reports to the manager of the database.

Article 56

Information upon request

Upon request from a Member State or the Commission, detailed information on authorisations granted in individual cases shall be made available to other Member States or to the Commission.

TITLE III

LABELLING

CHAPTER 1

Community Logo

Article 57

Community logo

In accordance with Article 25(3) of Regulation (EC) No 834/2007, the Community logo shall follow the model in Annex XI to this Regulation.

The Community logo shall be used in accordance with the technical reproduction rules laid down in Annex XI to this Regulation.

Article 58

Conditions for the use of the code number and place of origin

1. The indication of the code number of the control authority or control body referred to in Article 24(1)(a) of Regulation (EC) 834/2007 shall,

(a) start with the acronym identifying the Member State or the third country, as referred to in the international standard for the two letter country codes under ISO 3166 (*Codes for the representation of names of countries and their subdivisions*);

(b) include a term which establishes a link with the organic production method, as referred to in Article 23(1) of Regulation (EC) No 834/2007;

(c) include a reference number to be decided by the competent authority; and

(d) be placed immediately below the Community logo, where the Community logo is used in the labelling.

2. The indication of the place where the agricultural raw materials of which the products is composed have been farmed, as referred to in Article 24(1)(c) of Regulation (EC) 834/2007, shall be placed immediately below the code number referred to in paragraph 1.

CHAPTER 2

Specific labelling requirements for feed

Article 59

Scope, use of trade marks and sales descriptions

This Chapter shall not apply to pet food and feed for fur animals or feed for aquaculture animals.

The trade marks and sales descriptions bearing an indication referred to in Article 23(1) of Regulation (EC) No 834/2007 may be used only if at least 95 % of the product's dry matter is comprised of feed material from the organic production method.

Article 60

Indications on processed feed

1. Without prejudice to Articles 61 and 59, second paragraph of this Regulation, the terms referred to in Article 23(1) of Regulation (EC) 834/2007 may be used on processed feed provided that:

(a) the processed feed complies with the provisions of Regulation (EC) 834/2007 and in particular with Article 14 (1) (d) (iv) and (v) and Article 18 thereof;

(b) the processed feed complies with the provisions of this Regulation and in particular with Articles 22 and 26 thereof;

(c) at least 95 % of the product's dry matter is organic.

2. Subject to the requirements laid down in points (a) and (b) of paragraph 1, the following statement is permitted in the case of products comprising variable quantities of feed materials from the organic production method and/or feed materials from products in conversion to organic farming and/or non-organic materials:

'may be used in organic production in accordance with Regulations (EC) 834/2007 and (EC) 889/2008'

Article 61

Conditions for the use of indications on processed feed

1. The indication provided for in Article 60 shall be:

(a) separate from the wording referred to in Article 5 of Council Directive 79/373/EEC ([19]) or in Article 5(1) of Council Directive 96/25/EC ([20]);

(b) presented in a colour, format or character font that does not draw more attention to it than to the description or name of the animal feedingstuff referred to in Article 5(1)(a) of Directive 79/373/EEC or in Article 5(1)(b) of Directive 96/25/EC respectively;

(c) accompanied, in the same field of vision, by an indication by weight of dry matter referring:

  (i) to the percentage of feed material(s) from the organic production method;

  (ii) to the percentage of feed material(s) from products in conversion to organic farming;

  (iii) to the percentage of feed material(s) not covered by points (i) and (ii);

  (iv) to the total percentage of animal feed of agricultural origin;

(d) accompanied by a list of names of feed materials from the organic production method;

(e) accompanied by a list of names of feed materials from products in conversion to organic production.

2. The indication provided for in Article 60 may be also accompanied by a reference to the requirement to use the feedingstuffs in accordance with Articles 21 and 22.

CHAPTER 3

Other specific labelling requirements

Article 62

In-conversion products of plant origin

In-conversion products of plant origin may bear the indication 'product under conversion to organic farming' provided that:

(a) a conversion period of at least 12 months before the harvest has been complied with;

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[19] OJ L 86, 6.4.1979, p. 30.

[20] OJ L 125, 23.5.1996, p. 35.

(b) the indication shall appear in a colour, size and style of lettering which is not more prominent than the sales description of the product, the entire indication shall have the same size of letters;

(c) the product contains only one crop ingredient of agricultural origin;

(d) the indication is linked to the code number of the control body or control authority as referred to in Article 27(10) of Regulation 834/2007.

TITLE IV

CONTROLS

CHAPTER 1

Minimum control requirements

Article 63

Control arrangements and undertaking by the operator

1. When the control arrangements are first implemented, the operator shall draw up and subsequently maintain:

(a) a full description of the unit and/or premises and/or activity;

(b) all the practical measures to be taken at the level of the unit and/or premises and/or activity to ensure compliance with the organic production rules;

(c) the precautionary measures to be taken in order to reduce the risk of contamination by unauthorised products or substances and the cleaning measures to be taken in storage places and throughout the operator's production chain.

Where appropriate, the description and measures provided for in the first subparagraph may be part of a quality system as set up by the operator.

2. The description and the measures referred to in paragraph 1 shall be contained in a declaration, signed by the responsible operator. In addition, this declaration shall include an undertaking by the operator:

(a) to perform the operations in accordance with the organic production rules;

(b) to accept, in the event of infringement or irregularities, the enforcement of the measures of the organic production rules;

(c) to undertake to inform in writing the buyers of the product in order to ensure that the indications referring to the organic production method are removed from this production.

The declaration provided for in the first subparagraph shall be verified by the control body or control authority that issues a report identifying the possible deficiencies and non-compliances with the organic production rules. The operator shall countersign this report and take the necessary corrective measures.

3. For the application of Article 28(1) of Regulation (EC) No 834/2007 the operator shall notify the following information to the competent authority:

(a) Name and address of operator;

(b) Location of premises and, where appropriate, parcels (land register data) where operations are carried out;

(c) Nature of operations and products;

(d) Undertaking by the operator to carry out the operation in accordance with the provision laid down in Regulation (EC) No 834/2007 and this Regulation;

(e) In the case of an agricultural holding, the date on which the producer ceased to apply products not authorised for organic production on the parcels concerned;

(f) The name of the approved body to which the operator entrusted control of his undertaking, where the Member State has implemented the control system by approving such bodies.

Article 64

Modification of control arrangements

The operator responsible shall notify any change in the description or of the measures referred to in Article 63 and in the initial control arrangements set out in Articles 70, 74, 80, 82, 86 and 88 to the control authority or control body in due time.

Article 65

Control visits

1. The control authority or control body shall carry out at least once a year a physical inspection of all operators.

2. The control authority or control body may take samples for testing of products not authorised for organic production or for checking production techniques not in conformity with the organic production rules. Samples may also be taken and analysed for detecting possible contamination by products not authorised for organic production. However, such analysis shall be carried out where the use of products not authorised for organic production is suspected.

3. A control report shall be drawn up after each visit, countersigned by the operator of the unit or his representative.

4. Moreover, the control authority or control body shall carry out random control visits, primarily unannounced, based on the general evaluation of the risk of non-compliance with the organic production rules, taking into account at least the results of previous controls, the quantity of products concerned and the risk for exchange of products.

Article 66

Documentary accounts

1. Stock and financial records shall be kept in the unit or premises and shall enable the operator to identify and the control authority or control body to verify:

(a) the supplier and, where different, the seller, or the exporter of the products;

(b) the nature and the quantities of organic products delivered to the unit and, where relevant, of all materials bought and the use of such materials, and, where relevant, the composition of the compound feedingstuffs;

(c) the nature and the quantities of organic products held in storage at the premises;

(d) the nature, the quantities and the consignees and, where different, the buyers, other than the final consumers, of any products which have left the unit or the first consignee's premises or storage facilities;

(e) in case of operators who do not store or physically handle such organic products, the nature and the quantities of organic products bought and sold, and the suppliers, and where different, the sellers or the exporters and the buyers, and where different, the consignees.

2. The documentary accounts shall also comprise the results of the verification at reception of organic products and any other information required by the control authority or control body for the purpose of proper control. The data in the accounts shall be documented with appropriate justification documents. The accounts shall demonstrate the balance between the input and the output.

3. Where an operator runs several production units in the same area, the units for non organic products, together with storage premises for input products must also be subject to the minimum control requirements.

Article 67

Access to facilities

1. The operator shall:

(a) give the control authority or control body, for control purposes, access to all parts of the unit and all premises, as well as to the accounts and relevant supporting documents;

(b) provide the control authority or control body with any information reasonably necessary for the purposes of the control;

(c) submit, when requested by the control authority or control body, the results of its own quality assurance programmes.

2. In addition to the requirements set out in paragraph 1, importers and first consignees shall submit the information on imported consignments referred to in Article 84.

Article 68

Documentary evidence

For the purpose of the application of Article 29(1) of Regulation (EC) No 834/2007 the control authorities and the control bodies shall use the model of the documentary evidence set out in Annex XII to this Regulation.

Article 69

Vendor declaration

For the purpose of the application of Article 9(3) of Regulation (EC) No 834/2007 the vendor declaration that products supplied have not been produced from or by GMOs may follow the model set out in Annex XIII to this Regulation.

CHAPTER 2

Specific control requirements for plants and plant products from farm production or collection

Article 70

Control arrangements

1. The full description of the unit referred to in Article 63(1)(a) shall:

(a) be drawn up even where the operator limits his activity to the collection of wild plants;

(b) indicate the storage and production premises and land parcels and/or collection areas and, where applicable, premises where certain processing and/or packaging operations take place; and

(c) specify the date of the last application on the parcels and/or collection areas concerned of products, the use of which is not compatible with the organic production rules.

2. In case of collection of wild plants, the practical measures referred to in Article 63(1)(b) shall include any guarantees given by third parties which the operator can provide to ensure that the provisions of Article 12(2) of Regulation (EC) No 834/2007 are complied with.

Article 71

Communications

Each year, before the date indicated by the control authority or control body, the operator shall notify the control authority or control body of its schedule of production of crop products, giving a breakdown by parcel.

Article 72

Plant production records

Plant production records shall be compiled in the form of a register and kept available to the control authorities or bodies at all times at the premises of the holding. In addition to Article 71 such records shall provide at least the following information:

(a) as regards the use of fertiliser: date of application, type and amount of fertiliser, parcels concerned;

(b) as regards the use of plant protection products: reason and date of treatment, type of product, method of treatment;

(c) as regards purchase of farm inputs: date, type and amount of purchased product;

(d) as regards harvest: date, type and amount of organic or in conversion crop production.

Article 73

Several production units run by the same operator

Where an operator runs several production units in the same area, the units producing non-organic crops, together with storage premises for farm input products shall also be subject to the general and the specific control requirements laid down in Chapter 1 and this Chapter of this Title.

CHAPTER 3

Control requirements for livestock and livestock products produced by animal husbandry

Article 74

Control arrangements

1. When the control system applying specifically to livestock production is first implemented, the full description of the unit referred to in Article 63(1)(a) shall include:

(a) a full description of the livestock buildings, pasturage, open air areas, etc., and, where applicable, the premises for the storage, packaging and processing of livestock, livestock products, raw materials and inputs;

(b) a full description of the installations for the storage of livestock manure.

2. The practical measures referred to in Article 63(1)(b) shall include:

(a) a plan for spreading manure agreed with the control body or authority, together with a full description of the areas given over to crop production;

(b) where appropriate, as regards the spreading of manure, the written arrangements with other holdings as referred to in Article 3(3) complying with the provisions of the organic production rules;

(c) a management plan for the organic-production livestock unit.

Article 75

Identification of livestock

The livestock shall be identified permanently using techniques adapted to each species, individually in the case of large mammals and individually or by batch in the case of poultry and small mammals.

Article 76

Livestock records

Livestock records shall be compiled in the form of a register and kept available to the control authorities or bodies at all times at the premises of the holding. Such records shall provide a full description of the herd or flock management system comprising at least the following information:

(a) as regards animals arriving at the holding: origin and date of arrival, conversion period, identification mark and veterinary record;

(b) as regards livestock leaving the holding: age, number of heads, weight in case of slaughter, identification mark and destination;

(c) details of any animals lost and reasons thereof;

(d) as regards feed: type, including feed supplements, proportions of various ingredients of rations and periods of access to free-range areas, periods of transhumance where restrictions apply;

(e) as regards disease prevention and treatment and veterinary care: date of treatment, details of the diagnosis, the posology; type of treatment product, the indication of the active pharmacological substances involved method of treatment and veterinary prescription for veterinary care with reasons and withdrawal periods applying before livestock products can be marketed labelled as organic.

Article 77

Control measures on veterinary medicinal products for livestock

Whenever veterinary medicinal products are used the information according to Article 76(e) is to be declared to the control authority or body before the livestock or livestock products are marketed as organically produced. Livestock treated shall be clearly identified, individually in the case of large animals; individually, or by batch, or by hive, in the case of poultry, small animals and bees.

Article 78

Specific control measures on beekeeping

1. A map on an appropriate scale listing the location of hives shall be provided to the control authority or control body by the beekeeper. Where no areas are identified in accordance with Article 13(2), the beekeeper shall provide the control authority or control body with appropriate documentation and evidence, including suitable analyses if necessary, that the areas accessible to his colonies meet the conditions required in this Regulation.

2. The following information shall be entered in the register of the apiary with regard to the use of feeding: type of product, dates, quantities and hives where it is used.

3. Whenever veterinary medicinal products are to be used, the type of product, including the indication of the active pharmacological substance, together with details of the diagnosis, the posology, the method of administration, the duration of the treatment and the legal withdrawal period shall be recorded clearly and declared to the control body or authority before the products are marketed as organically produced.

4. The zone where the apiary is situated shall be registered together with the identification of the hives. The control body or authority shall be informed of the moving of apiaries by a deadline agreed on with the control authority or body.

5. Particular care shall be taken to ensure adequate extraction, processing and storage of beekeeping products. All the measures to comply with this requirement shall be recorded.

6. The removals of the supers and the honey extraction operations shall be entered in the register of the apiary.

Article 79

Several production units run by the same operator

Where an operator manages several production units, as provided for in Articles 17(1), 40 and 41, the units which produce non-organic livestock or non-organic livestock products shall also be subject to the control system as laid down in Chapter 1 and this Chapter of this Title.

CHAPTER 4

Control requirements for units for preparation of plant and livestock products and foodstuffs composed of plant and livestock products

Article 80

Control arrangements

In the case of a unit involved in the preparation for its own account or for account of a third party, and including in particular units involved in packaging and/or re-packaging of such products or units involved in labelling and/or re-labelling of such products, the full description of the unit referred to in Article 63(1)(a) shall show the facilities used for the reception, the processing, packaging, labelling and storage of agricultural products before and after the operations concerning them, as well as the procedures for the transport of the products.

CHAPTER 5

Control requirements for imports of plants, plant products, livestock, livestock products and foodstuffs comprising plant and/or livestock products, animal feedingstuffs, compound feedingstuffs and feed materials from third countries

Article 81

Scope

This Chapter applies to any operator involved, as importer and/or as first consignee, in the import and/or reception, for its own account or for account of another operator, of organic products.

Article 82

Control arrangements

1. In the case of the importer, the full description of the unit referred to in Article 63(1)(a) shall include the importer's premises and of his import activities, indicating the points of entry of the products into the Community and any other facilities the importer intends to use for the storage of the imported products pending their delivery to the first consignee.

In addition, the declaration referred to in Article 63(2) shall include an undertaking by the importer to ensure that any facilities that the importer will use for storage of products are submitted to control, to be carried out either by the control body or control authority or, when these storage facilities are situated in another Member State or region, by a control body or authority approved for control in that Member State or region.

2. In the case of the first consignee, the full description of the unit referred to in Article 63(1)(a) shall show the facilities used for the reception and storage.

3. Where the importer and the first consignee are the same legal person and operate in one single unit, the reports referred to in the second subparagraph of Article 63(2) may be formalised within one single report.

Article 83

Documentary accounts

The importer and the first consignee shall keep separate stock and financial records, unless where they are operating in one single unit.

On request of the control authority or control body, any details on the transport arrangements from the exporter in the third country to the first consignee and, from the first consignee's premises or storage facilities to the consignees within the Community shall be provided.

Article 84

Information on imported consignments

The importer shall, in due time, inform the control body or control authority of each consignment to be imported into the Community, providing:

(a) the name and address of the first consignee;

(b) any details the control body or authority may reasonably require,

  (i) in case of products imported in accordance with Article 32 of Regulation (EC) No 834/2007, the documentary evidence referred to in that Article;

  (ii) in case of products imported in accordance with Article 33 of Regulation (EC) No 834/2007, a copy of the certificate of inspection referred to in that Article.

On the request of the control body or control authority of the importer, the latter shall forward the information referred to in the first paragraph to the control body or control authority of the first consignee.

Article 85

Control visits

The control authority or control body shall check the documentary accounts referred to in Article 83 of this Regulation and the certificate referred to in Article 33(1)(d) of Regulation (EC) No 834/2007 or the documentary evidence referred to in Article 32(1)(c) of the latter Regulation.

Where the importer performs the import operations by different units or premises, he shall make available on request the reports referred to in the second subparagraph of Article 63(2) of this Regulation for each of these facilities.

CHAPTER 6

Control requirements for units involved in the production, preparation or import of organic products and which have contracted out to third parties in part or in total the actual operations concerned

Article 86

Control arrangements

With regard to the operations, which are contracted out to third parties, the full description of the unit referred to in Article 63(1)(a) shall include:

(a) a list of the subcontractors with a description of their activities and an indication of the control bodies or authorities to which they are subject;

(b) written agreement by the subcontractors that their holding will be subject to the control regime of Title V of Regulation (EC) No 834/2007;

(c) all the practical measures, including inter alia an appropriate system of documentary accounts, to be taken at the level of the unit to ensure that the products the operator places on the market can be traced to, as appropriate, their suppliers, sellers, consignees and buyers.

CHAPTER 7

Control requirements for units preparing feed

Article 87

Scope

This Chapter applies to any unit involved in the preparation of products referred to in Article 1(2)(c) of Regulation (EC) No 834/2007 on its own account or on behalf of a third party.

Article 88

Control arrangements

1. The full description of the unit referred to in Article 63(1)(a) shall indicate:

(a) the facilities used for the reception, preparation and storage of the products intended for animal feed before and after the operations concerning them;

(b) the facilities used for the storage of other products used to prepare feedingstuffs;

(c) the facilities used to store products for cleaning and disinfection;

(d) where necessary, the description of the compound feedingstuff that the operator intends to produce, in accordance with Article 5(1)(a) of Directive 79/373/EEC, and the livestock species or class for which the compound feedingstuff is intended;

(e) where necessary, the name of the feed materials that the operator intends to prepare.

2. The measures to be taken by operators, as referred to in Article 63(1)(b), to guarantee compliance with the organic production rules shall include the indications of measures referred to in Article 26.

3. The control authority or control body shall use these measures to carry out a general evaluation of the risks attendant on each preparation unit and to draw up a control plan. This control plan shall provide for a minimum number of random samples depending on the potential risks.

Article 89

Documentary accounts

For the purposes of proper control of the operations, the documentary accounts referred to in Article 66 shall include information on the origin, nature and quantities of feed materials, additives, sales and finished products.

Article 90

Control visits

The control visit referred to in Article 65 shall comprise a full physical inspection of all premises. Moreover, the control authority or control body shall make targeted visits based on a general evaluation of the potential risks of non-compliance with the organic production rules.

The control body or authority shall pay particular attention to the critical control points pointed out for the operator, with a view to establishing whether the surveillance and checking operations are carried out correctly.

All the premises used by the operator for the conduct of his activities may be checked as frequently as the attendant risks warrant.

CHAPTER 8

Infringements and exchange of information

Article 91

Measures in case of suspicion of infringements and irregularities

1. Where an operator considers or suspects that a product which he has produced, prepared, imported or that he has received from another operator, is not in compliance with organic production rules, he shall initiate procedures either to withdraw from this product any reference to the organic production method or to separate and identify the product. He may only put it into processing or packaging or on the market after elimination of that doubt, unless it is placed on the market without indication referring to the organic production method. In case of such doubt, the operator shall immediately inform the control body or authority. The control authority or control body may require that the product cannot be placed on the market with indications referring to the organic production method until it is satisfied, by the information received from the operator or from other sources, that the doubt has been eliminated.

2. Where a control authority or control body has a substantiated suspicion that an operator intends to place on the market a product not in compliance with the organic production rules but bearing a reference to the organic production method, this control authority or control body can

require that the operator may provisionally not market the product with this reference for a time period to be set by that control authority or control body. Before taking such a decision, the control authority or control body shall allow the operator to comment. This decision shall be supplemented by the obligation to withdraw from this product any reference to the organic production method if the control authority or control body is sure that the product does not fulfil the requirements of organic production.

However, if the suspicion is not confirmed within the said time period, the decision referred to in the first subparagraph shall be cancelled not later than the expiry of that time period. The operator shall cooperate fully with the control body or authority in resolving the suspicion.

3. Member States shall take whatever measures and sanctions are required to prevent fraudulent use of the indications referred to in Title IV of Regulation (EC) No 834/2007 and Title III and/or Annex XI of this Regulation.

Article 92

Exchange of information

1. Where the operator and his subcontractors are checked by different control authorities or control bodies, the declaration referred to in Article 63(2) shall include an agreement by the operator on his behalf and that of his subcontractors, that the different control bodies or control authorities can exchange information on the operations under their control and on the way this exchange of information can be implemented.

2. Where a Member State finds irregularities or infringements relating to the application of this Regulation in a product coming from another Member State and bearing indications as referred to in Title IV of Regulation (EC) No 834/2007 and Title III and/or Annex XI of this Regulation, it shall inform the Member State which designated the control body or control authority and the Commission thereby.

TITLE V

TRANSMISSION OF INFORMATION TO THE COMMISSION, TRANSITIONAL AND FINAL PROVISIONS

CHAPTER 1

Transmission of information to the Commission

Article 93

Statistical information

1. Member States shall provide the Commission with the annual statistical information on organic production referred to in Article 36 of Regulation (EC) No 834/2007 by using the computer system enabling electronic exchanges of documents and information made available by the Commission (Eurostat) before 1 July each year.

2. The statistical information referred to in paragraph 1 shall comprise, in particular the following data:

(a) the number of organic producers, processors, importers and exporters;

(b) the organic crop production and crop area under conversion and under organic production;

(c) the organic livestock numbers and the organic animal products;

(d) the data on organic industrial production by type of activities.

3. For the transmission of the statistical information referred to in paragraphs 1 and 2, Member States shall use the Single Entry point provided by the Commission (Eurostat).

4. The provisions relating to the characteristics of statistical data and metadata shall be defined within the context of the Community Statistical Programme on the basis of models or questionnaires made available via the system referred to in paragraph 1.

Article 94

Other information

1. Member States shall provide the Commission with the following information by using the computer system enabling electronic exchanges of documents and information made available by the Commission (DG Agriculture and rural development) for information other than statistical information:

(a) before 1 January 2009, the information referred to in Article 35(a) of Regulation (EC) No 834/2007 and afterwards each modification when that appears;

(b) by 31 March each year, the information referred to in Article 35(b) of Regulation (EC) No 834/2007, as regards control authorities and bodies approved on 31 December of the previous year,

(c) before 1 July each year, all other information required or needed in accordance with this Regulation.

2. The data shall be communicated, entered and updated in the system referred to in paragraph 1 under the responsibility of the competent authority as referred to in Article 35 of Regulation (EC) No 834/2007, by the authority itself or by the body to which that function has been delegated.

3. The provisions relating to the characteristics of data and metadata shall be defined on the basis of models or questionnaires made available via the system referred to in paragraph 1.

CHAPTER 2

Transitional and final provisions

Article 95

Transitional measures

1. For a transitional period expiring on 31 December 2010, cattle may be tethered in buildings already existing before 24 August 2000, provided that regular exercise is provided and rearing takes place in line with animal welfare requirements with comfortably littered areas as well as individual management and provided that the competent authority has authorised this measure. The competent authority may continue authorising this measure upon request of individual operators for its application in a limited period ending before the 31 December 2013, under the additional condition that the controls visits referred to in Article 65(1) are carried out at least twice a year.

2. The competent authority may authorise, for a transitional period expiring on 31 December 2010, the exceptions concerning housing conditions and stocking density granted to livestock producing holdings on the basis of the derogation provided for in part B, paragraph 8.5.1 of Annex I to Regulation (EEC) No 2092/91. The operators benefiting from this extension shall present a plan to the control authority or control body, containing the description of arrangements which are intended to ensure compliance with the provisions of the organic production rules by the end of the transitional period. The competent authority may continue authorising this measure upon request of individual operators for its application in a limited period ending before the 31 December 2013, under the additional condition that the controls visits referred to in Article 65(1) are carried out at least twice a year.

3. For a transition period expiring 31 December 2010 the final fattening phase of sheep and pigs for meat production as laid down under point 8.3.4 of Annex I.B of Regulation (EEC) No 2092/91 may take place indoors under the condition that the controls visits referred to in Article 65(1) are carried out at least twice a year.

4. The castration of piglets may be carried out without the application of anaesthesia and/or analgesia during a transition period expiring on 31 December 2011.

5. Pending the inclusion of detailed processing rules for pet food, national rules or in the absence thereof, private standards accepted or recognised by the Member States shall apply.

6. For the purpose of Article 12(1)(j) of Regulation (EC) No 834/2007 and pending the inclusion of specific substances according to Article 16(f) of that Regulation, only products authorised by the competent authorities may be used.

7. Authorisations of non-organic ingredients of agricultural origin granted by Member States under Regulation (EEC) No 207/93 may be deemed granted as under this Regulation. However, authorisations granted in accordance with Article 3(6) of the former Regulation shall expire on 31 December 2009.

8. For a transitional period expiring on the 1 July 2010, the operators may continue to use in the labelling the provisions as laid down in Regulation (EEC) No 2092/91 for:

(i) the system for calculation the percentage of organic ingredients of food;

(ii) the code number and/or the name of the control body or control authority.

9. Stocks of products produced, packaged and labelled before 1 January 2009 in accordance with Regulation (EEC) No 2092/91 may continue to be brought on the market bearing terms referring to organic production until stocks are exhausted.

10. Packaging material in accordance with Regulation (EEC) No 2092/91 may continue to be used for products brought to the market bearing terms referring to organic production until 1 January 2012, where the product otherwise complies with the requirements of Regulation (EC) 834/2007.

Article 96

Repeal

Regulations (EEC) No 207/93, (EC) No 223/2003 and (EC) No 1452/2003 are repealed.

References to the repealed Regulations and to Regulation (EEC) No 2092/91 shall be construed as references to this Regulation and shall be read in accordance with the correlation table in Annex XIV.

Article 97

Entry into force and application

This Regulation shall enter into force on the seventh day following that of its publication in the *Official Journal of the European Union*.

It shall apply as from 1 January 2009.

However, paragraph 2(a) of Article 27 and Article 58 shall apply as of 1 July 2010.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels, 5 September 2008.

For the Commission
Mariann FISCHER BOEL
Member of the Commission

ANNEX I

Fertilisers and soil conditioners referred to in Article 3(1)

Note:

A: authorised under Regulation (EEC) No 2092/91 and carried over by Article 16(3)(c) of Regulation (EC) No 834/2007
B: authorised under Regulation (EC) No 834/2007

Authorisation	Name	Description, compositional requirements, conditions for use
A	Compound products or products containing only materials listed hereunder: Farmyard manure	Product comprising a mixture of animal excrements and vegetable matter (animal bedding). Factory farming origin forbidden
A	Dried farmyard manure and dehydrated poultry manure	Factory farming origin forbidden
A	Composted animal excrements, including poultry manure and composted farmyard manure included	Factory farming origin forbidden
A	Liquid animal excrements	Use after controlled fermentation and/or appropriate dilution Factory farming origin forbidden
A	Composted or fermented household waste	Product obtained from source separated household waste, which has been submitted to composting or to anaerobic fermentation for biogas production Only vegetable and animal household waste Only when produced in a closed and monitored collection system, accepted by the Member State Maximum concentrations in mg/kg of dry matter: cadmium: 0,7; copper: 70; nickel: 25; lead: 45; zinc: 200; mercury: 0,4; chromium (total): 70; chromium (VI): 0
A	Peat	Use limited to horticulture (market gardening, floriculture, arboriculture, nursery)
A	Mushroom culture wastes	The initial composition of the substrate shall be limited to products of this Annex
A	Dejecta of worms (vermicompost) and insects	
A	Guano	
A	Composted or fermented mixture of vegetable matter	Product obtained from mixtures of vegetable matter, which have been submitted to composting or to anaerobic fermentation for biogas production
A	Products or by-products of animal origin as below: blood meal hoof meal horn meal bone meal or degelatinized bone meal fish meal meat meal feather, hair and ‘chiquette’ meal wool fur hair dairy products	Maximum concentration in mg/kg of dry matter of chromium (VI): 0

Authorisation	Name	Description, compositional requirements, conditions for use
A	Products and by-products of plant origin for fertilisers	Examples: oilseed cake meal, cocoa husks, malt culms
A	Seaweeds and seaweed products	As far as directly obtained by: (i) physical processes including dehydration, freezing and grinding (ii) extraction with water or aqueous acid and/or alkaline solution (iii) fermentation
A	Sawdust and wood chips	Wood not chemically treated after felling
A	Composted bark	Wood not chemically treated after felling
A	Wood ash	From wood not chemically treated after felling
A	Soft ground rock phosphate	Product as specified in point 7 of Annex IA.2. to Regulation (EC) No 2003/2003 of the European Parliament and of the Council (1) relating to fertilisers , 7 Cadmium content less than or equal to 90 mg/kg of P_20_5
A	Aluminium-calcium phosphate	Product as specified in point 6 of Annex IA.2. of Regulation 2003/2003, Cadmium content less than or equal to 90 mg/kg of P_20_5 Use limited to basic soils (pH > 7,5)
A	Basic slag	Products as specified in point 1 of Annex IA.2. of Regulation 2003/2003
A	Crude potassium salt or kainit	Products as specified in point 1 of Annex IA.3. of Regulation 2003/2003
A	Potassium sulphate, possibly containing magnesium salt	Product obtained from crude potassium salt by a physical extraction process, containing possibly also magnesium salts
A	Stillage and stillage extract	Ammonium stillage excluded
A	Calcium carbonate (chalk, marl, ground limestone, Breton ameliorant, (maerl), phosphate chalk)	Only of natural origin
A	Magnesium and calcium carbonate	Only of natural origin e.g. magnesian chalk, ground magnesium, limestone
A	Magnesium sulphate (kieserite)	Only of natural origin
A	Calcium chloride solution	Foliar treatment of apple trees, after identification of deficit of calcium
A	Calcium sulphate (gypsum)	Products as specified in point 1 of Annex ID. of Regulation 2003/2003 Only of natural origin
A	Industrial lime from sugar production	By-product of sugar production from sugar beet
A	Industrial lime from vacuum salt production	By-product of the vacuum salt production from brine found in mountains
A	Elemental sulphur	Products as specified in Annex ID.3 of Regulation 2003/2003
A	Trace elements	Inorganic micronutrients listed in part E of Annex I to Regulation 2003/2003
A	Sodium chloride	Only mined salt
A	Stone meal and clays	

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(1) OJ L 304, 21.11.2003, p. 1.

ANNEX II

Pesticides — plant protection products referred to in Article 5(1)

Note:

A: authorised under Regulation (EEC) No 2092/91 and carried over by Article 16(3)(c) of Regulation (EC) No 834/2007
B: authorised under Regulation (EC) No 834/2007

1. Substances of crop or animal origin

Authorisation	Name	Description, compositional requirement, conditions for use
A	Azadirachtin extracted from *Azadirachta indica* (Neem tree)	Insecticide
A	Beeswax	Pruning agent
A	Gelatine	Insecticide
A	Hydrolysed proteins.	Attractant, only in authorized applications in combination with other appropriate products of this list
A	Lecithin	Fungicide
A	Plant oils (e.g. mint oil, pine oil, caraway oil).	Insecticide, acaricide, fungicide and sprout inhibitor.
A	Pyrethrins extracted from *Chrysanthemum cinerariaefolium*	Insecticide
A	Quassia extracted from *Quassia amara*	Insecticide, repellent
A	Rotenone extracted from *Derris* spp. and *Lonchocarpus* spp. and *Terphrosia* spp.	Insecticide

2. Micro-organisms used for biological pest and disease control

Authorisation	Name	Description, compositional requirement, conditions for use
A	Micro-organisms (bacteria, viruses and fungi)	

3. Substances produced by micro-organisms

Authorisation	Name	Description, compositional requirement, conditions for use
A	Spinosad	Insecticide Only where measures are taken to minimize the risk to key parasitoids and to minimize the risk of development of resistance

4. Substances to be used in traps and/or dispensers

Authorisation	Name	Description, compositional requirement, conditions for use
A	Diammonium phosphate	Attractant, only in traps

Authorisation	Name	Description, compositional requirement, conditions for use
A	Pheromones	Attractant; sexual behaviour disrupter; only in traps and dispensers
A	Pyrethroids (only deltamethrin or lambdacyhalothrin)	Insecticide; only in traps with specific attractants; only against *Bactrocera oleae* and *Ceratitis capitata* Wied.

5. **Preparations to be surface-spread between cultivated plants**

Authorisation	Name	Description, compositional requirement, conditions for use
A	Ferric phosphate (iron (III) orthophosphate)	Molluscicide

6. **Other substances from traditional use in organic farming**

Authorisation	Name	Description, compositional requirement, conditions for use
A	Copper in the form of copper hydroxide, copper oxychloride, (tribasic) copper sulphate, cuprous oxide, copper octanoate	Fungicide. up to 6 kg copper per ha per year For perennial crops, Member States may, by derogation from the previous paragraph, provide that the 6 kg copper limit can be exceeded in a given year provided that the average quantity actually used over a 5-year period consisting of that year and of the four preceding years does not exceed 6 kg
A	Ethylene	Degreening bananas, kiwis and kakis; Degreening of citrus fruit only as part of a strategy for the prevention of fruit fly damage in citrus; Flower induction of pineapple; sprouting inhibition in potatoes and onions
A	Fatty acid potassium salt (soft soap)	Insecticide
A	Potassium aluminium (aluminium sulphate) (Kalinite)	Prevention of ripening of bananas
A	Lime sulphur (calcium polysulphide)	Fungicide, insecticide, acaricide
A	Paraffin oil	Insecticide, acaricide
A	Mineral oils	Insecticide, fungicide; only in fruit trees, vines, olive trees and tropical crops (e.g. bananas);
A	Potassium permanganate	Fungicide, bactericide; only in fruit trees, olive trees and vines.
A	Quartz sand	Repellent
A	Sulphur	Fungicide, acaricide, repellent

7. **Other substances**

Authorisation	Name	Description, compositional requirement, conitions for use
A	Calcium hydroxide	Fungicide Only in fruit trees, including nurseries, to control *Nectria galligena*
A	Potassium bicarbonate	Fungicide

ANNEX III

Minimum surface areas indoors and outdoors and other characteristics of housing in the different species and types of production referred to in Article 10(4)

1. **Bovines, equidae, ovine, caprine and porcine**

	Indoors area (net area available to animals)		Outdoors area (exercise area, excluding pasturage)
	Live weight minimum (kg)	M^2/head	M^2/head
Breeding and fattening bovine and equidae	up to 100	1,5	1,1
	up to 200	2,5	1,9
	up to 350	4,0	3
	over 350	5 with a minimum of 1 m^2/100 kg	3,7 with a minimum of 0,75 m^2/100 kg
Dairy cows		6	4,5
Bulls for breeding		10	30
Sheep and goats		1,5 sheep/goat	2,5
		0,35 lamb/kid	0,5
Farrowing sows with piglets up to 40 days		7,5 sow	2,5
Fattening pigs	up to 50	0,8	0,6
	up to 85	1,1	0,8
	up to 110	1,3	1
Piglets	over 40 days and up to 30 kg	0,6	0,4
Brood pigs		2,5 female	1,9
		6 male If pens are used for natural service: 10 m^2/boar	8,0

2. **Poultry**

	Indoors area (net area available to animals)			Outdoors area (m^2 of area available in rotation/head)
	No animals/m^2	cm perch/ animal	nest	
Laying hens	6	18	7 laying hens per nest or in case of common nest 120 cm^2/bird	4, provided that the limit of 170 kg of N/ha/year is not exceeded
Fattening poultry (in fixed housing)	10 with a maximum of 21 kg liveweight/m^2	20 (for guinea fowl only)		4 broilers and guinea fowl 4,5 ducks 10 turkey 15 geese In all the species mentioned above the limit of 170 kg of N/ha/year is not exceeded

	Indoors area (net area available to animals)			Outdoors area (m² of area available in rotation/head)
	No animals/m²	cm perch/ animal	nest	
Fattening poultry in mobile housing	16 (1) in mobile poultry houses with a maximum of 30 kg liveweight/ m²			2,5, provided that the limit of 170 kg of N/ha/year is not exceeded

(1) Only in the case of mobile houses not exceeding 150 m² floor space.

ANNEX IV

Maximum number of animals per hectare referred to in Article 15 (2)

Class or species	Maximum number of animals per ha equivalent to 170 kg N/ha/year
Equines over six months old	2
Calves for fattening	5
Other bovine animals less than one year old	5
Male bovine animals from one to less than two years old	3,3
Female bovine animals from one to less than two years old	3,3
Male bovine animals two years old or over	2
Breeding heifers	2,5
Heifers for fattening	2,5
Dairy cows	2
Cull dairy cows	2
Other cows	2,5
Female breeding rabbits	100
Ewes	13,3
Goats	13,3
Piglets	74
Breeding sows	6,5
Pigs for fattening	14
Other pigs	14
Table chickens	580
Laying hens	230

ANNEX V

Feed materials referred to in Article 22(1), (2) and (3)

1. NON-ORGANIC FEED MATERIALS OF PLANT ORIGIN

1.1. **Cereals, grains, their products and by-products:**

- Oats as grains, flakes, middlings, hulls and bran
- Barley as grains, protein and middlings
- Rice germ expeller
- Millet as grains
- Rye as grains and middlings
- Sorghum as grains
- Wheat as grains, middlings, bran, gluten feed, gluten and germ
- Spelt as grains
- Triticale as grains
- Maize as grains, bran, middlings, germ expeller and gluten
- Malt culms
- Brewers' grains

1.2. **Oil seeds, oil fruits, their products and by-products:**

- Rape seed, expeller and hulls
- Soya bean as bean, toasted, expeller and hulls
- Sunflower seed as seed and expeller
- Cotton as seed and seed expeller
- Linseed as seed and expeller
- Sesame seed as expeller
- Palm kernels as expeller
- Pumpkin seed as expeller
- Olives, olive pulp
- Vegetable oils (from physical extraction).

1.3. **Legume seeds, their product and by-products:**

- Chickpeas as seeds, middlings and bran
- Ervil as seeds, middlings and bran
- Chickling vetch as seeds submitted to heat treatment, middlings and bran
- Peas as seeds, middlings, and bran
- Broad beans as seeds, middlings and bran

- Horse beans as seeds middlings and bran
- Vetches as seeds, middlings and bran
- Lupin as seeds, middlings and bran

1.4. **Tuber, roots, their products and by-products:**

- Sugar beet pulp
- Potato
- Sweet potato as tuber
- Potato pulp (by-product of the extraction of potato starch)
- Potato starch
- Potato protein
- Manioc.

1.5. **Other seeds and fruits, their products and by-products:**

- Carob
- Carob pods and meals thereof
- Pumpkins,
- Citrus pulp
- Apples, quinces, pears, peaches, figs, grapes and pulps thereof
- Chestnuts
- Walnut expeller
- Hazelnut expeller
- Cocoa husks and expeller
- Acorns.

1.6. **Forages and roughages:**

- Lucerne
- Lucerne meal
- Clover
- Clover meal
- Grass (obtained from forage plants)
- Grass meal
- Hay
- Silage
- Straw of cereals
- Root vegetables for foraging

1.7. **Other plants, their products and by-products:**

- Molasses
- Seaweed meal (obtained by drying and crushing seaweed and washed to reduce iodine content)
- Powders and extracts of plants
- Plant protein extracts (solely provided to young animals)
- Spices
- Herbs

2. FEED MATERIALS OF ANIMAL ORIGIN

2.1. **Milk and milk products:**

- Raw milk
- Milk powder
- Skimmed milk, skimmed-milk powder,
- Buttermilk, buttermilk powder
- Whey, whey powder, whey powder low in sugar, whey protein powder (extracted by physical treatment)
- Casein powder
- Lactose powder
- Curd and sour milk

2.2. **Fish, other marine animals, their products and by-products:**

Under the following restrictions: Products origin only from sustainable fisheries and to be used only for species other than herbivores

- Fish
- Fish oil and cod-liver oil not refined
- Fish molluscan or crustacean autolysates
- Hydrolysate and proteolysates obtained by an enzyme action, whether or not in soluble form, solely provided to young animals
- Fish meal

2.3. **Egg and egg products**

- Eggs and egg products for use as poultry feed, primarily from the same holding.

3. FEED MATERIALS OF MINERAL ORIGIN

3.1. **Sodium:**

- unrefined sea salt
- coarse rock salt
- sodium sulphate
- sodium carbonate

- sodium bicarbonate
- sodium chloride

3.2. **Potassium:**

- potassium chloride

3.3. **Calcium:**

- lithotamnion and maerl
- shells of aquatic animals (including cuttlefish bones)
- calcium carbonate
- calcium lactate
- calcium gluconate

3.4. **Phosphorus:**

- defluorinated dicalcium phosphate
- defluorinated monocalcium phosphate
- monosodium phosphate
- calcium-magnesium phosphate
- calcium-sodium phosphate

3.5. **Magnesium:**

- magnesium oxide (anhydrous magnesia)
- magnesium sulphate
- magnesium chloride
- magnesium carbonate
- magnesium phosphate

3.6. **Sulphur:**

- sodium sulphate.

ANNEX VI

Feed additives and certain substances used as in animal nutrition referred to in Article 22(4)

1. FEED ADDITIVES

Additives listed must have been approved under Regulation (EC) No 1831/2003 of the European Parliament and of the Council (1) on additives for use in animal nutrition

1.1. Nutritional additives

(a) *Vitamins*

- Vitamins derived from raw materials occurring naturally in feedingstuffs;
- Synthetic vitamins identical to natural vitamins for monogastric animals;
- Synthetic vitamins A, D, and E identical to natural vitamins for ruminants with prior authorisation of the Member States based on the assessment of the possibility for organic ruminants to obtain the necessary quantities of the said vitamins through their feed rations.

(b) *Trace elements*

E1 Iron:
ferrous (II) carbonate
ferrous (II) sulphate monohydrate and/or heptahydrate
ferric (III) oxide;

E2 Iodine:
calcium iodate, anhydrous
calcium iodate, hexahydrate
sodium iodide;

E3 Cobalt:
cobaltous (II) sulphate monohydrate and/or heptahydrate
basic cobaltous (II) carbonate, monohydrate;

E4 Copper:
copper (II) oxide
basic copper (II) carbonate, monohydrate
copper (II) sulphate, pentahydrate;

E5 Manganese:
manganous (II) carbonate
manganous oxide and manganic oxide
manganous (II) sulfate, mono- and/or tetrahydrate;

E6 Zinc:
zinc carbonate
zinc oxide
zinc sulphate mono- and/or heptahydrate;

E7 Molybdenum:
ammonium molybdate, sodium molybdate;

E8 Selenium:
sodium selenate
sodium selenite.

1.2. Zoo-technical additives

Enzymes and micro-organisms

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(1) OJ L 268, 18.10.2003, p. 29.

1.3. **Technological additives**

(a) *Preservatives*

E 200	Sorbic acid
E 236	Formic acid (*)
E 260	Acetic acid (*)
E 270	Lactic acid (*)
E 280	Propionic acid (*)
E 330	Citric acid.

(*) For silage: only when weather conditions do not allow for adequate fermentation.

(b) *Antioxidant substances*

E 306 — Tocopherol-rich extracts of natural origin used as an antioxidant

(c) *Binders and anti-caking agents*

E 470	Calcium stearate of natural origin
E 551b	Colloidal silica
E 551c	Kieselgur
E 558	Bentonite
E 559	Kaolinitic clays
E 560	Natural mixtures of stearites and chlorite
E 561	Vermiculite
E 562	Sepiolite
E 599	Perlite.

(d) *Silage additives*

Enzymes, yeasts and bacteria can be used as silage additives

The use of lactic, formic, propionic and acetic acid in the production of silage shall only be permitted when weather conditions do not allow for adequate fermentation

2. CERTAIN SUBSTANCES USED IN ANIMAL NUTRITION

Substance listed must have been approved under Council Directive 82/471/EEC concerning certain products used in animal nutrition ([1])

Yeasts:

Saccharomyces cerevisiae

Saccharomyces carlsbergiensis

3. SUBSTANCES FOR SILAGE PRODUCTION

- sea salt
- coarse rock salt
- whey
- sugar
- sugar beet pulp
- cereal flour
- molasses

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[1] OJ L 213, 21.7.1982, p. 8.

ANNEX VII

Products for cleaning and disinfection referred to in Article 23 (4)

Products for cleaning and disinfection of buildings and installations for animal production:

- Potassium and sodium soap
- Water and steam
- Milk of lime
- Lime
- Quicklime
- Sodium hypochlorite (e.g. as liquid bleach)
- Caustic soda
- Caustic potash
- Hydrogen peroxide
- Natural essences of plants
- Citric, peracetic acid, formic, lactic, oxalic and acetic acid
- Alcohol
- Nitric acid (dairy equipment)
- Phosporic acid (dairy equipment)
- Formaldehyde
- Cleaning and disinfection products for teats and milking facilities
- Sodium carbonate

ANNEX VIII

Certain products and substances for use in production of processed organic food referred to in Article 27(1)(a)

Note:

A: authorised under Regulation (EEC) No 2092/91 and carried over by Article 21(2) of Regulation (EC) No 834/2007
B: authorised under Regulation (EC) No 834/2007

SECTION A — FOOD ADDITIVES, INCLUDING CARRIERS

For the purpose of the calculation referred to in Article 23(4)(a)(ii) of Regulation (EC) No 834/2007, food additives marked with an asterisk in the column of the code number, shall be calculated as ingredients of agricultural origin.

Authorisation	Code	Name	Preparation of foodstuffs of		Specific conditions
			plant origin	animal origin	
A	E 153	Vegetable carbon		X	Ashy goat cheese Morbier cheese
A	E 160b*	Annatto, Bixin, Norbixin		X	Red Leicester cheese Double Gloucester cheese Cheddar Mimolette cheese
A	E 170	Calcium carbonate	X	X	Shall not be used for colouring or calcium enrichment of products
A	E 220 Or	Sulphur dioxide	X	X	In fruit wines (*) without added sugar (including cider and perry) or in mead: 50 mg (**)
	E 224	Potassium metabisulphite	X	X	For cider and perry prepared with addition of sugars or juice concentrate after fermentation: 100 mg (**)
					(*) In this context, 'fruit wine' is defined as wine made from fruits other than grapes. (**) Maximum levels available from all sources, expressed as SO_2 in mg/l.
A	E 250 or	Sodium nitrite		X	For meat products (1):
	E 252	Potassium nitrate		X	For E 250: indicative ingoing amount expressed as $NaNO_2$: 80 mg/kg For E 252: indicative ingoing amount expressed as $NaNO_3$: 80 mg/kg For E 250: maximum residual amount expressed as $NaNO_2$: 50 mg/kg For E 252: maximum residual amount expressed as $NaNO_3$: 50 mg/kg
A	E 270	Lactic acid	X	X	
A	E 290	Carbon dioxide	X	X	
A	E 296	Malic acid	X		
A	E 300	Ascorbic acid	X	X	Meat products (2)
A	E 301	Sodium ascorbate		X	Meat products (2) in connection with nitrates and nitrites

Authorisation	Code	Name	Preparation of foodstuffs of		Specific conditions
			plant origin	animal origin	
A	E 306*	Tocopherol-rich extract	X	X	Anti-oxidant for fats and oils
A	E 322*	Lecithins	X	X	Milk products (2)
A	E 325	Sodium lactate		X	Milk-based and meat products
A	E 330	Citric acid	X		
A	E 331	Sodium citrates		X	
A	E 333	Calcium citrates	X		
A	E 334	Tartaric acid (L(+)–)	X		
A	E 335	Sodium tartrates	X		
A	E 336	Potassium tartrates	X		
A	E 341 (i)	Monocalcium-phosphate	X		Raising agent for self raising flour
A	E 400	Alginic acid	X	X	Milk-based products (2)
A	E 401	Sodium alginate	X	X	Milk-based products (2)
A	E 402	Potassium alginate	X	X	Milk-based products (2)
A	E 406	Agar	X	X	Milk-based and meat products (2)
A	E 407	Carrageenan	X	X	Milk-based products (2)
A	E 410*	Locust bean gum	X	X	
A	E 412*	Guar gum	X	X	
A	E 414*	Arabic gum	X	X	
A	E 415	Xanthan gum	X	X	
A	E 422	Glycerol	X		For plant extracts
A	E 440 (i)*	Pectin	X	X	Milk-based products (2)
A	E 464	Hydroxypropyl methyl cellulose	X	X	Encapsulation material for capsules
A	E 500	Sodium carbonates	X	X	'Dulce de leche' (3) and soured-cream butter and sour milk cheese (2)
A	E 501	Potassium carbonates	X		
A	E 503	Ammonium carbonates	X		
A	E 504	Magnesium carbonates	X		
A	E 509	Calcium chloride		X	Milk coagulation
A	E 516	Calcium sulphate	X		Carrier
A	E 524	Sodium hydroxide	X		Surface treatment of 'Laugengebäck'
A	E 551	Silicon dioxide	X		Anti-caking agent for herbs and spices

Authorisation	Code	Name	Preparation of foodstuffs of		Specific conditions
			plant origin	animal origin	
A	E 553b	Talc	X	X	Coating agent for meat products
A	E 938	Argon	X	X	
A	E 939	Helium	X	X	
A	E 941	Nitrogen	X	X	
A	E 948	Oxygen	X	X	

(1) This additive can only be used, if it has been demonstrated to the satisfaction of the competent authority that no technological alternative, giving the same guarantees and/or allowing to maintain the specific features of the product, is available.

(2) The restriction concerns only animal products.

(3) 'Dulce de leche' or 'Confiture de lait' refers to a soft, luscious, brown cream, made of sweetened, thickened milk.

SECTION B — PROCESSING AIDS AND OTHER PRODUCTS, WHICH MAY BE USED FOR PROCESSING OF INGREDIENTS OF AGRICULTURAL ORIGIN FROM ORGANIC PRODUCTION

Note:

A: authorised under Regulation (EEC) No 2092/91 and carried over by Article 21(2) of Regulation (EC) No 834/2007
B: authorised under Regulation (EC) No 834/2007

Authorisation	Name	Preparation of foodstuffs of plant origin	Preparation of foodstuffs of animal origin	Specific conditions
A	Water	X	X	Drinking water within the meaning of Council Directive 98/83/EC
A	Calcium chloride	X		Coagulation agent
A	Calcium carbonate	X		
	Calcium hydroxide	X		
A	Calcium sulphate	X		Coagulation agent
A	Magnesium chloride (or nigari)	X		Coagulation agent
A	Potassium carbonate	X		Drying of grapes
A	Sodium carbonate	X		Sugar(s) production
A	Lactic acid		X	For the regulation of the pH of the brine bath in cheese production (1)
A	Citric acid	X	X	For the regulation of the pH of the brine bath in cheese production (1) Oil production and hydrolysis of starch (2)
A	Sodium hydroxide	X		Sugar(s) production Oil production from rape seed (*Brassica* spp)
A	Sulphuric acid	X	X	Gelatine production (1) Sugar(s) production (2)
A	Hydrochloric acid		X	Gelatine production For the regulation of the pH of the brine bath in the processing of Gouda-, Edam and Maasdammer cheeses, Boerenkaas, Friese and Leidse Nagelkaas
A	Ammonium hydroxide		X	Gelatine production
A	Hydrogen peroxide		X	Gelatine production
A	Carbon dioxide	X	X	
A	Nitrogen	X	X	
A	Ethanol	X	X	Solvent
A	Tannic acid	X		Filtration aid
A				
A	Egg white albumen	X		
A	Casein	X		
A	Gelatin	X		
A	Isinglass	X		
A	Vegetable oils	X	X	Greasing, releasing or anti-foaming agent

Authorisation	Name	Preparation of foodstuffs of plant origin	Preparation of foodstuffs of animal origin	Specific conditions
A	Silicon dioxide gel or colloidal solution	X		
A	Activated carbon	X		
A	Talc	X		In compliance with the specific purity criteria for food additive E 553b
A	Bentonite	X	X	Sticking agent for mead (1) In compliance with the specific purity criteria for food additive E 558
A	Kaolin	X	X	Propolis (1) In compliance with the specific purity criteria for food additive E 559
A	Celluose	X	X	Gelatine production (1)
A	Diatomaceous earth	X	X	Gelatine production (1)
A	Perlite	X	X	Gelatine production (1)
A	Hazelnut shells	X		
A	Rice meal	X		
A	Beeswax	X		Releasing agent
A	Carnauba wax	X		Releasing agent

(1) The restriction concerns only animal products.
(2) The restriction concerns only plant products.

ANNEX IX

Ingredients of agricultural origin which have not been produced organically referred to in Article 28

1. UNPROCESSED VEGETABLE PRODUCTS AS WELL AS PRODUCTS DERIVED THEREFROM BY PROCESSES

1.1. **Edible fruits, nuts and seeds:**

— acorns	*Quercus* spp.
— cola nuts	*Cola acuminata*
— gooseberries	*Ribes uva-crispa*
— maracujas (passion fruit)	*Passiflora edulis*
— raspberries (dried)	*Rubus idaeus*
— red currants (dried)	*Ribes rubrum*

1.2. **Edible spices and herbs:**

— pepper (Peruvian)	*Schinus molle* L.
— horseradish seeds	*Armoracia rusticana*
— lesser galanga	*Alpinia officinarum*
— safflower flowers	*Carthamus tinctorius*
— watercress herb	*Nasturtium officinale*

1.3. **Miscellaneous:**

Algae, including seaweed, permitted in non-organic foodstuffs preparation

2. VEGETABLE PRODUCTS

2.1. **Fats and oils whether or not refined, but not chemically modified, derived from plants other than:**

— cocoa	*Theobroma cacao*
— coconut	*Cocos nucifera*
— olive	*Olea europaea*
— sunflower	*Helianthus annuus*
— palm	*Elaeis guineensis*
— rape	*Brassica napus, rapa*
— safflower	*Carthamus tinctorius*
— sesame	*Sesamum indicum*
— soya	*Glycine max*

2.2. **The following sugars, starches and other products from cereals and tubers:**

- — fructose
- — rice paper
- — unleavened bread paper
- — starch from rice and waxy maize, not chemically modified

2.3. **Miscellaneous:**

- pea protein *Pisum* spp.
- rum, only obtained from cane sugar juice
- kirsch prepared on the basis of fruits and flavourings as referred to in Article 27(1)(c).

3. ANIMAL PRODUCTS

aquatic organisms, not originating from aquaculture, and permitted in no-organic foodstuffs preparation

- gelatin
- whey powder '*herasuola*'
- casings

ANNEX X

Species for which organically produced seed or seed potatoes are available in sufficient quantities and for a significant number of varieties in all parts of the Community referred to in Article 45(3)

ANNEX XI

Community logo, referred to in Article 57

A. A COMMUNITY LOGO

1. **Conditions with regard to the presentation and use of the Community Logo**

1.1. The Community logo referred to above shall comprise of the models in part B.2 of this Annex.

1.2. The indications that must be included in the logo are listed in part B.3 of this Annex. It is possible to combine the logo with the indication mentioned in the Annex Council Regulation (EC) No 834/2007.

1.3. To use the Community logo and the indications referred to in part B.3 of this Annex, the technical reproduction rules laid down in the graphic manual in part B.4 of this Annex must be complied with.

B.2. **Models**

Español

Čeština

Dansk

Deutsch

Deutsch

Eesti keel

Eesti keel

Ελλαδα

English

Français

Italiano

Latviešu valoda

Lietuvių kalba

Magyar

Malti

Nederlands

Polski

Português

Slovenčina (slovenský jazyk)

Slovenščina (slovenski jezik)

Suomi

Svenska

Български

Română

Nederlands/Français

Suomi/Svenska

Français/Deutsch

B.3. **Indications to be inserted in the Community logo**

B.3.1. *Single indications:*

BG: БИОЛОГИЧНО ЗЕМЕДЕЛИЕ

ES: AGRICULTURA ECOLÓGICA

CS: EKOLOGICKÉ ZEMĚDĚLSTVÍ

DA: ØKOLOGISK JORDBRUG

DE: BIOLOGISCHE LANDWIRTSCHAFT, ÖKOLOGISCHER LANDBAU

ET: MAHEPÕLLUMAJANDUS, ÖKOLOOGILINE PÕLLUMAJANDUS

EL: ΒΙΟΛΟΓΙΚΗ ΓΕΩΡΓΙΑ

EN: ORGANIC FARMING

FR: AGRICULTURE BIOLOGIQUE

IT: AGRICOLTURA BIOLOGICA

LV: BIOLOĢISKĀ LAUKSAIMNIECĪBA

LT: EKOLOGINIS ŽEMĖS ŪKIS

HU: ÖKOLÓGIAI GAZDÁLKODÁS

MT: AGRIKULTURA ORGANIKA

NL: BIOLOGISCHE LANDBOUW

PL: ROLNICTWO EKOLOGICZNE

PT: AGRICULTURA BIOLÓGICA

RO: AGRICULTURĂ ECOLOGICĂ

SK: EKOLOGICKÉ POĽNOHOSPODÁRSTVO

SL: EKOLOŠKO KMETIJSTVO

FI: LUONNONMUKAINEN MAATALOUSTUOTANTO

SV: EKOLOGISKT JORDBRUK

B.3.2. *Combination of two indications:*

Combinations of two indications referring to the languages mentioned under B.3.1. are authorised, subject of being developed in accordance with the following examples:

NL/FR: BIOLOGISCHE LANDBOUW — AGRICULTURE BIOLOGIQUE

FI/SV: LUONNONMUKAINEN MAATALOUSTUOTANTO — EKOLOGISKT JORDBRUK

FR/DE: AGRICULTURE BIOLOGIQUE — BIOLOGISCHE LANDWIRTSCHAFT

B.4. **Graphic manual**

CONTENTS

1. INTRODUCTION

The graphic manual is an instrument for the operators to reproduce the logo.

2. GENERAL USE OF THE LOGO

2.1. **Coloured logo** (reference colours)

When the coloured logo is used, this logo must appear in colour by using direct colours (Pantone) or a four-coloured process. The reference colours are indicated herunder.

Logo in pantone

🟩 GREEN: Pantone 367

🟦 BLUE: Pantone Reflex Blue
Text in blue

Logo in four-colour process

🟩 GREEN: 30,5 % cyan + 60 % yellow

🟦 BLUE: 100 % cyan + 80 % magenta
Text in blue

2.2. **Single-colour logo: logo in black and white**

The logo in black and white can be used as shown:

2.3. Contrast with background colours

If the logo is used in colour on coloured backgrounds which makes it difficult to read, use a delimiting outer circle around the logo to improve its contrast with the background colours as shown:

Logo in coloured background

2.4. Typography

Use Frutiger or Myriad bold condensed in capitals for the wording.

The letter size of the wording shall be reduced according to the norms set down in Section 2.6

2.5. Language

You are free to use the language version or versions of your choice according to the specifications indicated in B.3.

2.6. Reduction sizes

If the application of the logo on different types of labelling makes reduction necessary, the minimum size shall be:

(a) For a logo with a single indication: minimum size 20 mm diameter.

(b) For a logo with a combination of two indications: minimum size 40 mm diameter.

2.7. **Particular conditions to use the logo**

The use of the logo serves to confer specific value to the products. The most effective application of the logo is therefore in colour, since it will thus have a greater presence and be recognised more easily and quickly by the consumer.

The use of the logo using a single colour (black and white) as established in Section 2.2 is only recommended in cases where its application in colour is not practical.

3. ORIGINAL BROMIDES

3.1. **Two-colour selection**

- Single indication in all the languages
- The examples of the language combinations referred to in B.3.2

ESPAÑOL

PANTONE 367

PANTONE REFLEX BLUE

DANSK

PANTONE 367

PANTONE REFLEX BLUE

DEUTSCH

PANTONE 367

PANTONE REFLEX BLUE

ΕΛΛΗΝΙΚΑ

PANTONE 367

PANTONE REFLEX BLUE

ENGLISH

PANTONE 367

PANTONE REFLEX BLUE

FRANÇAIS

PANTONE 367

PANTONE REFLEX BLUE

ITALIANO

PANTONE 367

PANTONE REFLEX BLUE

NEDERLANDS

PANTONE 367

PANTONE REFLEX BLUE

PORTUGUÊS

PANTONE 367

PANTONE REFLEX BLUE

SUOMI

PANTONE 367

PANTONE REFLEX BLUE

SVENSKA

PANTONE 367

PANTONE REFLEX BLUE

— The examples of the language combinations referred to in B.3.2

NEDERLANDS/FRANÇAIS

PANTONE 367

PANTONE REFLEX BLUE

SUOMI/SVENSKA

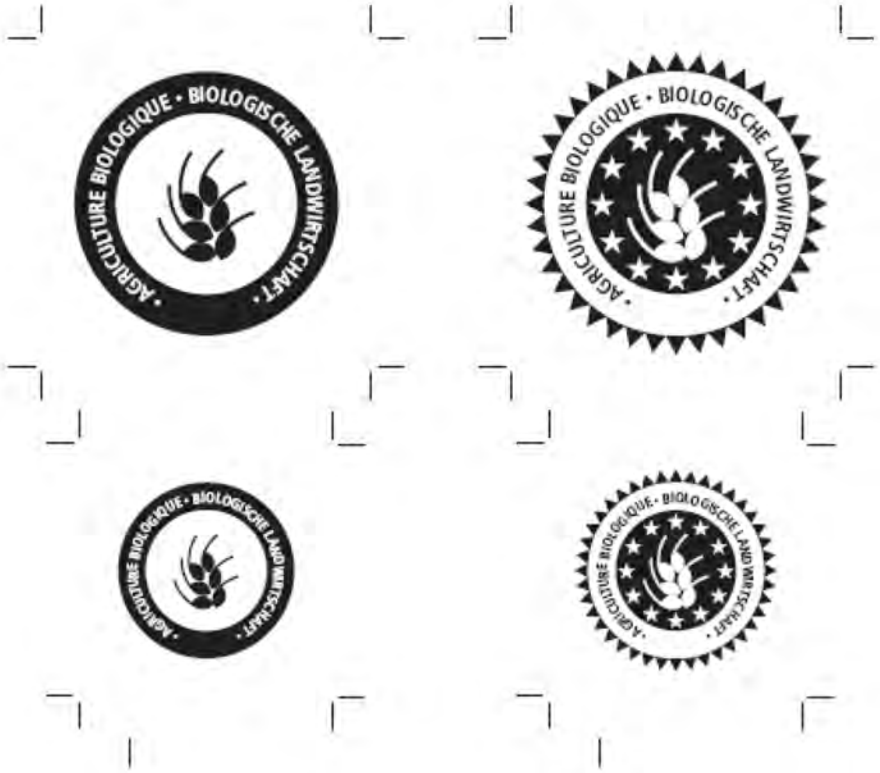
PANTONE 367

PANTONE REFLEX BLUE

FRANÇAIS/DEUTSCH

PANTONE 367

PANTONE REFLEX BLUE



3.2. **Outlines**

3.3. **Single-colour: logo in black and white**

3.4. **Colour sample sheets**

PANTONE REFLEX BLUE

PANTONE 367

ANNEX XII

Model of documentary evidence to the operator according to Article 29(1) of Regulation (EC) No 834/2007 referred to in Article 68 of this Regulation

Documentary evidence to the operator according to Article 29(1) of Regulation (EC) No 834/2007 Document Number:	
Name and address of operator: main activity (producer, processor, importer, etc):	Name, address and code number of control body/authority:
Product groups/Activity: — Plant and plant products: — Livestock and livestock products: — Processed products:	defined as: organic production, in-conversion products; and also non-organic production where parallel production/processing pursuant to Article 11 of Regulation (EC) No 834/2007 occurs
Validity period: Plant products from …to… Livestock products from …to… Processed products from …to…	Date of control(s):
This document has been issued on the basis of Article 29(1) of Regulation (EC) No 834/2007 and of Regulation (EC) No 889/2008. The declared operator has submitted his activities under control, and meets the requirements laid down in the named Regulations. Date, place: Signature on behalf of the issuing control body/authority:	

ANNEX XIII

Model of a vendor declaration referred to in Article 69

Vendor declaration according to Article 9(3) of Council Regulation (EC) No 834/2007	
Name, address of vendor:	
Identification (e.g. lot or stock number):	Product name:
Components: (Specify all components existing in the product/used the last in the production process) ……………… ……………… ……………… ……………… ………………	
I declare that this product was manufactured neither 'from' nor 'by' GMOs as those terms are used in Articles 2 and 9 of Council Regulation (EC) No 834/2007. I do not have any information which could suggest that this statement is inaccurate. Thus, I declare that the above named product complies with Article 9 of Regulation (EC) No 834/2007 regarding the prohibition on the use of GMOs. I undertake to inform our customer and its control body/authority immediately if this declaration is withdrawn or modified, or if any information comes to light which would undermine its accuracy. I authorise the control body or control authority, as defined in Article 2 of Council Regulation (EC) No 834/2007, which supervises our customer to examine the accuracy of this declaration and if necessary to take samples for analytic proof. I also accept that this task may be carried out by an independent institution which has been appointed in writing by the control body. The undersigned takes responsibility for the accuracy of this declaration.	
Country, place, date, signature of vendor:	Company stamp of vendor (*if appropriate*):

ANNEX XIV

Correlation Table referred to in Article 96

Regulation (EEC) No 2092/91	(1) Regulation (EC) No 207/93 (2) Regulation (EC) No 223/2003 (3) Regulation (EC) No 1452/2003	This Regulation
—		Article 1
—		Article 2(a)
Article 4(15)		Article 2(b)
Annex III, C (first indent)		Article 2(c)
Annex III, C (second indent)		Article 2(d)
—		Article 2(e)
—		Article 2(f)
—		Article 2(g)
—		Article 2(h)
Article 4(24)		Article 2(i)
—		Article 3(1)
Annex I.B, 7.1 and 7.2		Article 3(2)
Annex I.B, 7.4		Article 3(3)
Annex I.A, 2.4		Article 3(4)
Annex I.A, 2.3		Article 3(5)
—		Article 4
Article 6(1), Annex I.A, 3		Article 5
Annex I.A, 5		Article 6
Annex I.B and C (titles)		Article 7
Annex I.B, 3.1		Article 8(1)
Annex I.C, 3.1		Article 8(2)
Annex I.B, 3.4, 3.8, 3.9, 3.10, 3.11		Article 9(1) to (4)
Annex I.C, 3.6		Article 9(5)
Annex I.B, 8.1.1		Article 10(1)
Annex I.B, 8.2.1		Article 10(2)
Annex I.B, 8.2.2		Article 10(3)
Annex I.B, 8.2.3		Article 10(4)
Annex I.B, 8.3.5		Article 11(1)
Annex I.B, 8.3.6		Article 11(2)
Annex I.B, 8.3.7		Article 11(3)
Annex I.B, 8.3.8		Article 11(4), (5)
Annex I.B, 6.1.9, 8.4.1 to 8.4.5		Article 12(1) to (4)
Annex I.B, 6.1.9		Article 12(5)

Regulation (EEC) No 2092/91	(1) Regulation (EC) No 207/93 (2) Regulation (EC) No 223/2003 (3) Regulation (EC) No 1452/2003	This Regulation
Annex I.C, 4, 8.1 to 8.5		Article 13
Annex I.B, 8.1.2		Article 14
Annex I.B, 7.1, 7.2		Article 15
Annex I.B, 1.2		Article 16
Annex I.B, 1.6		Article 17(1)
Annex I.B, 1.7		Article 17(2)
Annex I.B, 1.8		Article 17(3)
Annex I.B, 4.10		Article 17(4)
Annex I.B, 6.1.2		Article 18(1)
Annex I.B, 6.1.3		Article 18(2)
Annex I.C, 7.2		Article 18(3)
Annex I.B, 6.2.1		Article 18(4)
Annex I.B, 4.3		Article 19(1)
Annex I.C, 5.1, 5.2		Article 19(2) to (4)
Annex I.B, 4.1, 4.5, 4.7 and 4.11		Article 20
Annex I.B, 4.4		Article 21
Article 7		Article 22
Annex I.B, 3.13, 5.4, 8.2.5 and 8.4.6		Article 23
Annex I.B, 5.3, 5.4, 5.7 and 5.8		Article 24
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Annex III, E.3 and B		Article 26
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Annex III.7		Article 31
Annex III, E.5		Article 32
Annex III.7a		Article 33
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Annex III.8 and A.2.5		Article 35
Annex I.A, 1.1 to 1.4		Article 36
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Annex I.B, 2.1.1, 2.2.1,2.3 and Annex I.C, 2.1, 2.3		Article 38
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Regulation (EEC) No 2092/91	(1) Regulation (EC) No 207/93 (2) Regulation (EC) No 223/2003 (3) Regulation (EC) No 1452/2003	This Regulation
Annex I.B, 3.4 (first indent and 3.6(b))		Article 42
Annex I.B, 4.8		Article 43
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	(3): Article 1(1), (2)	Article 45(1), (2)
	(3): Article 3(a)	Article 45(1)
	(3): Article 4	Article 45(3)
	(3): Article 5(1)	Article 45(4)
	(3): Article 5(2)	Article 45(5)
	(3): Article 5(3)	Article 45(6)
	(3): Article 5(4)	Article 45(7)
	(3): Article 5(5)	Article 45(8)
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	(3): Article 7	Article 49
	(3): Article 8(1)	Article 50(1)
	(3): Article 8(2)	Article 50(2)
	(3): Article 9(1)	Article 51(1)
	(3): Article 9(2), (3)	Article 51(2)
		Article 51(3)
	(3): Article 10	Article 52
	(3): Article 11	Article 53
	(3): Article 12(1)	Article 54(1)
	(3): Article 12(2)	Article 54(2)
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	(2): Article 1 and Article 5	Article 59
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Regulation (EEC) No 2092/91	(1) Regulation (EC) No 207/93 (2) Regulation (EC) No 223/2003 (3) Regulation (EC) No 1452/2003	This Regulation
Annex III.5		Article 65
Annex III.6		Article 66
Annex III.10		Article 67
—		Article 68
—		Article 69
Annex III, A.1.		Article 70
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Annex III, A.2.1		Article 74
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Annex III, A.2.3		Article 76
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Annex III, E		Article 87
Annex III, E.1		Article 88
Annex III, E.2		Article 89
Annex III, E.4		Article 90
Annex III, 9		Article 91
Annex III, 11		Article 92
		Article 93
—		Article 94
Annex I.B, 6.1.5		Article 95(1)
Annex I.B, 8.5.1		Article 95(2)
—		Article 95(3)-(8)
—		Article 95
—		Article 96
—		Article 97
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Regulation (EEC) No 2092/91	(1) Regulation (EC) No 207/93 (2) Regulation (EC) No 223/2003 (3) Regulation (EC) No 1452/2003	This Regulation
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Annex VIII		Annex III
Annex VII		Annex IV
Annex II, part C		Annex V
Annex II, part D		Annex VI
Annex II, part E		Annex VII
Annex VI, part A and B		Annex VIII
Annex VI, part C		Annex IX
—		Annex X
—		Annex XI
—		Annex XIII
—		Annex IX

Rev. Fac. Agron. (LUZ). 2000, 17: 318-326

Effects of vinasse on sugarcane (*Saccharum officinarum*) productivity[1]

Efecto de la vinasa en la productividad de la caña de azúcar (*Saccharum officinarum*)

J. Gómez y O. Rodríguez[2]

Abstract

Vinasse is a corrosive and contaminant industrial liquid residue from alcohol distillation. Vinasse contains high levels of organic matter, potassium, calcium and moderate amounts of nitrogen and phosphorus. The effects of several applications of mineral fertilization combined with vinasse on sugarcane productivity were evaluated, on plant-cane, first and second ratoon seasons (92-95). The experiment was established using a randomized split plot design with four replications. Treatments consisted of 3 chemical fertilizer doses in the main plots as: F0= 0 kg ha^{-1}; F1= 180 kg ha^{-1} N + 160 kg.ha^{-1} P_2O_5 + 220 kg ha^{-1} K_2O; F3= 80 kg ha^{-1} N + 45 kg.ha^{-1} P_2O_5 combined with 5 vinasse doses in the subplots as V0=0 $m^3.ha^{-1}$, V1=25 $m^3.ha^{-1}$, V2=50 $m^3.ha^{-1}$, V3=75 $m^3.ha^{-1}$ and V4=100 m^3 ha^{-1}. Sugar and cane yields increased with application of vinasse. Best results were obtained when using vinasse as 50 m^3 ha^{-1} on plant-cane and 100 m^3 ha^{-1} on first and second ratoons. The N, P_2O_5 and K_2O sugarcane demands were supplied by the 50 m^3 ha^{-1} vinasse dose (V2) in proportions of 55%, 72% and 100% respectively. Vinasse application demonstrated its efficiency as fertilizer material as well as reducing vinasse contaminant effects to waterways.

Key words: contaminants, fertilizer, nutrients, yield, sugarcane, vinasse.

Resumen

La vinasa es un residuo industrial líquido de la destilación del alcohol, altamente corrosivo y contaminante. La vinasa contiene elevados niveles de potasio, calcio y materia orgánica disuelta, así como niveles medios de nitrógeno y fósforo. En este trabajo realizado durante los años 92-95 en plantilla, primera y segunda soca de caña de azúcar, se estudiaron los efectos de la aplicación de varias dosis de vinasa en combinación con la fertilización mineral, sobre la productividad del cultivo. Se utilizó un diseño experimental completamente aleatorizado en parcelas divididas, con cuatro repeticiones. Los tratamientos fueron tres niveles de

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Recibido el 18-10-1999 ● Aceptado el 20-3-2001

[1] Financiamiento por CDCHT-UCLA y convenio CONICIT-UCLA F-57

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fertilización mineral (F0= 0 kg ha^{-1}; F1= 180 kg ha^{-1} N + 160 kg ha^{-1} P_2O_5 + 220 kg ha^{-1} K_2O; F3= 80 kg.ha^{-1} N + 45 kg ha^{-1} P_2O_5 combinados con cinco niveles de vinasa en las sub-parcelas, V0=0 m^3 ha^{-1}, V1=25 m^3.ha^{-1}, V2=50 m^3 ha^{-1}, V2=75 m^3 ha^{-1}, V5=100 m^3 ha^{-1}. El rendimiento en azúcar y en caña fue incrementado con la aplicación de la vinasa. Los mejores resultados fueron obtenidos con la aplicación de vinasa a niveles de 50 m^3 ha^{-1} en plantilla y de 100 m^3 ha^{-1} en primera y segunda soca. Los resultados demuestran que las demandas de N, P_2O_5 y K_2O de la caña de azúcar, fueron suministradas por la dosis de 50 m^3 ha^{-1} de vinasa, en proporción de 55 %, 72 % y 100 %, respectivamente. Los resultados de la aplicación de vinasa demostraron su eficacia como material fertilizante y la reducción de su efecto contaminante a las vías de agua.

Palabras clave: contaminantes, fertilizantes, nutrientes, rendimiento, caña de azucar, vinasa.

Introduction

One of the factors affecting sugarcane productivity is fertilization. However, mineral fertilizers have significantly increased their prices. As a result, it has become necessary to seek alternatives that would supply the soil with more economic nutrients.

The Turbio river plain in Lara state, Venezuela, is an important sugarcane production area (4). Several sugarcane alcohol distilleries are located in Lara state. Vinasse is a by-product of distilleries during alcohol production. In terms of volume, approximately 13 L of vinasse are produced by each L of alcohol obtained from cane must (3). Vinasse is a residue highly corrosive and contaminant to water sources (2, 3). According information (personal communications) of the Department of Environmental Control of *Licorerias Unidas S.A.* and the Department of Quality Control of *Alcoholes Occidente C.A.*, two local distilleries, they respectively produce around 1.000.000 and 700.000 L by day of vinasse, which disposition is a locally relevant affair.

Vinasse has high levels of potassium, calcium and organic matter in its chemical composition as well as moderate amounts of nitrogen and phosphorus (5) and could represent an alternative to supply such nutrients in crop production (4, 5).

Various research works carried out in other countries, particularly in Brazil, report that vinasse increases sugarcane productivity (2, 3, 5, 7) as well as they have demostrated that under controlled conditions, it can partially or completely replace mineral fertilization.

Current reports of vinasse research come from regions with different topography, climate and soil conditions to the areas where sugarcane is cultivated in Venezuela, so those experiences cannot be directly extrapolated to our conditions (2, 4, 6, 7, 9, 10). It is therefore necessary to adapt the technology of using vinasse in sugarcane production to the Turbio river plain conditions, by setting up research that determines the effects of vinasse as a fertilizer in sugarcane cultivation.

The former statements constitute the general framework of the current work. So the objectives of this work are:

1. To compare the use of vinasse as a fertilizer source versus a conventional mineral fertilizer application in a soil of the Turbio river valley.

2. To determine the effect of application of different doses of vinasse on yield and quality of the sugarcane crop in a soil of the Turbio river valley.

Materials and methods

This work was carried out as a three years field experiment (plant-cane, first ratoon and second ratoon), from 1992 to 1995, on a representative soil of the Turbio river plain sugarcane producing area in Lara state, Venezuela. According the Soil Taxonomy system of soil classification, the soil is a Fluventic Ustropept with the following properties; clay loam texture; moderately alkaline pH (7,4); moderately high salinity with EC (1:2) of 1,9 dS m^{-1}; low value of organic matter (3,1 %); moderately high CEC (23 cmol kg^{-1}); low P content (6 mg kg^{-1}); high Ca content (22.187 mg kg^{-1}); medium Mg content (343 mg kg^{-1}); low K content (46 mg kg^{-1}); good external and internal drainage (6).

A PR 980 sugarcane variety was used for the experiment. The experimental design used was a completely randomized with 4 replications. The treatment design was a split plot where 3 levels of chemical fertilizers (F) were assigned to the main plots and 5 levels of vinasse (V) were assigned to the subplots.

The doses of chemical fertilizer used were as follows:

FO= No chemical fertilizer use.

F1= 180 kg ha^{-1} of N + 160 kg ha^{-1} P_2O_5 + 220 kg ha^{-1} K_2O. These are the amounts of fertilizer usually applied in the area.

F2 = Complementary fertilization, using 80 kg ha^{-1} of N + 45 kg ha^{-1} of P_2O_5.

The following doses of vinasse were applied in the subplots as:

VO=0 m^3 ha^{-1}
V1=25 m^3 ha^{-1}
V2=50 m^3 ha^{-1}
V3=75 m^3 ha^{-1}
V4=100 m^3 ha^{-1}

For the first, second and third growing cycles (plant-cane, first ratoon and second ratoon, respectively), N and K doses were divided in two applications, half at the beginning and 45 days later, the other half. All P was applied at the beginning of each cycle. For plant-cane, first ratoon and second ratoon respectively, the dose of vinasse was divided in two applications, half 10 days after beginning the cycle and the other half, 45 days after the first application.

The vinasse was manually applied using 20 L plastic containers. The crop was irrigated the day after the application of vinasse.

Vinasse from a local distillery was used and analysis of N, P, K, Ca, Mg, pH and organic matter were performed according American Society for Testing and Materials (1) Vinasse analysis reports are the following: N (2 kg m^{-3}); P_2O_5 (2,3 kg m^{-3}); K_2O (7,5 kg m^{-3}), pH (4,2); organic matter (98,1 %).

Twenty stalks of the two central rows of each subplot were randomly harvested and weighed immediately. Sugar concentration was determined in sub samples taken from the biomass harvested in each plot. The results obtained are expressed in mg ha^{-1} of cane and in mg ha^{-1} of sugar.

Data were analyzed for significant differences using a split-plot analysis of variance and Duncan multiple range tests were used to separate means.

Results and discussion

The average yield of cane per ha for the different treatments are presented in table 1. There, it could be observed that for plant-cane, in the treatments where no chemical fertilizers are added (F0V0, F0V1, F0V2, F0V3, F0V4), a successive increase in cane yield is obtained with the successive increases in vinasse application. For first and second ratoon, the increase in yield also occurs with the application of vinasse as compared with its no application. The application of 100 m^3 ha^{-1} (F0V4), increased cane yield in 27 % for plant-cane, 23 % in first ratoon and 65 % in second ratoon in relationship with the treatment F0V0.

Variance analysis performed to these data showed that for cane yield on plant-cane, there were statistic high significant differences (1%) for vinasse application (V) and statistic significant differences (5%) for the interaction between the chemical fertilizer and vinasse (FxV). For the first ratoon, there were significant statistic differences for the chemical fertilizer (F), for vinasse (V) and for the interaction between the chemical fertilizer and vinasse (FxV). For the second ratoon, there were statistic high significant differences for the chemical fertilizer (F), for vinasse (V) and for the interaction between the chemical fertilizer and vinasse (FxV).

The average sugar yield per ha of the different treatments, are presented in table 2. In the treatments where no chemical fertilizers are added (F0V0, F0V1, F0V2, F0V3, F0V4), the sugar yield is increased in all the treatments where vinasse is applied as compared with no application. The application of 100 m^3 ha^{-1} (F0V4), increased sugar yield in 22 % for plant-cane, 30 % in first ratoon and 63 % in second ratoon in relationship with the treatment F0V0.

Variance analysis performed to these data showed that for sugar yield on plant-cane cycle, there were statistic high significant differences (1%) for vinasse application (V) and statistic significant differences (5%) for the interaction between the chemical fertilizer and vinasse (FxV). For the first ratoon, there were statistic high significant differences for the chemical fertilizer (F) and for vinasse (V) treatments. For the second ratoon, there were statistic high significant differences for the chemical fertilizer (F), for vinasse (V) and statistic significant differences for the interaction between the chemical fertilizer and vinasse (FxV).

Table 1. Average cane yield for the different chemical fertilizer and vinasse doses.

	Cane Yield (mg ha^{-1})		
Treatment	Plant-cane	First ratoon	Second ratoon
F0VO	94	77	51
FOV1	116	86	59
FOV2	112	96	75
FOV3	116	82	71
FOV4	119	95	84
F1V0	95	96	89
F1V1	105	100	110
F1V2	140	105	100
F1V3	124	106	99
F1V4	139	110	111
F2V0	93	80	69
F2V1	112	100	81
F2V2	136	103	72
F2V3	97	94	87
F2V4	94	109	100

Table 2. Average sugar yield for the different chemical fertilizer and vinasse doses.

	Sugar yield (mg ha^{-1})		
Treatment	Plant-cane	First ratoon	Second ratoon
F0VO	9,56	6,56	5,45
FOV1	12,79	7,68	6,41
FOV2	11,75	8,52	8,15
FOV3	12,95	7,83	7,75
FOV4	11,65	8,52	8,91
F1V0	11,22	9,09	9,75
F1V1	10,83	9,86	12,36
F1V2	15,61	10,17	10,03
F1V3	13,63	10,03	10,61
F1V4	14,69	10,72	12,71
F2V0	9,54	7,53	7,39
F2V1	12,43	9,79	9,06
F2V2	14,69	9,57	7,55
F2V3	9,87	9,36	10,11
F2V4	9,53	10,73	10,68

The data on table 1 and table 2 shows that yield of cane and sugar of the crop is always larger in plant-cane, and decreases with successive ratoons. This is the common trend of yield on sugar cane production (2, 3, 8, 10).

Results expressed as mean yields in cane per hectare for the different doses of vinasse applied over the three cultivation cycles are shown in table 3.

Table 3 shows that in the case of plant-cane and first ratoon, application of 50 m^3 ha^{-1} (V2) and 100 m^3 ha^{-1} (V4) of vinasse, significantively increased average cane yield. For second ratoon, all the vinasse doses used increased cane yield. In relative terms, the data shows that application of 50 $m^3.ha^{-1}$ of vinasse (table 3), increased cane yield by 38% as compared with the control sample (0 m^3 ha^{-1}). For first ratoon and second ratoon, the application of 100 m^3 ha^{-1} increased average cane yield by 24% and 38% respectively as compared with the control sample (F0V0).

These results show that the use of vinasse could be effectively used to increase the sugarcane yield. Similar results were reported by Rossetto (9), who obtained the best yield in cane per hectare when applied 60 m^3 ha^{-1} of vinasse on plant-cane growing cycle. COPERSUCAR (2), reported that application of vinasse to cane ratoons over three consecutive years, resulted in an increase in yield with a dose of 90 m^3 ha^{-1} as compared with no vinasse application.

Results expressed as mean yields in sugar per hectare for the different doses of vinasse applied over three consecutive production cycles are shown in table 4.

Application of 50 m^3 ha^{-1} of vinasse (V2) to plant-cane cycle, increased sugar yield (table 4), in yield of 39% conpored with control treatment (V0). For the first ratoon and for the second ratoon, the application of 100 $m^3.ha^{-1}$ of vinasse (V4), also increased average sugar yield (table 4), the increase being 30% and 43% respectively as compared with the control treatment (0 m^3 ha^{-1}). These results show that the application of vinasse as compared with the control sample, increased sugar yield.

Table 5 shows some advantages of using vinasse as a fertilizer. The table 5 shows that for plant-cane, the application of 80 kg ha^{-1} of N and 45 kg ha^{-1} of P_2O_5 supplemented by 50 m^3 ha^{-1} of vinasse (F2V2), increased yield in 41 mg ha^{-1} of cane and in 3,47 mg ha^{-1} of sugar as compared with F1V0. That is, using vinasse as complement fertilizer on plant-cane, resulted in a yield increase of 43% in cane and 31% in sugar as compared with mineral fertilization.

On first ratoon, use of 80 $kg.ha^{-1}$ of N and 45 kg ha^{-1} of P_2O_5 plus 100 m^3 ha^{-1} of vinasse (F2V4), increased yield in 13 mg ha^{-1} of cane and in 1,64 mg ha^{-1} of sugar as compared with mineral fertilization (F1V0). That is using vinasse as complement fertilizer resulted in a 13% increase in cane and 18% increase in sugar yield as compared with solo mineral fertilization (F1V0).

In second ratoon, the treatment F2V4, increased yield in 11 mg ha^{-1} of cane and in 0,93 mg ha^{-1} of sugar as compared with the treatment F1V0 (table 5). On second ratoon, using vinasse as complement fertilizer re-

Table 3. Sub plots (vinasse) effect on cane yields as compared by using a Duncan multiple range test*.

Treatment & Vinasse Dose ($m^3.ha^{-1}$)		Cane Yield ($mg\ ha^{-1}$) Production cycles		
		Plant-cane **	First Ratoon *	Second Ratoon **
V0	0	93,67 b	84,17 b	69,33 c
V1	25	110,92 ab	95,58 ab	83,65 b
V2	50	129,33 a	101,42 a	82,37 b
V3	75	112,17 ab	94,00 ab	85,92 b
V4	100	117,33 a	104,75 a	95,69 a

* Statistic differences at 5% level.

** Statistic differences at 1% level.

Data with same letters in each column are not statistically different from each other.

sulted in a 12% in cane and 10% in sugar yields as compared with solo mineral fertilization (table 5).

These results demonstrated that by using vinasse as a complement fertilizer, sugarcane productivity increases as cane and sugar production per hectare is increased.

As the vinasse used in this experiment has a content of 2 kg m^{-3} of N, 2,3 kg m^{-3} of P_2O_5 and 7,5 kg m^{-3} of K_2O, the analysis of these data suggests that with the dose of 50 $m^3\ ha^{-1}$ of vinasse, 55% of the N, 72% of the P_2O_5 and 100% of the K_2O provided by the mineral fertilization could be replaced by the vinasse.

Comparing the mineral fertilizer dose usually applied in the river Turbio plain area (F1V0), with the use of vinasse, the data suggests that application of vinasse as complement fertilizer (F2V4), increases sugarcane productivity because both, the yield of

Table 4. Sub plots (vinasse) effect on sugar yield as compared by using a Duncan multiple range test.*

Treatment & Vinasse Dose ($m^3\ ha^{-1}$)		Sugar Yield ($mg\ ha^{-1}$) Production cycles		
		Plant-cane **	First Ratoon **	Second Ratoon **
V0	0	10,11 b	7,73 b	7,53 c
V1	25	12,02 ab	9,11 ab	9,37 b
V2	50	14,01 a	9,42 a	8,91 b
V3	75	12,15 ab	9,07 ab	9,49 ab
V4	100	11,96 ab	10,07 a	10,77 a

** Statistic differences at 1% level.

Data with same letters in each column are not statistically different from each other.

Table 5. Comparison of mineral fertilization (F1V0) usually applied for sugarcane in the area against application of 50 m^3.ha^{-1} vinasse (F2V4) plus complementary mineral fertilization.

Treatment	Production			
	Cane mg ha^{-1}	Sugar mg ha^{-1}	Increase (%) Cane	 Sugar
Plant				
F1 VO: 180 kg ha^{-1} N+160 kg ha^{-1} P_20_5+220 kg ha^{-1} K_20	95	11,22		
F2 V2: 80 kg ha^{-1} N+45 kg ha^{-1} P_20_5+50 m^3 ha^{-1}Vinasse	136	14,69	43	31
Ratoon I				
F1 VO: 180 kg ha^{-1} N+160 kg ha^{-1} P205+ 50 kg ha^{-1} K_20	96	9,09		
F2 V4: 80 kg ha^{-1} N+45 kg/ha P_20_5+100 m^3 ha^{-1} Vinasse	109	10,73	13	18
Ratoon II				
F1 VO: 180 kg ha^{-1} N+160 kg ha^{-1} P_20_5 + 50 kg ha^{-1} K_20	89	9,75		
F2 V4:80 kg ha^{-1} N+45 kg ha^{-1} P_20_5+100 m^3 ha^{-1} Vinasse	100	10,68	12	10

the crop and the yield in sugar per hectare were significantly increased (table 5).

The application of vinasse to the soils for sugarcane fertilization reduces its disposition in waterways and so its contaminant effects besides increasing sugarcane yields and reducing fertilizer expenses.

Conclusions

Vinasse increased sugarcane productivity because the yield of the crop and the yield in sugar per hectare were both significantly increased.

Highest yields were obtained when 50 m^3 ha^{-1} of vinasse were incorporated for plant-cane cycle and 100 m^3 ha^{-1} of vinasse for first and second ratoons.

With the use of vinasse as a fertilizer, acceptable sugarcane yields were obtained without the addition of mineral fertilizer. However, it was found that mineral fertilizer plus vinasse as a complement was necessary to reach higher production levels.

The application of 50 m^3 ha^{-1} vinasse would substitute for 55% of the N, 72% of the P_2O_5 and 100% of the K_2O that has to be applied using mineral fertilization.

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Journal of Applied Microbiology 1998, **84**, 921–928

A REVIEW

Microbial flora of rum fermentation media

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6171/04/97: received 2 April 1997, revised 17 July 1997 and accepted 31 July 1997

1. INTRODUCTION

Rum is the alcoholic beverage made exclusively from sugar cane (*Saccharum officinarum* L.) juice and its by-products (molasses from the manufacture of cane sugar or syrups). The first stage of rum-making is an alcoholic fermentation of musts made of raw materials diluted with water. The fermented media are then distilled. The distillates are matured for a few days up to several years in tanks, wooden vats or oak casks, before being reduced, by water dilution, to a commercial alcoholic strength (Fahrasmane *et al.* 1996).

In rum production, the alcoholic fermentation is performed through the action of yeasts, traditionally comprising *Saccharomyces* strains and, depending on the type of rum, *Schizosaccharomyces* strains. Bacteria that are found mainly in raw materials (cane juice and molasses as well as dilution waters) have metabolic activity simultaneously with the ethanol-producing yeast flora during the alcoholic fermentation, interact with its kinetics and biochemistry and affect the organoleptic properties of rums (Table 1).

The nature and abundance of the bacterial flora depend on the sanitary status of the raw material and the must components.

The bacteriostatic or sterilizing thermal treatment of must components and the acidification of the media, as well as the use of antibiotics and fermentation yeasts, make it possible to control the bacterial flora, which produces aromatic compounds. Some of these compounds (acrylic acid, acrolein, etc.) may be detrimental to the organoleptic properties of the rum and be a source of unwanted specific toxicity.

Rum fermentation media containing yeast and bacterial flora of the ‘wild’ type are natural ecosystems giving rise to flavours in the rum, so that it possesses distinctive features linked to the local natural environment.

In the present study carried out on Guadeloupe, Martinique and Haiti, a list was established of the microbial flora of molasses or cane sugar-based fermentation media, while the dynamics of the bacterial population during the fermentation cycle were also investigated. Bacterial overpopulation affecting the organoleptic properties of the products was analysed and technical information is provided for the control of bacterial populations at levels that enable the production of aromatic rums.

The results and data presented are a synthesis of 20 years' work. Consequently taxonomic references are not the most recent.

2. RUM TECHNOLOGY EVOLUTION AND MICROBIOLOGY

At the end of the 15th century, Christopher Colombus, representing Genoese and Venetian interests, prospected for areas in America better adapted to sugar cane crops than the Mediterranean islands and shores. As a result, rum production started with the expansion of sugar cane cropping on the American continent from the 16th century onwards. Molasses, a by-product of cane sugar manufacture, were a source of fermentable sugars.

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Table 1 Features of the four main types of rum

	Rhum agricole	Rhum industriel	Heavy-flavour rum	Light-flavour rum
Raw materials	Sugar cane juice	Molasses	Molasses	Molasses
NA	>225	>225	>800 (Ester >500)	<225
Distillation type	Simple, continuous column	Simple, continuous column	Simple, continuous column	Rectification, multistage column
Fermentation type	Mixed	Mixed	Mixed	Pure
Microbial flora	Bacteria, *Saccharomyces*	Bacteria, *Saccharomyces*	Bacteria, *Schizosaccharomyces*	*Saccharomyces*

NA, non-alcohol (volatile compounds other than ethanol); values are in g hl^{-1} pure alcohol.

In those days, musts, rum fermentation media, were generally composed of 10–15% molasses by volume, 40–70% stillage, the residuary liquor from distillation otherwise named slop or spent wash, and water. Under these conditions, 'wild' fermentation is able to start spontaneously; micro-organisms show good resistance to previous handling during the manufacture of sugar (heating, clarification, etc.) and to competitors brought in with the wooden vats used for molasses fermentation but not cleaned out after previous operations. They arise in composition ponds and then become active during fermentation. Nowadays, 'rhum industriel' (made from molasses) results from the evolution of this kind of production.

Towards the middle of the 19th century, another system of rum production was developed in which the source of sugar was no longer molasses, but raw or boiled sugar cane juice as well as syrups. In fact, syrup was probably used as far back as the 18th century. This system originated from the slump in the sugar market and marked the beginning of 'rhum agricole' (made from sugar cane juice) production on plantations that were independent of sugar-manufacturers. The percentage of stillage in the must composition was lower (10–30%) than in molasses-based rum production. The fermentation flora was of the 'wild' type with elliptical yeast strains.

The composition and therefore the flora of rum fermentation media changed in the course of time in relation to technical and economic factors, control of water resources and increasing experience in microbiology. These changes in production processes, just as the move from still to column distillation during the 19th century, modified the composition and the organoleptic properties of rums.

Four types of rum are determined by raw materials, microbiology of the fermentation media and distillation. They are as follows (Table 1): 'rhum agricole'; 'rhum industriel'; light-flavour rum and heavy-flavour rum.

The physico-chemical conditions of the media have always largely determined the microbiology and the course of the fermentation process; acidity and non-sugar components are of primary importance in the 'wildness' of fermentation involving *Schizosaccharomyces*, while the non-sugar content has a considerable effect on the yield of the sugar–alcohol transformation; temperature (26–35 °C) has a substantial influence on the nature and importance of bacterial flora metabolites. These factors contribute to rum characteristics.

In addition to the microbial aspects, the yield of the sugar–alcohol transformation has a large variability both in rum and bioethanol production. The sugar content of the musts is generally about 100 g l^{-1}, while the fermentation cycle ranges from 18 to 40 h. In 1917, Magne showed that the considerable variations in yield for molasses were related to yeasting conditions: pure yeast 85–95% of Pasteur yield; yeast with antiseptic 70–85%; pressed yeast 50–75% and 'wild' fermentation 40–60%.

During the treatment of sugar cane stalks in distilleries, nearly half of all the losses of yield of alcohol occurs during the fermentation stage (Table 2).

Table 2 Losses at different stages of the process in the rum distillery as percent of ethanol equivalent

	Losses	
Operation	Ethanol production in Brazil*	Rum production in F.W.I.†
Extraction/crushing	6·0	9·0
Clarification	2·0	—
Fermentation	10·0	12·5
Distillation	3·0	0·9
Others	—	2·0

*According to Ebeling (1989).

†Means for 39 samples from 13 cottage distilleries in the French West Indies (F.W.I.).

Measurements of the sugar–alcohol yield in fermentation media containing molasses, syrup or cane juice in a given rum distillery indicate that the variations depend on the raw material used (Destruhaut *et al.* 1985): Gay-Lussac yield, 0·64 l of pure alcohol (lPA) kg^{-1} glucose; Pasteur yield, 0·61 lPA kg^{-1} glucose; theoretical maximal yield, 0·59 lPA kg^{-1} glucose (97% of Pasteur yield); yield on molasses, 0·52 lPA kg^{-1} glucose (85% of Pasteur yield); yield on cane juice, 0·47 lPA kg^{-1} glucose (77% of Pasteur yield); yield on syrup, 0·40 lPA kg^{-1} glucose (66% of Pasteur yield).

In Brazil, the average yield is 0·53 lPA kg^{-1} glucose in bioethanol produced from cane juice and enriched by the addition of concentrate or molasses (Ebeling 1989) (Table 2).

From sugar beet, in the same ethanol production system, Allar and de Miniac (1985) obtained yields of 0·59 and 0·60 with molasses using condensed recycling and with waste water involving slop recycling, respectively.

These figures indicate that, being higher in molasses, the non-sugar component in raw materials is a nutrient source as well as a factor affecting fermentation yield. A significant improvement in rum yields is also possible.

The spectra of short-chain fatty acids of rums show a particular pattern, both in terms of quality as well as quantity, resulting from the bacterial activity in fermentation media; these compounds contribute to the formation of esters. Propionic, butyric and valeric acid levels are particularly high in rums compared with other spirits (Suomalainen 1975). Propenoic acid indicates an intense bacterial activity (Fahrasmane *et al.* 1983). Formic acid can provide information on the conditions of rum production and also contribute to quality evaluation; an increase in formic acid content often reveals bacterial problems (Jouret *et al.* 1990).

3. YEASTS IN RUM PRODUCTION

Greg (1895) in Jamaica and Pairault (1903) in the French West Indies, especially in Martinique, followed by Allan (1906) and Ashby (1909) in Jamaica and then Kayser (1917) in the French West Indies were among the few researchers in a position to observe that *Schizosaccharomyces* strains are the only alcoholic yeasts to develop in molasses- and slop-based fermentation media in which acidity is due to the addition of slops. The osmotic pressure is prejudicial to the activity of elliptic yeasts. The latter yeasts (*Saccharomyces, Torula, Zygosaccharomyces*, etc.) are active in media in which the slop content is low or replaced by water.

3.1 Evolution of the yeast flora

Bryan Higgins, an Irish naturalist, was the first to study rum production in Jamaica in a scientific way. His work (1799–1803) is considered as a classic reference. About 100 years later, in Jamaica, the Englishman Greg (1895), who studied microbiology with the Danish workers Hansen and Jorgensen, published several articles on the subject. At the beginning of the 20th century, in Martinique, Pairault (1903), the head chemist of the French colonial army, came to the conclusion that 'wild' yeast should imperatively be replaced by pure fermentations. Kayser, the director of the fermentation laboratory at the Institut Pasteur in Paris, carried out a detailed survey of rum yeasts in 1913. As a result, he advocated pure fermentation with selected yeasts. These researchers, who thought that the bacterial flora adversely influenced rum fermentation, were especially concerned with improving productivity. On the contrary, two chemists who studied rum production in Jamaica (Allan 1905; Ashby 1907) agreed on the leading role of bacteria in the aroma development of heavy-flavour rums.

After 1918, some distillers in the French West Indies who wanted to increase the alcoholic yield decided to put into practice the advice of Pairault and Kayser on pure fermentations. Although the result was an increase in yields, the quality of these products evidently fell because of their increased chemical neutrality. Rocques (1927) was commissioned by the French Ministry of Agriculture to carry out a study which concluded that 'rums produced from pure and rapid fermentations are characterized by low levels of acid and ester as well as relatively high contents in the higher alcohols'.

Most rum producers subsequently gave up the use of selected yeasts and decided that 'wild' fermentations gave the best results, by producing rums with richer flavour.

Arroyo (1945), working in Puerto Rico, thought that controversies about the seeding of fermentation media and the role of bacteria in rum production were due to misunderstandings and over-hasty generalizations. Indeed, production targets in organoleptic properties seemed not to have been taken into account in choosing the correct moment for modification of the fermentation stage. Therefore, this scientist considered that some bacterial species, which can be found to a certain extent according to the kind of rum produced, increased the volume and the persistence of the aroma.

Kervegant (1946) wrote an account of the history and state of the art in this field in his 500-page book entitled *Rhums et eaux-de-vie de canne*.

In the 1970s in the French West Indies, operators attempting to control fermentation risks (cessation, prolongation and acidification) decided to use dried baker's yeast—a cheap and easily available commodity—as a booster to alcoholic fermentation. Moreover, production was moving towards lighter products to meet the market demand and, as a result, slops were no longer used in must composition.

According to a classification of 'wild' yeasts drawn up by Parfait and Sabin (1975) (Table 3), *Schizosaccharomyces* yeasts can only be found in the fermentation media used in heavy-flavour rum production. *Saccharomyces* are alcoholic agents

Table 3 Occurrence of yeast strains in the raw material, must and stillage in 26 samples (10 from plant using molasses and 16 using cane juice)

Isolated yeasts	Raw material	Must	Stillage
Saccharomyces cerevisiae	10	19	15
Saccharomyces chevalieri	3	5	4
Saccharomyces rouxii	1	1	1
Saccharomyces aceti	1	5	3
Saccharomyces microellipsodes		1	
Saccharomyces delbruckii		1	
Saccharomyces carlsbergensis		2	1
Schizosaccharomyces pombe		1	1
Pichia membranaefaciens			1
Hansenula anomala	2	2	2
Hansenula minuta			1
Candida krusei	1		2
Candida pseudotropicalis	1		
Candida tropicalis	1		
Torulopsis candida	2		
Torulopsis globusa	3		1
Torulopsis glabrata	4	2	3
Torulopsis stellata	1	1	

From Parfait and Sabin (1975). Identifications according to Lodder (1970).

in 'wild' fermentation media as well as seeded media in which the slop content is low or, as in most cases, not used.

An inquiry carried out in the early 1970s into Haitian distilleries, where fermentations were obtained from cane juice diluted with stillage, showed that *Schizosaccharomyces* were found as the alcoholic fermentation yeast (Fahrasmane *et al.* 1988). Three species were identified from 60 samples. Under Lodder's nomenclature, they were classified as follows: *Schizosaccharomyces pombe* LINDNER (55 samples); *S. malidevorans* RANKINE and FORNACHON (four samples) and *S. japonicus* YAKAWA and MAKI (one sample).

After a more recent classification by Barnett *et al.* (1990), *S. pombe* and *S. malidevorans* are considered as the same species, i.e. *S. pombe*. *Schizosaccharomyces japonicus* has been renamed as *Hasegawea japonica* YAMADA and BANNO. The latter yeast species has a low fermenting capacity and relatively slow kinetics compared with the other *Schizosacharomyces* species tested in the laboratory.

As early as 1945, Arroyo pointed out that economic necessities such as production standardization would lead to fermentation control through selected yeasts.

3.2 Prospects

The selection of rum yeasts from 'wild' strains of sugar cane-based media is now under way at our laboratory. We are currently developing protocols for the use of these strains. One of our strains has the characteristic of high temperature resistance (36 °C). Among our comparative works for rum yeast selection, the best results were obtained with a local strain. The world's first selected rum yeast from our collection, a *Saccharomyces cerevisiae* var. *cerevisiae*, is marketed by Lallemand Inc. under the appellation Danstill 493 EDV. Attempts are being made to define the characteristics of a 'fermenting' cane that is better adapted to the distillery objectives than sugar cane and its by-products.

The search for new means of nutritional supplementation of fermentation media to improve yield and productivity, such as sterols from clarifying mud (Bourgeois and Fahrasmane 1988) and the selection of yeasts adapted to sugar cane-based media, is essential in order to improve the fermentation.

Yield improvement in rum production should take account of the fact that aroma gives the rums their organoleptic characteristics, which are mainly developed by the bacteria in aromatic rum production.

4. BACTERIAL FLORA

The fermentation media contain a bacterial flora whose nature depends on the raw materials used and the environment; the bacterial count is related to the healthiness of the must components. Some substances, produced by bacteria that essentially acidify the media, may sometimes disturb the alcoholic fermentation and are detrimental to the organoleptic properties of the end-product.

Along with the bacteria that are significant from a technological point of view (see Table 4), a minor flora of common forms is also present (*Enterobacteria, Streptococcus, Pseudomonas,* etc.) (Ganou-Parfait *et al.* 1989) as well as sulphate-reducing bacteria (SRB). Until now, few studies have been made on these bacteria.

Bacterial metabolites have been proposed as markers for rums and as discriminants between 'rhums industriels' and 'rhums agricoles'. Alkylpyrazines, which are components of molasses, appear to be of interest in distinguishing 'rhums blancs agricoles' from molasses-based rums (Jouret *et al.* 1994).

4.1 Origin and nature of the bacterial flora

In the French West Indies, the fermentation of molasses- and cane juice-based media traditionally occurs without further protection other than acidification of musts at pH 4·5 by the addition of sulphuric acid. This acid treatment has progressively replaced slop addition since the beginning of the century.

Table 4 Significant bacteria in rum technology

Type	Genus	Species	Origin	Presence	Optimum temp.	Optimum pH	Technological features	Effect −	Effect +
Aerobic bacteria	*Micrococcus*	*luteus*	Worm-eaten cane	Start F cycle	37 °C	6·5	Acrylate, propenol propanol production. Ethanol-resistant	Acrylate	
		varians	Worm-eaten cane		37 °C	6·5		Propenal	
	Bacillus	*cereus*	Rodent-eaten cane	Start and end F cycle	37 °C	6·3			
		subtilis	Rodent-eaten cane		37 °C	6·3	Ferment lactate in volatile fatty acids	Acrylate	Aldehyde
		megaterium	Rodent-eaten cane		37 °C	6·3		Propenal	Butanediol
		sphaericus	Rodent-eaten cane		37 °C	6·3			
	Brevibacterium	*incertae sedis*	Sugar cane stalk		30 °C	6·5			
	Corynebacterium	*incertae sedis*	Sugar cane stalk	Musts and fermented media	37 °C	6·5	Metabolize glycerol and higher alcohols. Ethanol-resistant	Propenol	
	Erysipelothrix		Sugar cane stalk		30 °C	6·5		Acrolein	
	Kurthia	*zopfli*	Worm-eaten cane		30 °C	6·5		Acidity	
	Listeria		Rodent-eaten cane		37 °C	6·0			
	Microbacterium	*lacticum*	Sugar cane stalk		37 °C	6·5			
Microaerophilic bacteria	*Propionibacterium*	*acidipropionici*	Sugar cane stalk	During F cycle					Rum characteristics
		jensenii	Molasses		37 °C	6·5	Produce priopionic acid		
		freudenreichii							
	Lactobacillus	*fermentum*	Sugar cane stalk		30–40 °C	6·0		Acidity	
		fructivorans	Molasses	During F cycle	30–40 °C	6·0	Significant growth at pH 3·2	Propenol	Aldehyde
		hilgardii	Water		30–40 °C	6·0	Acidifying	Yield	Ester and precursors
		viridescens			30–40 °C	6·0		Propenal	
	Leuconostoc	*mesenteroides*	Sugar cane stalk		30 °C	6·5	Sugar changed into dextrane	Propenol	
		paramesenteroides	Molasses		30 °C	6·5	Acidifying	Yield	
Anaerobic bacteria	*Clostridium*	*butyricum*							
		beijerinckii					Higher alcohols production from sugars		
		acetobutylicum							
		felsineum	Soils	At the end of F cycle			Sugar consumption		
		puniceum	Waters		37 °C	6·5	Production of propionic acid from glycerol and lactate	Acrylate	Ester precursors
		thermosulfurigenes							
		thermohydrosulfuricum					Formic acid production		
		sporogenes					Butyric acid production		
		bifermentans							

F, Fermentation; Effect +, positive effect on rum organoleptic properties; Effect −, negative effect on rum organoleptic properties and yield.
Taxonomic references according to *Bergey's Manual*, 8th edn.

4.1.1 Cane juice. During a fermentation cycle, an aerobic microflora first appears in musts, coming partly from the waters used for dilution and from the equipment. It is composed of corynebacteria, *Micrococcus* species, enterobacteria and *Bacillus* species. Secondly, during the active phase of alcoholic fermentation, yeasts and microaerophilic bacteria appear, including *Lactobacillus*, *Propionibacterium* and *Leuconostoc* species (Ganou-Parfait *et al.* 1989; Ganou-Parfait and Saint-Marc 1994) (Table 4).

The qualitative and quantitative composition of the bacterial flora is related to the phytosanitary condition of the sugar cane. Juices extracted from sound and fresh sugar cane contain a flora with a predominance of lactic bacteria.

The crushing of unsound cane stalks significantly increases the bacterial count in the must up to 10^9 cfu ml^{-1}.

4.1.2 Molasses. In the course of sugar production, the greater part of the non-sporulated bacterial flora is destroyed. As a result, molasses are generally less contaminated than cane juice (10^2–10^3 bacteria g^{-1}). However, some aerobic and anaerobic sporulated bacteria remain. *Lactobacillus* and *Propionibacterium* species develop especially in molasses-based musts (Ganou-Parfait and Saint-Marc 1994).

4.1.3 Dilution waters. The bacteria from dilution waters are added to those coming from cane juice and molasses. A specific feature of these waters is the existence of anaerotolerant pathogens such as coliforms, faecal *Streptococcus* and *Clostridium* species and SRB, which are for the most part inhibited by the ethanol produced during alcoholic fermentation.

The mineral content depends on the water used (well or surface water). We observed that the water's mineral level appeared to be related to the bacterial populations. Waters containing high concentrations of mineral matter are the most contaminated by bacteria (Ganou-Parfait *et al.* 1991).

4.1.4 Slops. Slops are used to dilute molasses for the production of heavy-flavour rums. Since they are stored between their production and their use, they are exposed to bacterial acidification, and thereby acidify the fermentation media and seed it with an abundant anaerobic bacterial flora.

4.2 Dynamics and control of the bacterial flora

During the fermentation cycle, different respiratory types appear. They are determined by the media conditions, but in a more significant way with cane juices than with molasses. Aerobic bacteria are particularly active at the beginning during the filling of the vats, a procedure that can take between 3 and 6 h in small plants; microaerophiles and anaerobic bacteria then appear owing to the increasing activity of alcoholic fermentation yeasts.

In cane juice-based media, the aerobic flora at the beginning of fermentation is composed of *Micrococcus* species (10^1 cfu ml^{-1}), *Bacillus* species (10^2 cfu ml^{-1}) and coryneforms (10^5 cfu ml^{-1}), some of these forms being related to reduction in the healthiness of the raw materials (*Listeria* from worm-eaten canes and *Kurthia* from rodent-eaten canes). In addition, there are some common bacteria such as enterobacteria and *Streptococcus* species, etc. Almost all of these bacteria produce undesirable substances such as acrylic acid, acrolein and allylic (Ganou-Parfait *et al.* 1987; Lencrerot *et al.* 1984; Ganou-Parfait *et al.* 1988). In the active fermentation phase, lactic bacteria are developed (10^5–10^6 cfu ml^{-1}), as well as *Propionibacterium* species (10^4 cfu ml^{-1}), *Clostridium* species (10^3 cfu ml^{-1}) and *Leuconostoc* species (10^2 cfu ml^{-1}).

The *Leuconostoc* count increases when using canes from fields that are burnt before harvest to make cutting easier (Picard and Torribio 1972).

The flora of the molasses-based media is chiefly composed of lactic bacteria (10^5–10^6 cfu ml^{-1}) and propionibacteria (10^5 cfu ml^{-1}); in some cases *Leuconostoc* species can also be found (10^4 cfu ml^{-1}) depending on the quality of the molasses. The aerobic flora is rather inactive because of the low contamination of molasses by aerobic micro-organisms and the vats' filling-time which is generally shorter than with cane juice (1–3 h).

The lowering of pH by addition of sulphuric acid is not the only way to regulate the aerobic bacterial flora. The control can be improved firstly by shortening the filling phase and, secondly, by seeding the media with yeasts, so that the fermentation phase can be started rapidly. It is also possible to use mother vats, which enable seeding with yeasts in good physiological condition. Thus, the production of detrimental substances can be limited. The initial sugar contents of musts in rum production are under 100 g l^{-1}, while the fermentation is rapid and lasts from 18 to 36 h. In terms of time and sugar consumption, the aerobic phase represents 10–20% of the fermentation cycle. The conditions under which the fermentation starts may partly explain the considerable yield losses at the fermentation stage.

It appears that the microaerophilic, *Lactobacillus* species and *Propionibacterium* species flora is the most significant in rum production media when the bacteriological quality of the raw materials and of the water is good and when the aerobic phase is shortened. The *Lactobacillus* species flora consumes sugar and has an acidifying effect since it produces acids (lactic, acetic and formic) that can be esterified. This flora also produces 2-3 butanediol and diacetyl (Jay 1982). To a certain extent, these compounds and their by-products positively contribute to the development of the organoleptic properties of rum (Peynaud and Lafon 1951). The *Propionibacterium* species flora, owing to its special property of producing propionic acid, distinguishes rum from other spirits by leading to relatively high concentrations of this acid (Suomalainen 1975; Jounela-Eriksson 1979). The type of raw material and the microaerophilic bacteria mentioned above are more important than the fermentation yeast in making aromatic rums a local product. Nevertheless, selected yeast should not be neglected since its use under optimum conditions enables good fermentation yields and increased productivity.

Other kinds of bacteria are only significant under certain conditions that are detrimental to the development of fermentation and the quality of the product. For instance, when there is a sanitary degradation of must components leading to an increase in the bacterial count up to 10^9 cfu ml^{-1} (Ganou-Parfait and Saint-Marc 1994), the result is a considerable and excessive acidification of the distillery products as well as an off-flavour increase (Fahrasmane *et al.* 1983; Lencrerot *et al.* 1984); at the same time, the yeast is inhibited by lactic and acetic acid and by bacteriocins (Essia Ngang *et al.* 1989, 1990). If the musts are insufficiently acidified, thus promoting bacterial development, their optimum growth varies from 6·0 to 6·5 (Table 4); the consequences are the same as those mentioned above. If the vats are overheated above 37 °C, which is the optimum temperature for the growth of many of the bacteria, the yeast is inhibited and fermentation consequently comes to an arrest (Arroyo 1945; Merrit 1966; Lonvaud-Funel 1988).

5. CONCLUSION

The key factors for bacterial control include acidification of the musts, temperature control and the use of selected yeasts. The latter provides an active fermentation with a reduced latency time, giving rise to a positive bacterial effect on the quality and authenticity of the products.

Heavy-flavour rum is an aromatic quintessence produced from media containing a 'wild' local flora; the expression of its bacterial component is quite extraordinary. On the other hand, light-flavour rums—in which the bacterial count and activity are minimized—are related to rums mainly because of the raw materials used. The 'rhums traditionnels' of the French West Indies arise from a combination of raw materials, native and/or selected yeasts and native bacteria; the products' aromas are intermediate between the extremes of light-flavour rum and heavy-flavour rum. Thus, nowadays 'rhums traditionnels' are modern counterparts of the local archetypal products made before the 20th century that have benefited from the progress in microbiology.

Sugar cane and its by-products have always been used in rum production; European regulations have given recognition to this fact (O.J. of the European Communities 1989). The diversity of production processes has led to several types of rums in which local bacterial flora is a key factor. *Lactobacillus* and *Propionibacterium* species are the most important genera in the context of a controlled technology.

Alcoholic fermentation yeasts added according to defined technical stages have optimized efficiency. Above all, yeast is a technological efficiency factor. However, the yeast also plays a role in the synthesis of the components and the precursors of aroma. For example, the synthesis of volatile fatty acids is modulated, according to the strain, by the citric acid concentration in the raw material (Fahrasmane *et al.* 1985).

The production of aromatic rums in which ethanol is a carrier-solvent for flavour-giving molecules enables this spirit to be used rather like an aromatic resource.

There are several ways of consuming and using colourless (white) or matured rums. The volume of rum sold in France in 1992 (75 000 hectolitres pure alcohol) is higher than that of Cognac, Armagnac brandy and Cider brandy together. Aromatic rum from the French West Indies is a choice ingredient for cooking with respect to its flavouring properties.

The current state of technological and chemical knowledge on rums points to the important role of the bacterial flora as far as the aromatic product composition is concerned (acids and esters, etc.).

In the future, the use of sensorial analysis, in addition to physico-chemical methods and leading on from microbiological research, will make it possible to estimate the correct limits of the bacterial expression needed to make high-quality aromatic products.

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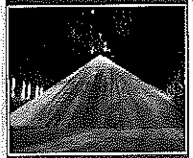
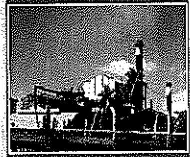
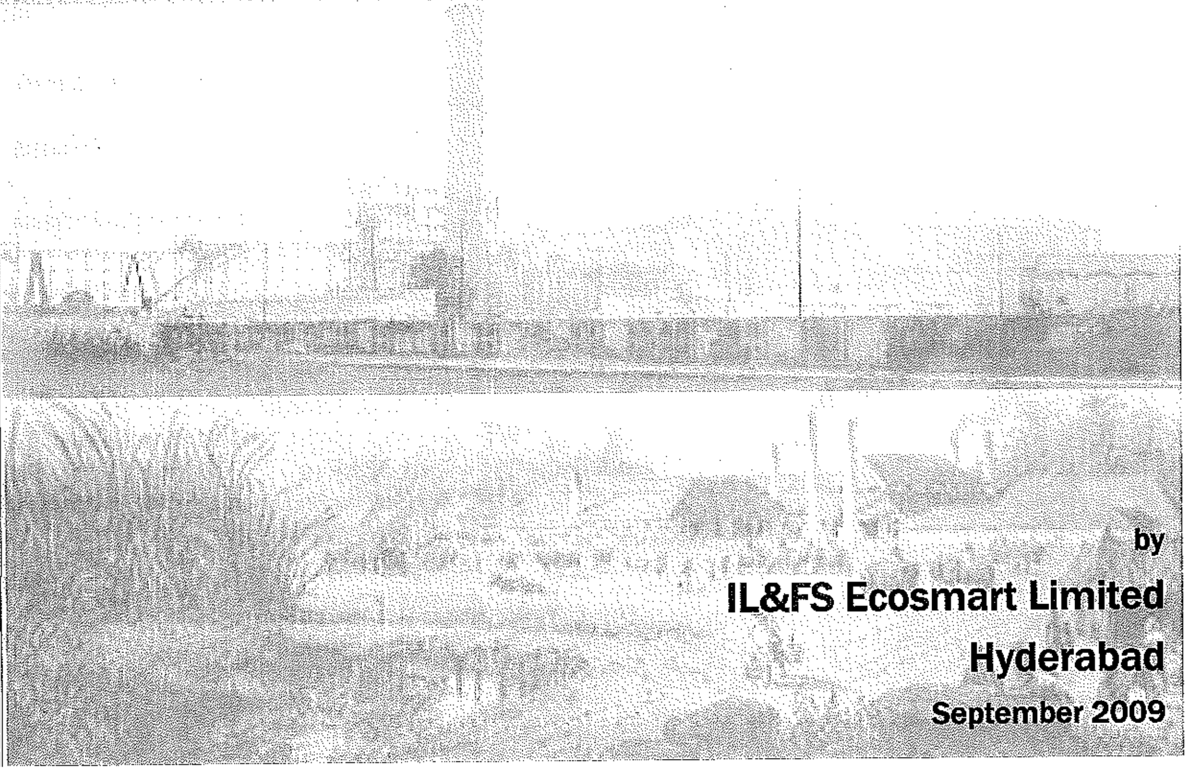
TECHNICAL EIA GUIDANCE MANUAL
FOR
SUGAR INDUSTRY

Prepared for

Ministry of Environment and Forests
Government of India







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September 2009

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ACRONYMS

AAQ	Ambient Air Quality
APHA	American Public Health Association
ADB	Asian Development Bank
B/C	Benefits Cost Ratio
BOQ	Bill of Quantities
BOD	Biological / Bio-chemical Oxygen Demand
BIS	Bureau of Indian Standards
CEAA	Canadian Environmental Assessment Agency
CEA	Central Electricity Authority
CPCB	Central Pollution Control Board
COD	Chemical Oxygen Demand
CRZ	Coastal Regulatory Zone
CHP	Combined Heat and Power
CAGR	Compound Average Growth Rate
COINDS	Comprehensive Industry Document Series
CFE	Consent for Establishment
CCA	Conventional Cost Accounting
CER	Corporate Environmental Reports
CREP	Corporate Responsibility for Environment Protection
CSR	Corporate Social Responsibility
COC	Cycles of Concentration
DO	Dissolved Oxygen
EcE	Economic- cum - Environmental
ETP	Effluent Treatment Plant
ESP	Electrostatic Precipitator
EIAA	Environment Impact Assessment Authorities
EPA	Environment Protection Act
EBM	Environmental Baseline Monitoring
ECI	Environmental Condition Indicators
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
EPI	Environmental Performance Indicators
EAC	Expert Appraisal Committee
EPZ	Export Processing Zones

F/M	Food to Micro-organisms Ratio
FCA	Full Cost Assessment
GLC	Gas Liquid Chromatography
GC	General Conditions
GIS	Geographic Information System
GEF	Global Environmental Facility
GEMS	Global Environmental Monitoring System
IVI	Importance Value Index
IMD	Indian Meteorological Department
INFOTERRA	Global Environmental Information Exchange Network of UNEP
IL&FS	Infrastructure Leasing and Financial Services
ISO	International Organization for Standardization
ICRA	Investment Information and Credit Rating Agency of India Limited
LANDSAT	Land use Satellite / Land Remote Sensing Satellite
LDAR	Leak Detection And Repair
LCA	Life Cycle Assessment
MSP	Minimum Support Price
MoEF	Ministry of Environment and Forest
MPNG	Ministry of Petroleum and Natural Gas
MLSS	Mixed Liquor Suspended Solids
NAQM	National Air Quality Monitoring
NBA	National Board of Accreditation
NOAA	National Oceanic and Atmospheric Administration (Landsat)
NDIR	Non Dispersive Infra Red
NGO	Non Government Organizations
O&G	Oil and Grease
O&M	Operation and Maintenance
OSHA	Operational Safety and Health Administration
OECD	Organization for Economic Co-operation and Development
PAH	Polycyclic Aromatic Hydrocarbons
PAP	Project affected People
PCC	Pollution Control Committee
PPV	Peak particle Velocity
QA/QC	Quality Assurance/ Quality Control
R&D	Research and Development
R&R	Resettlement and Rehabilitation
RPM	Respirable Particulate Matter
RSPM	Respirable Suspended Particulate Matter

SAR	Sodium Absorption Ratio
SEAC	State Level Expert Appraisal Committee
SEIAA	State Level Environment Impact Assessment Authority
SEZ	Special Economic Zones
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
SPOT	Satellites Pour l'Observation de la Terre
SS	Suspeuded Solids
STP	Sewage Treatment Plant
SY	Sugar Yield
TCA	Total Cost Assessment
TCD	Tones of Cane crushed per Day
TDS	Total Dissolved Solvents
TGM	Technical Guidance Manual
TQM	Total Quality Movement
UNEP	United Nations Environment Programme
USEPA	US Environmental Protection Agency
UT	Union Territory
UTEIAA	Union Territory Environmental Impact Assessment Authority
UTPCC	Union Territory Pollution Control Committee
VEC	Valued Environmental Components
VHP	Very High Polarity
VOC	Volatile Organic Compound
WB	World Bank Group / The World Bank
WBSCD	World Business Council on Sustainable Development
YoY	Year on Year

1.

INTRODUCTION TO THE TECHNICAL EIA GUIDANCE MANUALS PROJECT

Environmental Impact Assessment (EIA) is a process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made. These studies integrate the environmental concerns of developmental activities in to the process of decision-making.

EIA has emerged as one of the successful policy innovations of the 20th Century to ensure sustained development. Today, EIA is formalized as a regulatory tool in more than 100 countries for effectively integration of environmental concerns in the economic development process. The EIA process in India was made mandatory and was also given a legislative status through a Notification issued in January 1994. The Notification, however, covered only a few selected industrial developmental activities. While there are subsequent amendments, this Notification issued on September 14, 2006 supersedes all the earlier Notifications, and has brought out structural changes in the clearance mechanism.

The basic tenets of this EIA Notification could be summarized into following:

- Pollution potential as the basis for prior environmental clearance based on pollution potential instead of investment criteria; and
- Decentralization of clearing powers to the State/Union Territory (UT) level Authorities for certain developmental activities to make the prior environmental clearance process quicker, transparent and effective mechanism of clearance.

Devolution of the power to grant clearances at the state level for certain category of the developmental activities / projects is a step forward to fulfill the basic tenets of the re-engineering *i.e.*, quicker, transparent and effective process but many issues come on its way of functional efficiency. These issues could be in technical and operational domains as listed below:

Technical issues

- Ensuring level playing ground to avoid arbitrariness in the decision-making process
- Classification of projects which do not require public hearing and detailed EIA (Category B2)
- Variations in drawing the Terms of Reference (ToR) for EIA studies for a given developmental activity across the States/UTs
- Varying developmental-activity-specific expertise requirement for conducting EIA studies and their appraisal
- Availability of adequate sectoral experts and variations in competency levels
- Inadequate data verification, cross checking tools and supporting institutional framework

- Meeting time targets without compromising with the quality of assessments/ reviews
- Varying knowledge and skill levels of regulators, consultants and experts
- Newly added developmental activities for prior environmental clearance, *etc.*

Operational issues

- State level /UT level EIA Authorities (SEIAA/UTEIAA) are formulated for the first time and many are functioning
- Varying roles and responsibilities of involved organizations
- Varying supporting institutional strengths across the States/UTs
- Varying manpower availability *etc.*

1.1 Purpose

The purpose of developing the sector-specific Technical EIA Guidance Manuals (TGM) is to provide clear and concise information on EIA to all the stakeholders *i.e.,* the project proponent, the consultant, the reviewer, and the public. The TGMs are organized to cover following:

- Conceptual facets of an EIA
- Details on the developmental activity including environmental concerns and control technologies *etc.*
- Operational aspects; and
- Roles and responsibilities of various organizations involved in the process of prior environmental clearance

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, inorder to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue. Text within each section was researched from many sources, and was usually condensed from more detailed sources pertaining to specific topics.

The contents of the document are designed with a view to facilitate in addressing the relevant technical and operational issues as mentioned in the earlier section. Besides, facilities various stakeholders involved in the EIA clearance process *i.e.,*

- Project proponents will be fully aware of the procedures, common ToR for EIA studies, timelines, monitoring needs, *etc.,* inorder to plan the projects /studies appropriately.
- Consultants across India will have similar understanding about a given sector, and also the procedure for EIA studies, so that the quality of the EIA reports gets improved and streamlined.
- Reviewers across the States/UTs will have the same understanding about an industry and would be able to draw a benchmark to establish the significant impacts for the purpose of prescribing the ToR for EIA studies and also in the process of review and appraisal.
- Public who are concerned about a new or expansion projects, can have access to this manual to know the manufacturing/production details, rejects/wastes from the operations, choice of cleaner/control technologies, regulatory requirements, likely

environmental and social concerns, mitigation measures, *etc.*, inorder to seek clarifications appropriately in the process of public consultation. The procedural clarity in the document will further strengthen them to understand the stages involved in clearance and roles & responsibilities of various organizations.

- In addition, these manuals would substantially ease the pressure on reviewers at the scoping stage and would bring in functional efficiency at the central and state levels.

1.2 Project Implementation

The Ministry of Environment & Forests (MoEF), Government of India took up the task of developing sector-specific TGMs for all the developmental activities listed in the re-engineered EIA Notification. The Infrastructure Leasing and Financial Services (IL&FS), Ecosmart Limited (Ecosmart), has been entrusted with the task of developing these manuals for 27 industrial and related sectors. Sugar industry is one of these sectors, for which this manual is prepared.

The ability to design comprehensive EIA studies for specific industries depends on the knowledge of several interrelated topics. Therefore, it requires expert inputs from multiple dimensions *i.e.,* administrative, project management, technical, scientific, social, economic, risk *etc.*, inorder to comprehensively analyze the issues of concern and to draw logical interpretations. Thus, Ecosmart has designed a well-composed implementation framework to factor inputs of the experts and stakeholders in the process of finalization of these manuals.

The process of manual preparation involved collection & collation of the secondary available information, technical review by sectoral resource persons and critical review and finalization by a competent Expert Committee composed of core and sectoral peer members.

The MoEF appreciates the efforts of Ecosmart, Expert Core and Peer Committee, resource persons and all those who have directly and indirectly contributed to this Manual.

1.3 Additional Information

This TGM is brought out by the MoEF to provide clarity to all the stakeholders involved in the 'Prior Environmental Clearance' process. As such, the contents and clarifications given in this document do not withstand in case of a conflict with the statutory provisions of the Notifications and Executive Orders issued by the MoEF from time-to-time.

TGMs are not regulatory documents. Instead, these are the tools designed to assist in successful completion of an EIA.

For the purpose of this project, the key elements considered under TGMs are: conceptual aspects of EIA; development activity-specific information; operational aspects; and roles and responsibilities of involved stakeholders.

This manual is prepared considering the Notification issued on September 14, 2006 and the updations. For recent updations, if any, may please refer the website of the MoEF, Government of India *i.e.,* www.envfor.nic.in.

2.
CONCEPTUAL FACETS OF EIA

2.1 Environment in EIA Context

'Environment' in EIA context mainly focuses, but is not limited to physical, chemical, biological, geological, social, economical, and aesthetic dimensions along with their complex interactions, which affect individuals, communities and ultimately determines their forms, character, relationship, and survival. In the EIA context, 'effect' and 'impact' can often be used interchangeably. However, 'impact' is considered as a value judgment of the significance of an effect.

Sustainable development is built on three basic premises *i.e.,* economic growth, ecological balance and social progress. Economic growth achieved in a way that does not consider the environmental concerns, will not be sustainable in the long run. Therefore, sustainable development needs careful integration of environmental, economic, and social needs inorder to achieve both an increased standard of living in short term, and a net gain or equilibrium among human, natural, and economic resources to support future generations in the long term.

"It is necessary to understand the links between environment and development inorder to make choices for development that will be economically efficient, socially equitable and responsible, as well as environmentally sound." Agenda 21

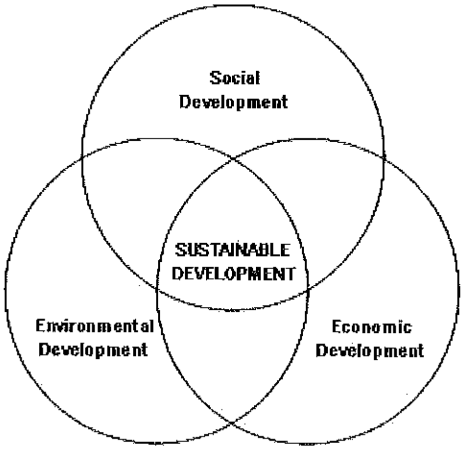


Figure 2-1: Inclusive Components of Sustainable Development

2.2 Pollution Control Strategies

Pollution control strategies can be broadly categorized in to preventive and reactive. The reactive strategy refers to the steps that may be applied once the wastes are generated or contamination of receiving environment takes place. The control technology or a combination of technologies to minimize the impact due to the process rejects/wastes varies with the quantity and characteristics, desired control efficiency and economics.

Many a number or combination of techniques could be adopted for treatment of a specific waste or the contaminated receiving environment, but are often judged based on techno-economic feasibility. Therefore, the best alternative is to take all possible steps to avoid pollution it self. This preventive approach refers to a hierarchy that involves i) prevention & reduction; ii) recycling and re-use; iii) treatment; and iv) disposal, respectively.

Therefore, there is a need to shift the emphasis from the reactive to preventive strategy *i.e.,* to promote preventive environmental management. Preventive environmental management tools may be classified into following three groups:

Management based tools	Process based tools	Product based tools
Environmental Management System (EMS) Environmental Performance Evaluation Environmental Audits Environmental Reporting and Communication Total cost Accounting Law and Policy Trade and Environment Environmental Economics	Environmental Technology Assessment Toxic Use Reduction Best Operating Practices Environmentally Best Practice Best Available Technology (BAT) Waste Minimization Pollution Prevention Cleaner Production Cleaner Technology Eco-efficiency	Industrial Ecology Extended Producers Responsibility Eco-labeling Design for Environment Life Cycle Assessment (LCA)

These tools are precisely discussed in next sections.

2.3 Tools for Preventive Environmental Management

The tools for preventive environmental management can be broadly classified into following three groups.

- Tools for assessment and analysis
- Tools for action
- Tools for communication

Specific tools under each group are discussed precisely in next sections.

2.3.1 Tools for assessment and analysis

2.3.1.1 Risk assessment

Risk is associated with the frequency of failure and consequence effect. Predicting such situations and evaluation of risk is essential to take appropriate preventive measures. The major concern of the assessment is to identify the activities falling in a matrix of high & low frequencies at which the failures occur and the degree of its impact. The high frequency, low impact activities can be managed by regular maintenance *i.e.,* LDAR (Leak Detection and Repair) programmes. Whereas, the low frequency, high impact activities are of major concern (accidents) in terms of risk assessment. As the frequency is low, often the required precautions are not realized or maintained. However, the risk assessment will identify the areas of major concerns which require additional preventive measures: likely consequence distances considering domino effects, which will give the possible casualties and ecological loss in case of accidents. These magnitudes demand the attention for preventive and disaster management plans. Thus is an essential tool to ensure safety of operations.

2.3.1.2 Life cycle assessment

A broader approach followed to deal with environmental impacts during manufacturing is called LCA. This approach recognizes that environmental concerns are associated with every step of the processing w.r.t. the manufacturing of the products and thus examines environmental impacts of the product at all stages of the product life cycle. LCA includes the product design, development, manufacturing, packaging, distribution, usage and disposal. LCA is concerned with reducing environmental impacts at all the stages and looking at the total picture rather than just one stage of the production process.

By availing this concept, firms can minimize the life cycle environmental costs of their total product system. LCA gives sufficient scope to think about the alternatives, which are lower at cost..

2.3.1.3 Total cost assessment

Total Cost Assessment (TCA) is an enhanced financial analysis tool that is used to assess the profitability of alternative courses of action (eg., raw material substitution to reduce the costs of managing the wastes generated by process; an energy retrofit to reduce the costs of energy consumption). This is particularly relevant for pollution prevention options, because of their nature, often produce financial savings that are overlooked in conventional financial analysis, either because they are misallocated, uncertain, hard to quantify, or occur more than three to five years after the initial investment. TCA involves all of the relevant costs and savings associated with an option so that it can compete for scarce capital resources fairly, on a level playing field. The assessments are often beneficial in respect of the following:

- Identification of costly resource inefficiencies
- Financial analysis of environmental activities/projects such as investment in cleaner technologies
- Prioritization of environmental activities/projects
- Evaluation of product mix and product pricing
- Bench marking against the performance of other processes or against the competitors

A comparison of cost assessments is given below:

- Conventional Cost Accounting (CCA): Direct and indirect financial costs+ Recognized contingent costs
- Total Cost Assessment (TCA): A broader range of direct, indirect, contingent and less quantifiable costs
- Full Cost assessment (FCA): TCA + External social costs borne by society

2.3.1.4 Environmental audit/statement

The key objectives of an environmental audit includes compliance verification, problem identification, environmental impact measurement, environmental performance measurement, conforming effectiveness of EMS, providing a database for corrective actions and future actions, developing companies environmental strategy, communication and formulating environmental policy.

The MoEF has issued Notification on '*Environmental Statements*' (ES) in April, 1992 and further amended in April, 1993 – As per the Notification, the industries are required to submit environmental statements to the respective State Pollution Control Boards (SPCBs). ES is a pro-active tool for self-examination of the industry itself to reduce/minimize pollution by adopting process modifications, recycling and reusing of the resources. The regular submission of ES will indicate the systematic improvement in environmental pollution control being achieved by the industry. In other way, the specific points in ES may be used as environmental performance indicators for relative comparison, implementation and to promote better practices.

2.3.1.5 Environmental benchmarking

Environmental performance and operational indicators could be used to navigate, manage and communicate the significant aspects and give enough evidence of good environmental house keeping. Besides prescribing standards, an insight to identify the performance indicators and prescribing schedule for systematic improvement in performance of these indicators will yield better results.

Relative indicators may be identified for different industrial sectors and be integrated in the companies and organizations to monitor and manage the different environmental aspects of the company, to benchmark and compare two or more companies from the same sector. These could cover the water consumption, wastewater generation, energy consumption, solid/hazardous waste generation, chemical consumption etc. per tonne of final product. Once these bench marks are developed, the industries which are below them may be guided and enforced to reach the level and those which are better than the bench mark may be encouraged further by giving incentives etc.

2.3.1.6 Environmental indicators

Indicators can be classified in to Environmental Performance Indicators (EPI) and Environmental Condition Indicators (ECI). The EPIs can be further divided into two categories *i.e.,* operational performance indicators and management performance indicators.

The operational performance indicators are related to the process and other operational activities of the organization, these would typically address the issue of raw material consumption, energy consumption, water consumption in the organization, the quantities of waste water generated, other solid wastes generated, emission from the organization *etc.*

Management performance indicators are related to the management efforts to influence the environmental performance of the organizations operations.

The environmental condition indicators provide information about the environment. These indicators provide information about the local, regional, national or global condition of the environment. This information helps the organization to understand the environmental impacts of its activities and thus helps in making decisions to improve the environmental performance.

Indicators basically used to evaluate environmental performance against the set standards and thus indicate the direction in which to proceed. Selection of type of indicators for a firm or project depends upon its relevance, clarity and realistic cost of collection and its development.

2.3.2 Tools for action

2.3.2.1 Environmental policy

An environmental policy is a statement of the organization's overall aim and principles of action w.r.t. the environmental, including compliance with all relevant regulatory requirements. It is a key tool in communicating the environmental priorities of the organization to all its employees. To ensure organizations commitment towards a formulated environmental policy, it is essential that top management be involved in the process of formulating the policy and setting priorities. Therefore, the first step is to get the commitment from the high level of management. The organization should then conduct an initial environmental review and draft an environmental policy. This draft should be discussed and approved by the board of directors and finally the approved environmental policy statement must be communicated internally among all its employees and must also be made available to the public.

2.3.2.2 Market-based economic instruments

Market based instruments are regulations that encourage behavior through market signals rather than through explicit directives regarding pollution control levels. These policy instruments such as tradable permits pollution charge are often described as harnessing market forces. Market based instruments can be categorized into the four major categories *i.e.,*

- **Pollution Charge:** Charge system will assess a fee or tax on the amount of pollution a firm or source generates. It is worthwhile for the firm to reduce emissions to the point, where its marginal abatement costs are equal to the tax rate. Thus firms control pollution to different degrees *i.e.,* High cost controllers – less; low-cost controllers – more. The charge system encourages the industries to further reduce the pollutants. The charges thus collected can form a fund for restoration of the environment. Another form of pollution charge is a deposit refund system, where the consumers pay a surcharge when purchasing a potentially polluting product, and receive a refund on return of the product after useful life span at appropriate centers. The concept of extended producer's responsibility is brought in to avoid accumulation of dangerous products in the environment.
- Tradable Permits: Under this system, firms that achieve the emission levels below their allotted level may sell the surplus permits. Similarly the firms, which are required to spend more to attain the required degree of treatment/allotted levels, can purchase permits from others at lower costs and may be benefited.
- Market Barrier Reductions: Three known market barrier reduction types are as follows:
  - Market Creation: Measures that facilitate the voluntary exchange of water rights and thus promote more efficient allocation of scarce water supplies.
  - Liability Concerns: Encourage firms to consider potential environmental damages of their decisions

  - Information Programmes: Ecolabeling and energy- efficiency product labeling requirements
- **Government Subsidy Reduction:** Subsidies are the mirror images of taxes and, in theory, can provide incentive to address environmental problems. However, it has been reported that the subsidies encourage economically in-efficient and environmentally un-sound practices, and often leads to market distortions due Arial differences. However, these are important to sustain the expansion of production, in the national interests. In such cases, the subsidy may be comparable to the net social benefit.

2.3.2.3 Innovative funding mechanism

There are many forums under which the fund is made available for the issues which are of global/regional concern (GEF, OECD, Deutch green fund *etc.*) *i.e.,* climate change, Basal convention and further fund sources are being explored for the Persistent Organic Pollutants Convention. Besides these global funding mechanisms, a localized alternative mechanism for boosting the investment in environmental pollution control must be put in place. For example in India the Government has established mechanism to fund the common effluent treatment plants, which are specifically serving the small and medium scale enterprises *i.e.,* 25% share by the state Government, matching grants from the Central Government and surety for 25% soft loan. It means that the industries need to invest only 25% initially, thus encouraging voluntary compliance.

There are some more options *i.e.,* if the pollution tax/charge is imposed on the residual pollution being caused by the industries, municipalities *etc.,* fund will automatically be generated, which in turn, can be utilized for funding the environmental improvement programmes. The emerging concept of build-operate-transfer (BOT) is an encouraging development, where there is a possibility to generate revenue by application of advanced technologies. There are many opportunities which can be explored. However, what is required is the paradigm shift and focused efforts.

2.3.2.4 EMS and ISO certification

EMS is that part of the overall management system which includes the organizational structure, responsibilities, practices, procedures, process and resources for determining and implementing the forms of overall aims, principles of action w.r.t. the environment. It encompasses the totality of organizational, administrative and policy provisions to be taken by a firm to control its environmental influences. Common elements of an EMS are the identification of the environmental impacts and legal obligations, the development of a plan for management & improvement the assignment of the responsibilities and monitoring of the performance.

2.3.2.5 Total environmental quality movement

Quality is regarded as

- A product attribute that had to be set at an acceptable level and balanced against the cost
- Something delivered by technical systems engineered by experts rather than the organization as a whole

- Assured primarily through the findings and correction of mistakes at the end of the production process

One expression of the total environmental quality movement (TEQM) is a system of control called Kaizen. The principles of Kaizen are

- Goal must be continuous improvement of quality instead of acceptable quality
- Responsibility of the quality shall be shared by all members of an organization
- Efforts should be focused on improving the whole process and design of the products

With some modifications, TQM approach can be applied in the improvement of corporate environmental performance in both process and product areas.

2.3.2.6 Eco-Labeling

It is known as the practice of supplying information on the environmental characteristics of a product or service to the general public. These labeling schemes can be grouped in to three types:

- Type I: Multiple criteria base; third party (Govt. or non-commercial private organizations) programme claims overall environmental preferability.
- Type II: Specific attribute of a product; often issued by a company/industrial association
- Type III: Agreed set of indices; provides quantified information; self declaration

Among the above, Type I are more reliable because they are established by a third party and considers the environmental impacts of a product from cradle to grave. However, the labeling program will only be effective if linked with complementary program of consumer education and up on restriction of umbrella claims by the producers.

2.3.2.7 Cleaner Production

Cleaner production is one of the tools, which has lot of bearing on environmental pollution control. It is also seen that the approach is changing with time *i.e.*, dumping-to-control-to-recycle-to-prevention. Promotion of cleaner production principles involve an insight into the production process not only to get desired yield but also to optimise on raw material consumption *i.e.*, resource conservation and implications of the waste treatment and disposal.

2.3.2.8 4-R Concept

The concept endorses utilization of wastes as a by-product to the extent possible *i.e.*, Re-cycle, Recover, Re-use, Recharge. Recycling refers to using wastes/by-products in the process again as a raw material to maximize the production. Recovery refers to engineering means such as solvent extraction, distillation, precipitation *etc.*, to separate the useful constituents of the wastes, so that these recovered materials can be used. Re-use refers to the utilization of waste from one process as a raw material to other. Recharging is an option in which the natural systems are used for renovation of waste for further use.

2.3.2.9 Eco-Efficiency

The World Business Council on Sustainable Development (WBCSD) defines eco-efficiency as "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with earth's carrying capacity". The business implements the eco-efficiency on four levels *i.e.,* optimized processes, recycling of wastes, eco-innovation and new services. Fussler (1995) defined six dimensions of eco efficiency, which are given below to understand/examine the system.

- Mass: There is an opportunity to significantly reduce mass burdens (raw materials, fuels, utilities consumed during the life cycle)
- Reduce Energy Use: The opportunity is to redesign the product or its use to provide significant energy savings.
- Reduce Environmental Toxins: This is concern to the environmental quality and human health. The opportunity here is to significantly control the dispersion of toxic elements.
- Recycle when Practical: Designing for recycling is important.
- Working with Mother Nature: Materials are borrowed and returned to the nature without negatively affecting the balance of the ecosystem.
- Make it Last Longer: It relates to useful life and functions of products. Increasing the functionality of products also increase their eco efficiency.

The competitiveness among the companies and long-term survival will continue and the successful implementation of eco efficiency will contribute to their success. There is a need to shift towards responsible consumerism equal to the efficiency gains made by corporations – doing more with less.

2.3.2.10 Industrial ecosystem or metabolism

Eco-industrial development is a new paradigm for achieving excellence in business and environmental performance. It opens-up innovative new avenues for managing business and conducting economic development by creating linkages among local 'resources', including businesses, non-profit groups, governments, unions, educational institutions, and communities can creatively foster the dynamic and responsible growth. Antiquated business strategies based on isolated enterprises are no longer responsive enough to market, environmental and community requirements.

Sustainable eco-industrial development looks systematically at development, business and environment, attempting to stretch the boundaries of current practice on - one level, it is as directly practical as making the right connections between the wastes and resources needed for production and at the other level it is a whole new way of thinking about doing business and interacting with communities. At a most basic level, it is each organization seeking higher performance within it self. However, most eco-industrial activity is moving to a new level by increasing the inter connections between the companies.

Strategic partnership, networked manufacturing and performed supplier arrangements are all the examples of ways used by the businesses to ensure growth, contain costs and to reach out for new opportunities.

For most businesses, the two essentials for success are the responsive markets and access to cost-effective, quality resources for producing products or delivering services. In absence of these two factors, virtually, every other incentive becomes a minor consideration.

Transportation issues are important at two levels, the ability to get goods to market in an expeditious way is essential to success in this day of just in time inventories. The use of least impact transportation with due consideration of speed and cost supports business success and addresses concerned in the community.

Eco-industrial development works because it consciously mixes a range of targeted strategies shaped to the contours of the local community, most importantly, it works because the communities wants nothing less than the best possible in or near their neighborhoods. For companies, it provides a path towards significantly higher operating results and positive market presence. For our environment, it provides great hope that the waste will be transformed in to valued product and that the stewardship will be a joint pledge of both businesses and communities.

2.3.2.11 Voluntary Agreements

Voluntary environmental agreements among the industries, government, public representatives, NGOs and other concerned towards attaining certain future demands of the environment are reported to be successful. Such agreements may be used as a tool where Government would like to make the standards stringent in future (phase-wise-stringent). These may be used when conditions are temporary and requires timely replacements. Also these may be used as supplementary/ complimentary in implementation of the regulation. The agreements may include:

- Target objectives (emission limit values/standards)
- Performance objectives (operating procedures)
- R&D activities – Government and industry may have agreement to establish better control technologies.
- Monitoring & reporting of the agreement conditions by other agents (NGOs, public participants, civil authority *etc.*)

In India, the MoEF has organized such programme, popularly known as the corporate responsibility for environment protection (CREP) considering identified 17 categories of high pollution potential industrial sectors. Publication in this regard, is available with Central Pollution Control Board (CPCB).

2.3.3 Tools for Communication

2.3.3.1 State of environment

The Government of India brought out the state of environment report for entire country and similar reports available for many of the states. These reports are published at regular intervals to record trends and to identify the required interventions at various levels. These reports consider the internationally accepted DPSIR framework for the presentation of the information. DPSIR refers to.

- D – Driving forces – causes of concern *i.e.,* industries, transportation *etc.*
- P – Pressures – pollutants emanating from driving forces *i.e.,* emission

- S – State – quality of environment *i.e.,* air, water & soil quality
- I – Impact – Impact on health, eco-system, materials, biodiversity, economic damage *etc.*
- R – Responses – action for cleaner production, policies (including standards/guidelines), targets *etc.*

Environment reports including the above elements gives a comprehensive picture of a specific target area inorder to take appropriate measures for improvement. Such reports capture the concerns which are considered in EIAs.

2.3.3.2 Corporate Environmental Reporting

Corporate environmental reports (CER) are only one form of environmental reporting defined as publicly available, stand alone reports, issued voluntarily by the industries on their environmental activities (Borphy and starkey-1996). CER is a means to environmental improvement and greater accountability, not an end in itself.

Three categories of environmental disclosure are:

- Involuntary Disclosure: Without its permission and against it will (env. Campaign, press *etc.*)
- Mandatory Disclosure: As required by law
- Voluntary Disclosure: The disclosure of information on a voluntary basis

2.4 Objectives of EIA

Objectives of EIA include the following:

- To ensure environmental considerations are explicitly addressed and incorporated into the development decision-making process;
- To anticipate and avoid, minimize or offset the adverse significant biophysical, social and other relevant effects of development proposals;
- To protect the productivity and capacity of natural systems and the ecological processes which maintain their functions; and
- To promote development that is sustainable and optimizes resource use and management opportunities.

2.5 Types of EIA

Environmental assessments could be classified into four types *i.e.,* strategic environmental assessment, regional EIA, sectoral EIA and project level EIA. These are precisely discussed in the subsequent sections.

Strategic Environmental Assessment

Strategic Environmental Assessment (SEA) refers to systematic analysis of the environmental effects of development policies, plans, programmes and other proposed strategic actions. SEA represents a proactive approach to integrating environmental considerations into the higher levels of decision-making – beyond the project level, when major alternatives are still open.

Regional EIA

EIA in the context of regional planning integrates environmental concerns into development planning for a geographic region, normally at the sub-country level. Such an approach is referred to as the economic-cum-environmental (EcE) development planning (Asian Development Bank, 1993a). This approach facilitates adequate integration of economic development with management of renewable natural resources within the carrying capacity limitation to achieve sustainable development. It fulfils the need for macro-level environmental integration, which the project-oriented EIA is unable to address effectively. Regional EIA addresses the environmental impacts of regional development plans and thus, the context for project-level EIA of the subsequent projects, within the region. In addition, if environmental effects are considered at regional level, then the cumulative environmental effects of all the projects within the region can be accounted.

Sectoral EIA

Instead of project-level-EIA, an EIA should take place in the context of regional and sectoral level planning. Once sectoral level development plans have the integrated sectoral environmental concerns addressed, the scope of project-level EIA will be quite minimal. Sectoral EIA will helps in addressing specific environmental problems that may be encountered in planning and implementing sectoral development projects.

Project Level EIA

Project level EIA refers to the developmental activity in isolation and the impacts that it exerts on the receiving environment. Thus, it may not effectively integrate the cumulative effects of the development in a region.

From the above discussion, it is clear that EIA shall be integrated at all the levels *i.e.*, strategic, regional, sectoral and the project level. Whereas, the strategic EIA is a structural change in the way the things are evaluated for decision-making, the regional EIA refers to substantial information processing and drawing complex inferences. The project-level EIA is relatively simple and reaches to meaningful conclusions. Therefore in India, largely, the project-level EIA studies are taking place and are being considered. However, in the re-engineered Notification, provisions have been incorporated for giving a single clearance for the entire industrial estates for e.g., Leather parks, pharma cities *etc*., which is a step towards the regional approach.

As we progress and the resource planning concepts emerge in our decision-making process, the integration of overall regional issues will become part of the impact assessment studies.

2.6 Basic EIA Principles

By integrating the environmental impacts of the development activities and their mitigation early in the project planning cycle, the benefits of EIA could be realized in all stages of a project, from exploration and planning, through construction, operations, decommissioning, and beyond site closure.

A properly-conducted-EIA also lessens conflicts by promoting community participation, informing decision makers, and also helps in laying the base for environmentally sound projects. An EIA should meet at least three core values (EIA Training Resource Manual, UNEP 2002,):

- Integrity: The EIA process should be fair, objective, unbiased and balanced
- Utility: The EIA process should provide balanced, credible information for decision-making
- Sustainability: The EIA process should result in environmental safeguards

Ideally an EIA process should be:

- Purposive- should inform decision makers and result in appropriate levels of environmental protection and community well-being.
- Rigorous- should apply 'best practicable' science, employing methodologies and techniques appropriate to address the problems being investigated.
- Practical- should result in providing information and acceptable and implementable solutions for problems faced by proponents.
- Relevant- should provide sufficient, reliable and usable information for development planning and decision making.
- Cost-effective- should impose the minimum cost burdens in terms of time and finance on proponents and participants consistent with meeting accepted requirements and objectives of EIA
- Efficient- should achieve the objectives of EIA within the limits of available information, time, resources and methodology.
- Focused- should concentrate on significant environmental effects and key issues; *i.e.*, the matters that need to be taken into account in making decisions.
- Adaptive- should be adjusted to the realities, issues and circumstances of the proposals under review without compromising the integrity of the process, and be iterative, incorporating lessons learned throughout the project life cycle.
- Participative- should provide appropriate opportunities to inform and involve the interested and affected publics, and their inputs and concerns should be addressed explicitly in the documentation and decision making.
- Inter-disciplinary- should ensure that the appropriate techniques and experts in the relevant bio-physical and socio-economic disciplines are employed, including use of traditional knowledge as relevant.
- Credible- should be carried out with professionalism, rigor, fairness, objectivity, impartiality and balance, and be subject to independent checks and verification.
- Integrated- should address the interrelationships of social, economic and biophysical aspects.
- Transparent- should have clear, easily understood requirements for EIA content; ensure public access to information; identify the factors that are to be taken into account in decision making; and acknowledge limitations and difficulties.
- Systematic- should result in full consideration of all relevant information on the affected environment, of proposed alternatives and their impacts, and of the measures necessary to monitor and investigate residual effects.

2.7 Project Cycle

The generic project cycle including that of Sugar industry has six main stages:

1. Project concept
2. Pre-feasibility
3. Feasibility
4. Design and engineering
5. Implementation
6. Monitoring and evaluation.

It is important to consider the environmental factors on an equal basis with technical and economic factors throughout the project planning, assessment and implementation phases. EIA should be introduced at the earliest in the project cycle and must be an integral part of the project pre-feasibility and feasibility stage. If the EIA considerations are given due respect in the site selection process by the project proponent, the subsequent stages of the clearance process would get simplified and would also facilitate easy compliance to the mitigation measures through out the project life cycle.

A project's feasibility study should include a detailed assessment of significant impacts, the prediction and quantification of impacts and delineation of Environmental Management Plan (EMPs). Findings of the EIA study should preferably be incorporated in the project design stage so that the project as well as the site alternatives is studied and necessary changes, if required, are incorporated in the project design stage. This practice will also help the management in assessing the negative impacts and in designing cost-effective remedial measures. In general, EIA enhances the project quality and improves the project planning process.

2.8 Environmental Impacts

Environmental impacts resulting from proposed actions can be grouped into following categories:

- Beneficial or detrimental
- Naturally reversible or irreversible
- Repairable via management practices or irreparable
- Short term or long term
- Temporary or continuous
- Occurring during construction phase or operational phase
- Local, regional, national or global
- Accidental or planned (recognized before hand)
- Direct (primary) or Indirect (secondary)
- Cumulative or single

The category of impact as stated above, and the significance will facilitate the Expert Appraisal Committee (EAC)/State Level EAC (SEAC) to take a look at ToR for EIA studies as well as, in decision taking process about the developmental activity.

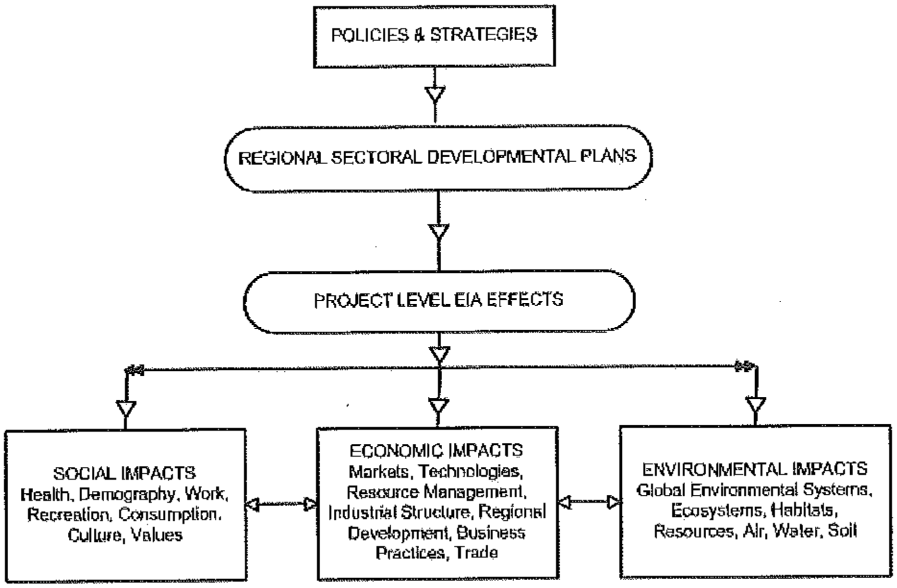


Figure 2-2: Types of Impacts

The nature of impacts could fall within three broad classifications *i.e.*, direct, indirect and cumulative, based on the characteristics of impacts. The assessment of direct, indirect and cumulative impacts should not be considered in isolation or considered as separate stages in the EIA. Ideally, the assessment of such impacts should form an integral part of all stages of the EIA. The TGM does not recommend a single method to assess the types of impacts, but suggests a practical framework/approach that can be adapted and combined to suit a particular project and the nature of impacts.

2.8.1 Direct Impacts

Direct impacts occur through direct interaction of an activity with an environmental, social, or economic component. For example, a discharge of sugar industry or an effluent from the Effluent Treatment Plant (ETP) into a river may lead to a decline in water quality in terms of high biological oxygen demand (BOD) or dissolved oxygen (DO).

2.8.2 Indirect Impacts

Indirect impacts on the environment are those which are not a direct result of the project, often produced away from or as a result of a complex impact pathway. The indirect impacts are also known as secondary or even tertiary impacts. For example, ambient air SO_2 rise due to stack emissions may deposit on land as SO_4 and cause acidic soils. Another example of indirect impact is the decline in water quality due to rise in temperature of water bodies receiving cooling water discharge from the nearby industry. This in turn, may lead to a secondary indirect impact on aquatic flora in that water body and may further cause reduction in fish population. Reduction in fishing harvests, affecting the incomes of fishermen is a third level impact. Such impacts are characterized as socio-economic (third level) impacts. The indirect impacts may also include growth-inducing impacts and other effects related to induced changes to the pattern of land use or additional road network, population density or growth rate. In the process, air, water and other natural systems including the ecosystem may also be affected.

2.8.3 Cumulative Impacts

Cumulative impact consists of an impact that is created as a result of the combination of the project evaluated in the EIA together with other projects in the same vicinity, causing related impacts. These impacts occur when the incremental impact of the project is combined with the cumulative effects of other past, present and reasonably foreseeable future projects. Figure 2-3 depicts the same. Respective EAC may exercise their discretion on a case-by-case basis for considering the cumulative impacts.

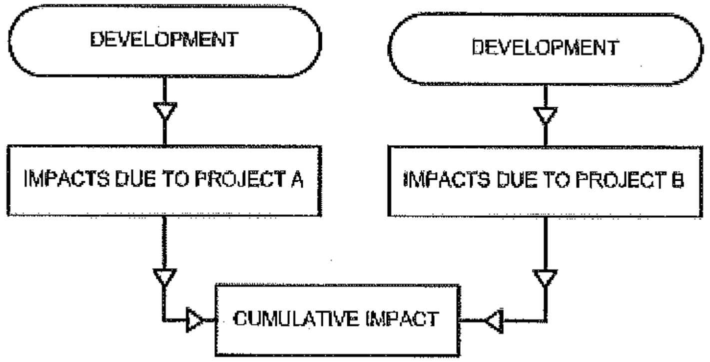


Figure 2-3: Cumulative Impact

2.8.4 Induced Impact

The cumulative impacts can be due to induced actions of projects and activities that may occur if the action under assessment is implemented such as growth-inducing impacts and other effects related to induced changes to the pattern of future land use or additional road network, population density or growth rate (e.g., excess growth may be induced in the zone of influence around a sugar project, and in the process causing additional effects on air, water and other natural ecosystems). Induced actions may not be officially announced or be part of any official plan. Increase in workforce and nearby communities contributes to this effect.

They usually have no direct relationship with the action under assessment, and represent the growth-inducing potential of an action. New roads leading from those constructed for a project, increased recreational activities (e.g., hunting, fishing), and construction of new service facilities are examples of induced actions.

However, the cumulative impacts due to induced development or third level or even secondary indirect impacts are difficult to be quantified. Because of higher levels of uncertainties, these impacts cannot normally be assessed over a long time horizon. An EIA practitioner usually can only guess as to what such induced impacts may be and the possible extent of their implications on the environmental factors. Respective EAC may exercise their discretion on a case-by-case basis for considering the induced impacts.

2.9 Significance of Impacts

This TGM establishes the significance of impacts first and proceeds to delineate the associated mitigation measures. So the significance here reflects the "worst-case scenario" before mitigation is applied, and therefore provides an understanding of what may happen if mitigation fails or is not as effective as predicted. For establishing significance of different impacts, understanding the environmental system responses and interaction is essential. Hence, the impact interactions and pathways are to be understood and established first. Such an understanding will help in the assessment process to quantify the impact as accurately as possible. Complex interactions, particularly in the case of certain indirect or cumulative impacts, may give rise to non-linear responses which are often difficult to understand and therefore their significance difficult to assess. It is hence understood that indirect or cumulative impacts are more complex than the direct impacts and most often currently the impact assessments are limited to direct impacts. In case mitigation measures are delineated before determining significance of the effect, the significance represents the residual effects.

However, the ultimate objective of an EIA is to achieve sustainable development. The development process shall invariably cause some residual impacts even after implementing an EMP effectively. Environmentalists today are faced with a vital, not-easy-to-answer question—"What is the tolerable level of environmental impact within the sustainable development framework?" As such, it has been recognized that every ecosystem has a threshold for absorbing deterioration and a certain capacity for self-regeneration. These thresholds based on concept of carrying capacity are as follows:

- Waste emissions from a project should be within the assimilative capacity of the local environment to absorb without unacceptable degradation of its future waste absorptive capacity or other important services.
- Harvest rates of renewable resource inputs should be within the regenerative capacity of the natural system that generates them; depletion rates of non-renewable inputs should be equal to the rate at which renewable substitutes are developed by human invention and investment.

The aim of this model is to curb over-consumption and unacceptable environmental degradation. But because of limitation in available scientific basis, this definition provides only general guidelines for determining the sustainable use of inputs and outputs. To establish the level of significance for each identified impact, a three-stage analysis may be referred:

- First, an impact is qualified as being either negative or positive.
- Second, the nature of impacts such as direct, indirect, or cumulative is determined using the impact network
- Third, a scale is used to determine the severity of the effect; for example, an impact is of low, medium, or high significance.

It is not sufficient to simply state the significance of the effect. This determination must be justified, coherent and documented, notably by a determination methodology, which must be described in the methodology section of the report. There are many recognized methodologies to determine the significance of effects.

2.9.1 Criteria/methodology to determine the significance of the identified impacts

The criteria can be determined by answering some questions regarding the factors affecting the significance. This will help the EIA stake-holders, the practitioner in particular, to determine the significance of the identified impacts eventually. Typical examples of such factors (one approach reported by Duval and Vonk 1994) include the following:

- Exceedance of a Threshold: Significance may increase if a threshold is exceeded. e.g., Emissions of PM10 exceed the permissible threshold.
- Effectiveness of Mitigation: Significance may increase as the effectiveness of mitigation measures decreases. e.g., control technologies, which may not assure consistent compliance to the requirements.
- Size of Study Area: Significance may increase as the zone of effects increases.
- Incremental Contribution of Effects from Action under Review: Significance may increase as the relative contribution of an action increases.
- Relative Contribution of Effects of Other Actions: Significance may decrease as the significance of nearby larger actions increase.
- Relative Rarity of Species: Significance may increase as a species becomes increasingly rare or threatened.
- Significance of Local Effects: Significance may increase as the significance of local effects is high.
- Magnitude of Change Relative to Natural Background Variability: Significance may decrease if effects are within natural assimilative capacity or variability.
- Creation of Induced Actions: Significance may increase as a induced activities also highly significant and
- Degree of Existing Disturbance: Significance may increase if the surrounding environment is pristine.

For determining significance of impacts, it is important to remember that secondary and higher order effects can also occur as a result of a primary interaction between a project activity and the local environment. Wherever a primary effect is identified, the practitioner should always think if secondary or tertiary effects on other aspects of the environment could also arise.

The EIA should also consider the effects that could arise from the project due to induced developments, which take place as a consequence of the project. e.g., Population density and associated infrastructure and jobs for people attracted to the area by the project. It also requires consideration of cumulative effects that could arise from a combination of the effects due to other projects with those of other existing or planned developments in the surrounding area. So the necessity to formulate a qualitative checklist is suggested to test significance, in general.

3.
SUGAR INDUSTRY

3.1 Introduction

Sugar is extracted from two different raw materials *i.e.*, sugarcane and beet. While both produce identical refined sugar, sugarcane is grown in semi-tropical regions, accounts for around two-thirds of world sugar production and beet is grown in temperate climates, and accounts for the balance one third of world production.

In India, sugarcane is the key raw material for the production of sugar. Most of the sugarcane produced in India is a 10-12 month crop planted during January to March. Besides, 18 to 20 months crop is also practiced in northern Maharashtra, parts of Andhra Pradesh and Karnataka. In most areas, the 12-month crop is followed by just one ratoon crop, that is, a new crop grown from the stubble of the harvested crop. At present, sugarcane is being cultivated throughout the country except in certain hilly tracts in Kashmir, Himachal Pradesh, *etc*. The sugarcane growing areas may be broadly classified into two agro-climatic regions *i.e.*, subtropical and tropical. The major sugarcane producing states in the sub-tropical areas include Uttar Pradesh (UP), Uttaranchal, Bihar, Punjab, and Haryana. In tropical areas of India, sugarcane is grown primarily in Maharashtra, Andhra Pradesh (AP), Tamil Nadu (TN), and Gujarat.

Table 3-1: State-wise Sugar Cane & Sugar Production in India

SY	Sugarcane (Production in Million Tounes)						Sugar (Production in Million Tonnes)					
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006 (Oct-Apr)**
AP	17.69	18.08	15.39	15.07	15.74	17.94	1.02	1.05	1.21	0.89	0.98	1.19
Gujarat	12.70	12.47	14.07	12.67	14.57	13.31	1.07	1.06	1.25	1.07	0.80	1.17
Haryana	8.17	9.27	10.65	9.28	8.06	6.84	0.59	0.62	0.64	0.58	0.40	0.41
Karnataka	42.92	33.02	32.49	16.02	14.28	15.20	1.61	1.55	1.87	1.12	1.04	1.75
Maharashtra	49.59	45.14	42.17	25.67	20.48	34.69	6.71	5.61	6.22	3.18	2.22	5.13
TN	33.19	32.62	24.17	17.66	23.40	33.30	1.78	1.84	1.64	0.92	1.11	1.40
UP	106.07	117.98	120.95	112.75	118.72	121.53	4.76	5.26	5.65	4.55	5.04	5.77
Uttaranchal	7.35	7.56	7.33	7.65	6.44	6.13	0.00	0.44	0.50	0.39	0.38	0.43
Punjab	7.77	9.25	9.29	6.62	5.17	5.29	0.50	0.59	0.59	0.39	0.32	0.33

SY	Sugarcane (Production in Million Tonnes)						Sugar (Production in Million Tonnes)					
	2001	2002	2003	2004	2005	2006	2001	2002	2003	2004	2005	2006 (Oct-Apr)
Others	10.51	11.83	10.89	10.48	10.25	12.65	0.49	0.50	0.58	0.47	0.41	0.61
Total	295.96	297.21	287.38	233.86	237.09	266.88	18.51	18.53	20.15	13.55	12.69	18.17

SY: October-September; SY2006 sugarcane production is as per 2nd Advance Estimates released on February 22, 2006.

Source: The Indian Sugar Industry, July 2006, ICRA Sector Analysis

Available figures on sugarcane cultivation indicates that higher the size of farm holding, higher is the percentage of farmer households cultivating wheat, pulses, oilseeds, and sugarcane. Use of farm implements such as tractor is also higher for larger landholdings. Nearly 9% of all farmer households with landholdings of 4-10 hectares (ha) cultivate sugarcane, as compared to only 1% for farmers with landholdings of 0.01-0.2 ha. The use of farm inputs indicate that 61% of sugarcane growers use improved seeds, 96% use fertilizers, and 51% use pesticides. While use of farm inputs remains high, the usage of farm implements such as tractors is moderate and confined primarily to larger landholdings. Further, nearly 58% of the land under sugarcane is on landholdings of greater than 2 ha. Scale economies can be achieved through larger land-holdings and higher degree of mechanization in crops such as sugarcane.

Table 3-2: Distribution of Area under Sugarcane for Different Size of Landholding

	<0.2 ha	0.2–0.5 ha	0.5-1 ha	1-2 ha	2-4 ha	4-10 ha	>10 ha	Total
	(Production in Million hectares)							
AP	2.7	8.1	14.4	19.9	26.8	28.1		100
Gujarat	0.0	5.7	5.7	9.3	27.4	37.7	14.1	100
Haryana		2.5	2.5	7.9	32.9	53.5	0.5	100
Karnataka	0.5	1.9	7.4	34.8	33.0	15.9	6.5	100
Maharashtra	0.5	1.9	7.4	34.8	33.0	15.9	6.5	100
TN	0.9	9.0	15.5	22.4	28.7	23.6		100
UP	0.6	5.1	13.3	25.7	29.8	22.8	2.6	100
Punjab			3.2	31.7	23.3	34.9	6.9	100
Total	0.8	5.0	11.8	23.8	29.0	25.0	4.6	100

Source: The Indian Sugar Industry, July 2006, ICRA Sector Analysis

The sugarcane yields are substantially higher in the tropical states such as AP, Karnataka, and TN as compared to the sub-tropical regions. The southern states, over a period of time, have increased the productivity through appropriate adoption of new varieties replacing the traditional ones. The cane yield of southern states is also higher when compared with northern states where sugarcane is known to grow over a wide range of environmental conditions and therefore is exposed more to both biotic (insect pests, diseases, and weeds) and abiotic (drought, salinity, alkalinity, water logging and extreme temperatures) stresses.

Data on net irrigated area for non-cereal crops indicates that with an area of 2.9 million ha in 2003, sugarcane had the largest irrigated area during the kharif season. In the rabi season, sugarcane had only 1.2 million ha. Data on the sources of irrigation for sugarcane in major producing states indicates that tube wells constitute the most important source of irrigation in UP. By comparison, river springs and wells constitute the most important source in Maharashtra and Karnataka.

Table 3-3: Percentage of area Under Irrigation During the Agricultural Year for Sugarcane by Source of Irrigation – 2003

	River/ Spring	Canal	Reservoir	Tank	Tube well	Well	Others	Area under irrigation (thousand ha)
Kharif	7.9	9.7	0.3	0.9	65.1	16.8	1.3	29,211
AP	0.0	10.4	0.6	5.2	72.8	9.6	1.4	975
Gujarat	0.0	36.9	0.0	0.0	26.7	36.4	0.0	860
Haryana	1.1	15.3	0.0	1.8	81.8	0.0	0.0	792
Karnataka	30.9	9.9	0.0	0.7	21.5	37.0	0.0	2,040
Maharashtra	25.1	6.0	0.0	2.5	14.9	50.7	1.7	5,224
Punjab	1.5	1.1	0.0	0.0	98.0	0.0	0.0	728
TN	0.0	12.7	0.0	1.4	29.2	59.4	0.0	1,642
UP	1.0	9.7	0.0	0.1	91.7	0.4	0.1	15,475
Uttaranchal	0.0	17.4	0.0	0.0	59.2	0.0	23.4	194
Rabi	5.2	8.7	0.1	0.6	71.1	14.9	0.7	11,980
AP	4.5	0.5	0.0	2.3	86.6	6.1	0.0	414
Gujarat	0.0	37.8	0.0	0.0	18.8	43.5	0.0	650
Haryana	0.0	28.9	0.0	0.0	71.1	0.0	0.0	47
Karnataka	21.9	8.8	0.0	0.0	28.5	40.9	0.0	702
Maharashtra	26.1	5.8	0.4	1.6	7.5	60.1	0.0	1,110
Punjab	0.0	11.9	0.0	0.0	100.0	0.0	0.0	28
TN	0.0	14.8	0.0	0.1	37.8	47.	0.0	922

	River/ Spring	Canal	Reservoir	Tank	Tube well	Well	Others	Area under irrigation (thousaud ha)
						4		
UP	0.4	6.3	0.2	0.6	93.5	0.1	1.0	7,538
Uttaranchal	0.0	18.1	0.0	0.0	81.9	0.0	0.0	146

Source: The Indian Sugar Industry, July 2006, ICRA Sector Analysis

After a period of rising sugarcane production during SY1993-2002, India's sugarcane production declined significantly during SY2003 and SY2004. The decline was primarily because of deficient Southwest (June- September) monsoon conditions in UP and Maharashtra. Sugarcane is a highly water-intensive crop, notwithstanding the progress made since the 1980s. Indian agriculture continues to depend significantly on the monsoon. This is evident from the adverse impact of deficient monsoon conditions on agricultural production.

Table 3-4: Southwest Monsoon Conditions in Major Sugarcane-producing Regions

	2000	2001	2002	2003	2004	2005	2006 (June 1 to July 12)
East Uttar Pradesh	+9	+4	-27	+18	-21	-16	+18
West Uttar Pradesh	+2	-15	-17	+32	-36	-17	-10
Haryana, Chandigarh & Delhi	-11	0	-35	+25	-21	-5	+9
Punjab	-15	+8	-26	-1	-42	-4	-20
Gujarat Region	-29	-8	-21	+19	+5	+41	+27
Saurashtra, Kutch & Diu	-43	-6	-24	+33	-7	+28	+30
Madhya Maharashtra	-13	-12	-8	-10	+11	+45	+53
Marathawada	+13	-12	+6	-17	-17	+9	-8
TN & Pondicherry	-14	-23	-43	+8	-5	-6	-12
Coastal AP	+29	-15	-18	+8	-5	+13	-9
Telangana	+29	-15	-16	+7	-24	+32	-35
North Interior Karnataka	+14	-33	-21	-33	-8	+30	+10
South Interior Karnataka	+14	-18	-41	-23	-5	+35	+17

Source: The Indian Sugar Industry, July 2006, ICRA Sector Analysis

Production trends

Sugarcane output during SY2003-04 was also adversely impacted by pest attacks on sugarcane grown in Maharashtra, Karnataka and some pockets of UP and Uttaranchal. As a result, sugarcane production declined 3.3% during SY2003 and 18.6% during SY2004. During SY2005, sugarcane output increased 1.4% to 237.09 metric tonnes (MT), mainly because of higher output in UP, TN and Gujarat, which offset declines in Maharashtra and Karnataka.

Sugarcane output has recovered substantially in Maharashtra, TN, and Gujarat, with lower increase in UP. The 2005 monsoons provided ample rainfall in the cane growing areas of Karnataka, Gujarat and Maharashtra. However, floods were estimated to have caused damage to more than 50% sugarcane crop over an area of 17,351 ha in AP; 66,292 ha; and 1,93,191 ha in Karnataka has been affected. During SY2006, sugar mills started operations 2-3 weeks earlier than normal, thereby limiting early season cane diversion towards *gur* production. Strong sugar prices have led to higher cane prices, and timely payments to farmers by mills has increased the availability of cane for sugar production. Comparatively low *gur* prices have also discouraged cane diversion to *gur* production. During 2006, the progress of sugarcane acreage indicates a 3.9% (year on year [yoy]) increase in acreage to 4.45 million ha up to July 31, 2006. Increase in acreage has been reported from UP, Maharashtra, AP, TN, and Punjab. However, acreage of sugarcane production has declined in Karnataka

Sugar production declined 6.3% during SY2005, and 32.8% during SY2004. During October 2005-April 2006, India's sugar production aggregated 18.18 MT, representing an increase of 48% over the corresponding previous year.

Seasonal nature of production

Sugarcane and sugar production is seasonal with more than 90% of sugarcane and sugar production in the winter months of November-March. The sugarcane crushing season lasts on an average of 100-150 days per annum depending on the region, weather, irrigation and cultivation practices as well as cane availability, in itself a function of the prices paid to cane growers.

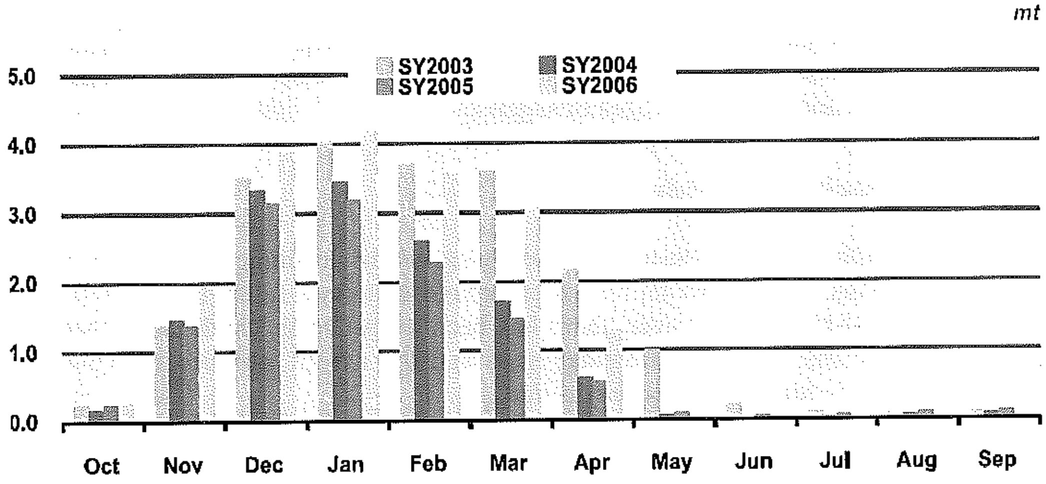


Figure 3-1: Monthly Sugar Production

Sugarcane and sugar production is partly dependent on monsoons. Higher acreage under sugarcane in a season of normal monsoons and higher yields results in higher sugarcane and sugar production. Both area and production of sugarcane fluctuate considerably from year to year. This is due to variations in climatic conditions, the vulnerability of areas cultivated under rain fed conditions, fluctuations in prices of *gur* and *khandsari* (semi-white centrifugal sugar), and changes in returns from competing crops. Despite this instability, both area and production of sugarcane have increased considerably over the past three decades. The average area of sugarcane cultivation increased from 2.4 million ha in the early-sixties to about 4.3 million ha at present.

As the procurement prices of sugarcane are controlled by the Central

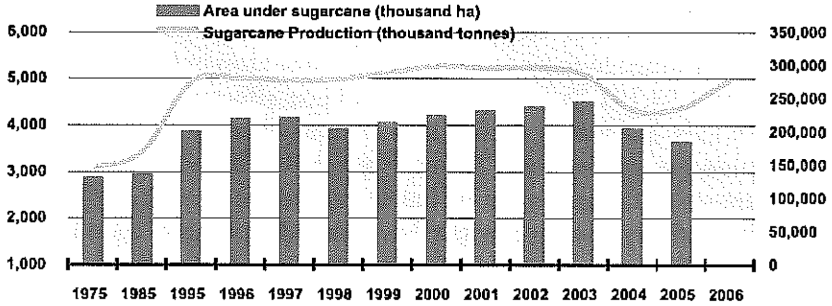


Figure 3-2: Sugarcane Acreage, Production and Sugar Production

The number of farmers cultivating sugarcane has increased as per the Government records. With yield of around 65,000 kilogram (kg) per hectare, and minimum support price (MSP) of Rs. 79.5 per quintal for SY2006, sugarcane can be the most profitable crop, wherever irrigation is available. In India, the sugarcane acreage under irrigation facilities is as high as 92%. The attraction of farmers towards sugarcane cultivation can be demonstrated by the fact that the area under sugarcane cultivation has increased consistently.

Sugarcane is a kharif crop (harvesting months of early kharif season and late kharif season extend over August to October and November to January, respectively), and normal area under sugarcane is 4.3 million ha during the kharif season, accounting for 4.2% of kharif area under all crops. Sugarcane can be planted as per the recommendation for the region. Autumn-planted cane gives 15-20% higher yield than the spring planted cane. UP accounts for more than 50% of the sugarcane acreage, 47% of sugarcane production, and 40% of sugar production. Thus, India's sugar production declined in SY2002, SY2004, and SY2005 because of deficient monsoon conditions in East and West UP, and a decline in area of sugarcane cultivation in these regions.

Declining yields

India's sugar industry has been plagued by declining yields from sugarcane in recent years. Yields per ha rose from around 43 tonnes in the early-1960s to 70 tonnes in the mid-1990s. However, there has been a decline in yields since then. The extension of sugarcane area to marginal lands and the use of varieties susceptible to disease were partly responsible for the decline.

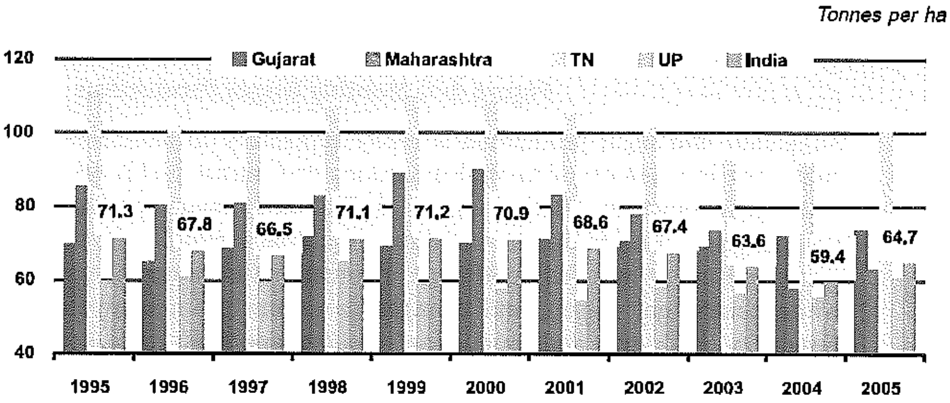


Figure 3-3: Yields of Sugarcane

Growth of sugar industry

India's total consumption of sugar has increased steadily despite fluctuations in production. Sugar consumption during SY2005 was estimated at around 19.6 MT. Consumption has increased at a five-year compound average growth rate (CAGR) of 4.8%. Consumption increased at a five-year CAGR of 5.2% during 1995-2000.

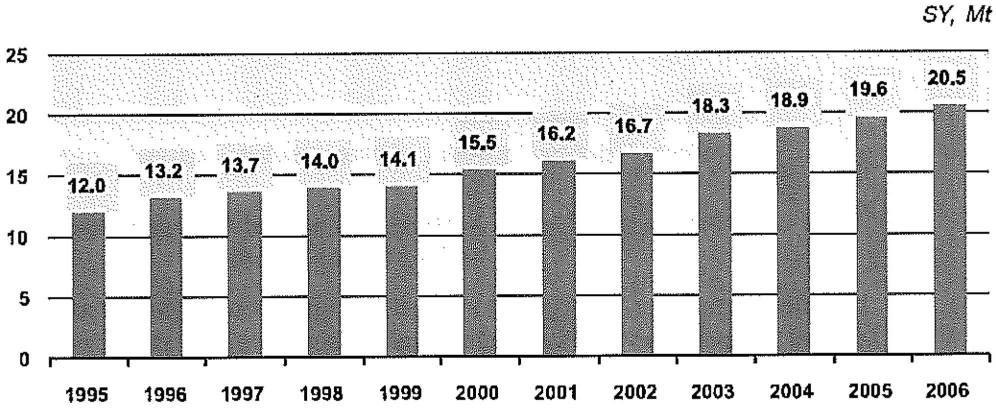


Figure 3-4: India's Sugar Consumption

India is the largest consumer of sugar in the world. However, two consecutive years of reduced production resulted in relatively higher domestic prices and lower demand, which eventually led to increased diversion of sugarcane for the production of *gur* and *khandsari*. Low sugar stocks (optimum stocks are 3 months) could exert an upward pressure on prices. Consumption of *gur* and *khandsari* has declined from 6.4 MT in the mid-1960s to around 6 MT at present. However, per capita consumption of these products has actually declined significantly from about 15 kg to 5.6 kg at present. On a volume basis, per capita consumption of *gur* and *khandsari* was overtaken by white sugar in the mid-1980s, reflecting distribution of subsidized levy sugar at times at prices close to the retail price of *khandsari* and *gur*, and relatively low prices of free market sugar maintained through the monthly release mechanism and the importation of large quantities of sugar when needed, along with bans on exports. As a result of these measures, sugar recorded the lowest price increase vis-à-vis all other essential commodities such as cereals, pulses, edible oils, and even compared to the alternate sweeteners e.g., *gur* and *khandsari*.

During 12M FY2006 (April 2005-March 2006), the sugar companies reported higher revenues and improved their profitability. Sales of ICRA's sample of 44 listed sugar companies increased 42.1% (yoy) to Rs. 145.60 billion during 12M FY2006. An increase in raw material costs on account of higher cane prices was more than offset by higher increase in prices, and decline in employee costs. As a result, operating profits increased 48% (yoy). Operating margins increased from 16.6% during 12MFY2005 to 17.3% during 12MFY2006. Lower interest and depreciation costs resulted in an 87.4% (yoy) increase in net profits. However, lower other income resulted in stable net margins during FY2005 and FY2006. On a quarterly basis, operating margins improved from 21% during Q4 FY2005 to 22.8% during Q4 FY2006.

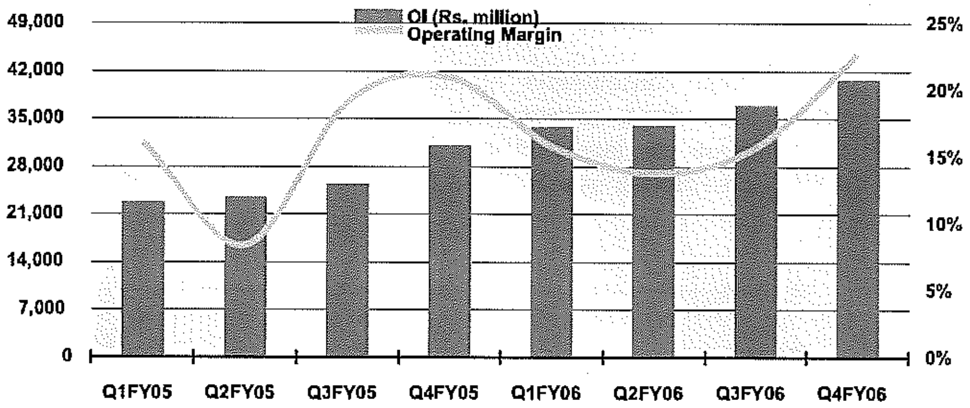


Figure 3-5: Trends in Gross Sales and Operating Margins for Indian Sugar Industry

Despite fluctuations in production, India's sugar consumption has increased steadily at around 5% per annum. Per capita sugar consumption has steadily increased from 5.3 kg per annum in the early-1960s to around 18 kg per annum at present. India's sugar consumption is expected to grow at a modest rate of 4.5% per annum in the medium term. Although *gur* and *khandsari* are still the main sugar products consumed in rural areas, demand for white sugar is expected to continue to increase both in absolute and per capita terms. Moreover, the growth of sugar demand by food industries and other non-household users, estimated to account for about 45% of total consumption, could provide additional impetus to longer-term market growth.

The Industrial classification of the industries based on the capacity may be as <2500 tonnes of cane crushed per day (TCD) (small), 2500 to 5000 TCD (medium) and >5000 TCD (large).

3.2 Scientific Aspects

3.2.1 Industrial process based classification of sugar

Sugarcane is brought to the factory, weighed and sent to the milling plant. Juice is extracted in the milling plant and heated and treated by double sulphitation process in most of the factories in India. In this double sulphitation process, juice is heated to 75°C and treated with lime and sulphur dioxide (SO_2). The juice is adjusted to neutral pH and passed to the heat exchanger to raise its temperature to the boiling point. It is then sent for clarification where juice is clarified and then sent to the multiple effect evaporator and the sediment from the clarifier is sent to the vacuum filters or pressure filters. The concentrated syrup from the evaporator is again bleached by passing SO_2 through and the pH of the syrup drops down to about 5.4. It is then sent to the vacuum pan, where the thickened syrup is boiled 3-4 times as per purity inorder to extract the sucrose content on the crystals. After this, the commercial sugar and molasses are separated in the centrifuges.

The various types of sugar include raw sugar, centrifugal sugar, white refined sugar, and non-centrifugal sugar.

- **Raw sugar**: It is brown sugar, which includes molasses and various impurities at the stage before it is crystallized. Raw sugars are produced in the processing of cane juice but only as intermediates *en route* to white sugar. Raw sugar is sometimes prepared as jaggery rather than as a crystalline powder: in this technique, sugar and molasses are poured together into molds and allowed to dry.

- **Centrifugal sugar**: This is raw sugar which has been crystallized and most of the molasses spun off by the use of a centrifuge.
- **White sugar**: In developed countries, most white sugar is sugar that has undergone one further refining process. There are various degrees of refining and the consequent purity and consistency of sugar crystals. As in other developing countries, most of the mill sugar produced and consumed in India is plantation white, meaning sugar that has undergone a first stage of refining at the mill, but which is less refined than the refined white sugar consumed in developed countries.
- **Non-centrifugal sugar**: This sugar is *gur*, which includes the molasses. It is produced by primitive artisanal processes and mostly consumed in rural areas. In Northwestern India, mainly in UP, there is also very substantial production of *khandsari*, which is a type of sugar produced by small scale country mills with the use of a centrifuge.

Gur is not a close substitute for sugar, and is mainly consumed by low income rural people as a food stuff rather than as a sweetening agent. *Khandsari*, however, is a close substitute. It can contain high proportions of fine crystals and is sometimes difficult to distinguish from plantation white sugar.

In excess of 70 percent (%) of the world's sugar production is based on sugarcane, with the remainder based on sugar beet. Typical cane processing facilities may process between 500 to 10,000 tons of cane per day. Beet processing facilities may process between 2,000 tons beet/24 hrs to 15,000 tons beet/24 hrs.

It is a trend to use Bagasse for Co-generation whereby after meeting the captive power requirement, excess power is sold to Local Grid.

Sugarcane contains 70% water, 14% fiber, 13.3% saccarose (about 10 to 15% sucrose), and 2.7% soluble impurities. Sugar beet has a water content of 75%, and the saccarose concentration is approximately 17 %.

3.2.2 Manufacturing process of raw sugar

Production of very high polarity raw sugar

The study on world sugar export market reveals that at any given point of time, Global Tradable Surplus is about 500-600 lakh tones out of which 50% is raw sugar, 35-40% is refined sugar and 10-15% is plantation white sugar. In the year 2007-08 due to good monsoon, bumper crop of sugarcane has resulted in the huge stock of sugar after meeting the domestic consumption. The sugar mills would have to face storage problem, burden of interest, insurance and subdued sugar prices, financial conditions of the sugar factories would have gravely affected. The Government therefore, allowed export of sugar by announcing transport subsidy to sugar units. As the new sugar refineries have come up many sugar mills turn to production of very high pol (VHP) raw sugar for the refineries.

Table 3-5: VHP Raw Sugar Production

S.No	Parameters	VHP Raw Sugar
1	Colour (Icu)	600-1200
2	Pol %	99.0 – 99.30
3	Moisture (%)	0.10 – 0.12
4	Ash (%)	0.12 – 0.20
5	R S %	0.12 – 0.15
6	Starch (ppm)	100 – 150 max
7	Dextran (ppm)	75 max

Manufacturing process

- To avoid bacterial contamination and to control dextran, 10-17 parts per million (ppm) of quarternary ammonium compound base effective biocide is used, steam/hot water washing is carried twice in a shift.
- Screening of raw juice is carried with double stage DSM screen having 0.6/0.7 millimetre (mm) aperture.
- Mixed juice phosphate level is kept 300 to 325 milligrams per litre mg/L by addition of phosphoric acid of A Grade.
- Raw juice is heated to 76 to 78 °C
- Simple detection process is followed only by adding milk of lime 60 to 80 brix to maintain the pH in the range of 7.2 to 7.6, juice is heated up to 102 °C to 103°C and clarified.
- Addition of 1 to 3 ppm of mud setting and colourant is added to get brilliant colour.
- Juice or syrup sulphitation is not required.
- There massecuite boiling system is followed as that of white sugar.
- B m/c single cured seed taken for A m/c as a footing partially melted
- C m/c double cured melted
- B & C melt taken for A m/c boiling

Curing

- A m/c is cured in steep cone machine of 38" x 49" machine
- Time cycle of A m/c is adjusted according to quality of dropping sugar without any lumps.

Conveying

Raw sugar conveyed in sugar hoppers blowing hot and cold air.

Grading

Mesh/screen fitted on top side for separation of rotary and for other deck *i.e.,* 6,8,10 mm mesh serves the purpose for bottom side with any type of plate having 2 mm thickness or tarpolein/plastic paper no difficulty is experienced at grading.

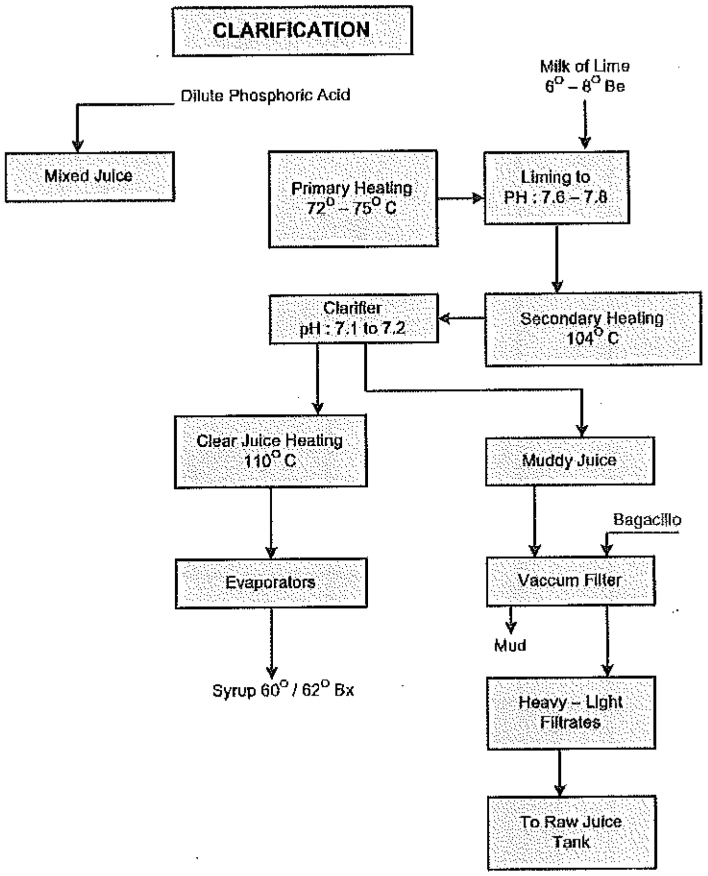


Figure 3-6: Clarification Process in Raw Sugar Manufacturing

Source: DSTA, TECH-PROC-56th CONV-2008

Precautions to be taken during the manufacturing of raw sugar

- Supply of clean, fresh cane to keep dextran within the limits
- Elimination of maximum suspended bagacillo
- Mill sanitation
- pH of lined juice and clear juice to avoid distraction of reducing sugars
- Phosphate level is to be maintained 300-350 ppm
- Production of hard uniform grain having equal size in the range of 600-1200 micron.
- Viscosity is to be reduced by utilizing hot water condensate at the end of strike of A.B. & C m/c boiling.
- Drying and cooling of raw sugar is strictly followed.

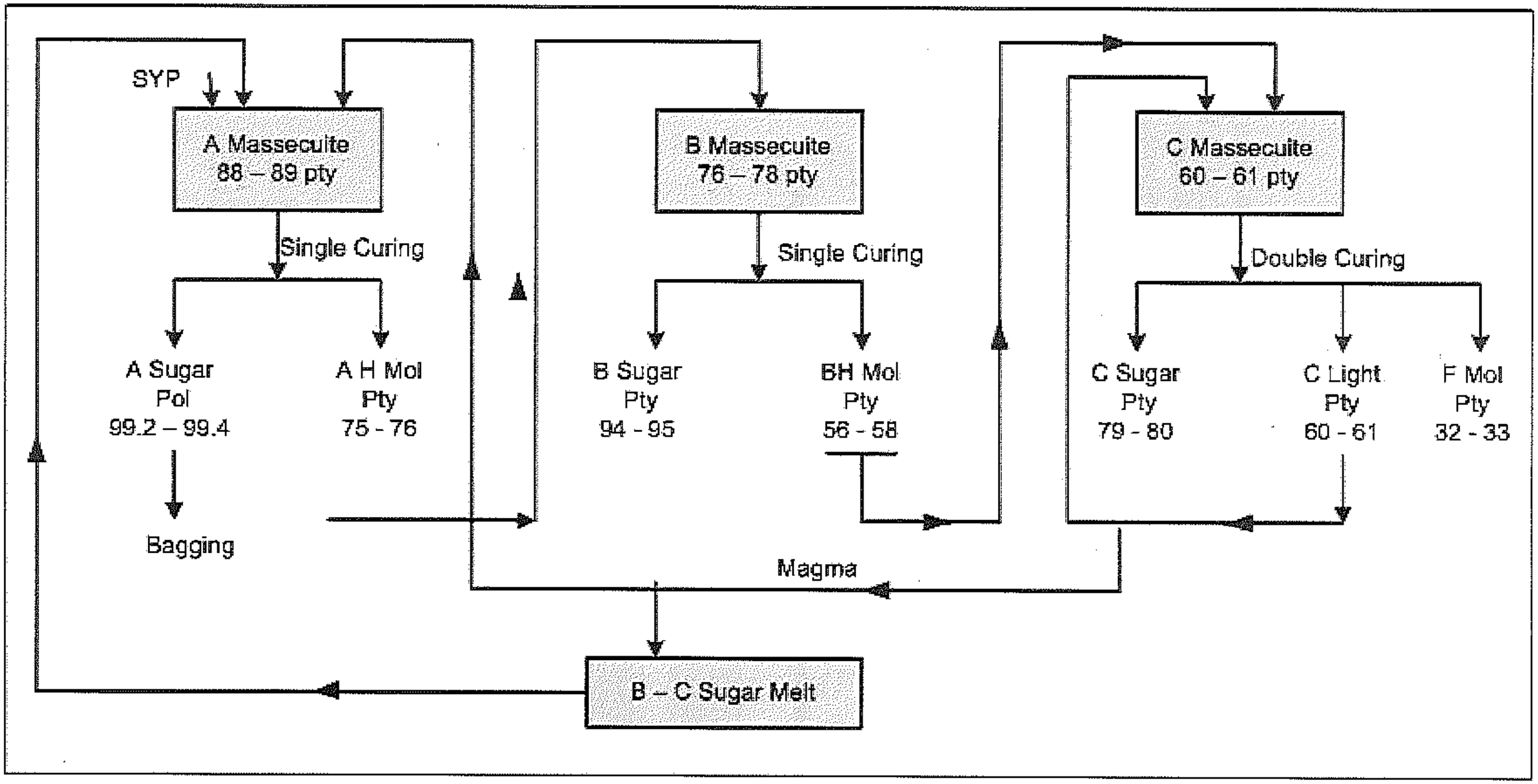


Figure 3-7: Process Flow Chart of Three Stage Boiling System

Source: DSTA, TECH-PROC-56th CONV-2008

3.2.3 Manufacturing of refined sugar

There are 10 discrete stages of the refining process with various options available at each stage:

- Raw sugar delivery
- Melting
- Clarification
- Filtration
- Decolorization
- Ion exchange resin column
  - Melt concentration
  - Brine recovery system
- Scum desweetening
- Crystallization
- Centrifugation
- Drying, storage and packaging
- Recovery house (Raw sugar house would be as recovery house)

A. Raw sugar delivery

In raw sugar handling the mechanized system is advisable as it would help in reducing the loss of sugar handling from port to factory. The present sugar handling systems are crude, labour-intensive, expensive and time consuming as well as losses are high.

B. Raw sugar melting and screening

Raw sugar from raw sugar centrifugal machine will be conveyed to the melter through a screw conveyer. This raw sugar will be melted in a specially designed horizontal melter with sweet water received from the decolorization station and hot water with controlled brix. Double screened melt will be pumped to the buffer tank for clarification.

C. Ion exchange resin process brief

For the production of refined sugar, decolorization of the melt is required through ion exchange resins. Two stage decolorizing process for this particular application is recommended. In this process, the decolorization is effected by passing the clear melt through a styrene based resin.

The resin, after completing the duty cycle, which is normally of 16-24 hrs, is desweetened by back flushing vigorously with hot, soft water to disperse the bed and to remove any suspended matter which may have collected during the duty cycle.

Regeneration is carried out with 10% sodium chloride solution having 2% concentration of sodium hydroxide.

Operation sequence:

- Sweeten on
- Service run
- Sweeten off
- Back wash

- Regeneration
- Displacement
- Descaling

i. Melt concentration

The fine liquor is concentrated in the evaporator to brix 74-76° to save energy and to maintain the product quality by stabilizing the brix of the evaporated fine liquor. A thin-film falling film-type double effect evaporator would be used for concentration of fine liquor. Typically the heating surface of each falling film would be around 500 m^2.

ii. Brine recovery system

This recovery process is based on the concentration of COD and colouring material in the retentate, while smaller molecules such as sodium chloride, sodium hydroxide, and water can easily cross the membrane (permeate).

In this recovery system, organic spiral - wound NF membranes are being used with high concentration factor of effluent. The spiral-wound membranes are much cheaper to tubular type. In this process each effluent from caustic brine regeneration is processed in a cross-flow filtration skid equipped with spiral nano-filtration membranes. Under a pressure of 20 bars, the spent brine would be highly purified to give a new load of recovered brine, which would be used for the next regeneration cycle.

The membranes are easy to clean and the efficiency of resin regeneration with nano-filtration brine would be about 70-80% and it can be further increased by installing brine concentrator.

D. Scum de-sweetening station

Flotation scums, being a suspension of tricalcium phosphate floe, floated off impurities and air bubbles in concentrated sugar liquor, form a complex system. The separation of floe and impurities from the solution inorder to recover sugar presents a number of difficulties. These often make the operation costly, either in actual expense or through loss of sucrose in the course of the recovery treatment.

The problems encountered in treatment of scum for sugar recovery arise out of the slimy and gelatinous character of the floe and the impurities occluded in it. These characteristics adversely affect the two basic methods-filtration and centrifugal separation - that have been available for the purpose.

The three stage scum desweetening process followed by specially designed pressure filtration is an advanced and proven process of extracting the sugar from the scum. The process flow is clearly illustrated in the Figure 3-8.

E. Crystallization - refined massecuite boiling

Table 3-6: Process brief of Crystallization of Refined Sugar

Inlet	Clarified, filtered, decolorized Liquor
Colour	150 – 200 IU

Inlet	**Clarified, filtered, decolorized Liquor**
Brix	60 – 62 deg
Purity	99+
Outlet	**Refined Sugar**

Grades of refined sugar would be EEC-I, EEC-II 85 mill white sugar.

Process description

It is the process in which sugar is crystallized from concentrated fine liquor obtained by water evaporation under vacuum; the operation is carried out under vacuum to prevent the sugar from burning or decomposing by heat and to obtain the crystals of the adequate size.

The most-effective decolorization is achieved by crystallization. Crystallization occurs in a saturated/supersaturated solution, which also means that crystals are always surrounded by a liquid phase.

Color is removed by crystallization, assuming the syrup separation is executed well. For high quality massecuites like A and refined sugar, color removal is at least 90%, but can go as high as 97.5-98%. Lower purity massecuites like B & C exhibits less color removal of 95- 95.5% and up to 80% (75 - 80%) respectively.

Back boiling or mixed boiling system will be followed for producing refined sugar of single quality. When the boiling is complete around 89 brix; pan is dropped into crystallizer and cured in batch centrifugal machine. This cured sugar is dried and cooled into drier before weighing & bagging.

F. Centrifugation

Centrifugation requires greatest attention as it ensures the effective crystallization. Inadequate mode of operation, badly cleaned screens, and mal-adjusted washing nozzles to mention a few of the key parameters of centrifugal work can destroy good results obtained in crystallization.

Drying, storage and packaging

These three steps should not be forgotten. They have little or nothing to do with color removal but more with secondary color formation and/or sugar contamination. This aspect is necessary for hygienic handling of the sugar as a human food.

The sugar comes out humid from the centrifugal process. It is then dried in a rotary dryer - a large rotating drum where the sugar dries upon coming into contact with the air. The dry and cooled refined sugar passes over a vibrating screen to separate lumps of sugar, which may be formed during the drying and cooling process. After this, it is transported by belt conveyor/ hopper and elevator to the top of the conditioning sugar silos where the sugar is separated by a set of vibrating screens. The screened sugar is sent to the silos as per the grain size classifications.

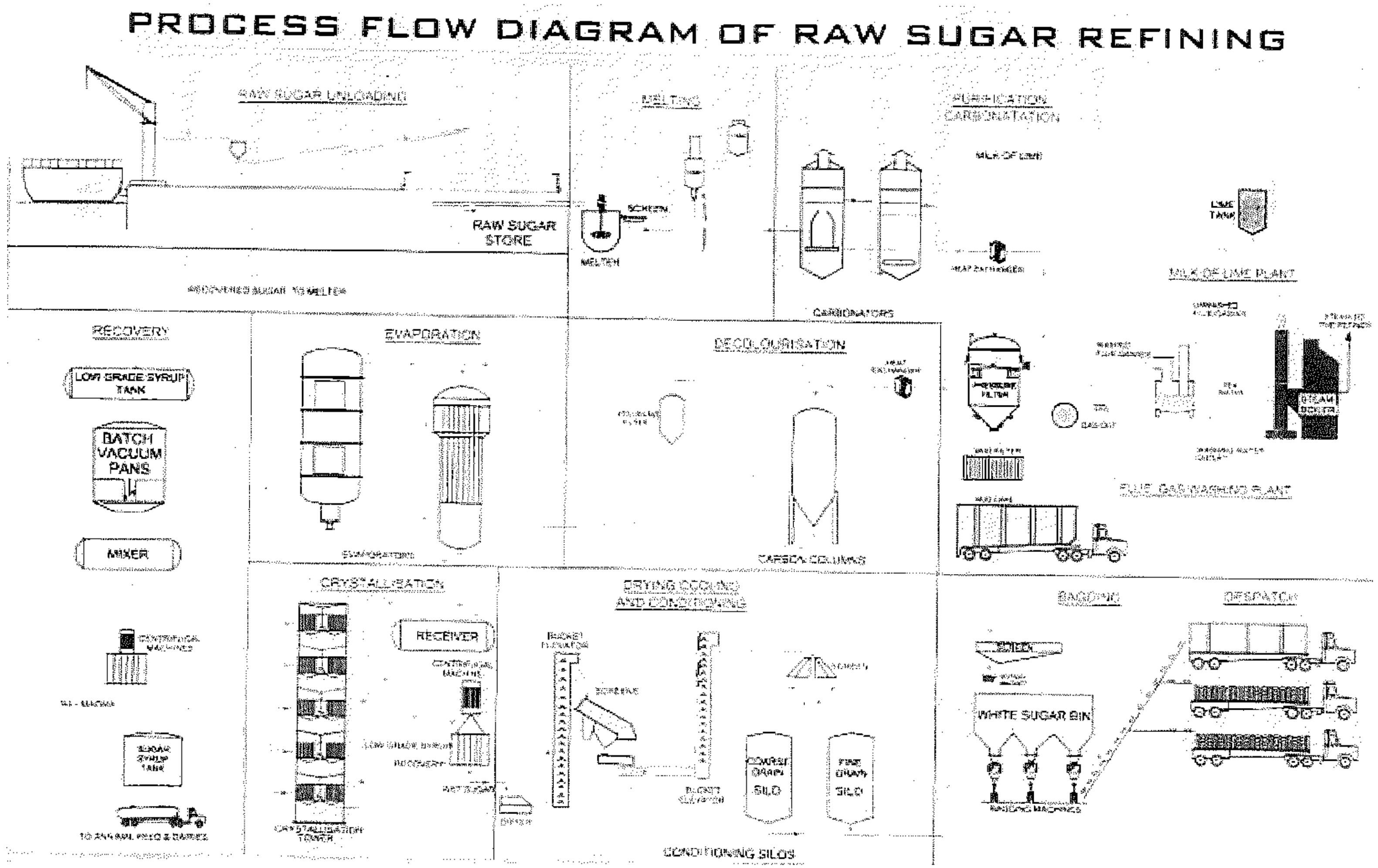


Figure 3-8: Process Flow Diagram of Raw Sugar Refining

Recovery house

The recovery house is the 'dirty' end of the sugar refinery where, as the name implies, the refiner tries to recover as much as possible of the sugar in any residual liquors before rejecting them as the molasses. Maximum sugar must be recovered from runoffs to get the optimum yield of the refinery. Series of boiling and other processes are followed to get the maximum sugar out of those liquors, and producing at the end, a thick material called **sugar syrup** and used in cattle feed preparations. The yield performance of any sugar refinery depends upon the performance of the recovery house.

Advantage achieved in raw sugar production over to the white sugar to the process point of view

- Rise in recovery percent cane by 0.63%
- Capacity utilization is increased by 6 to 8%
- Sulphur is not used in the process
- reduction in lime consumption by 58%
- Scale formation rate is very low and soft in nature
- Reduction in molasses % cane by 0.6-0.9 %
- Massecuite % cane is reduced by 5 to 6%

3.2.4 Sequence of steps in sugar production

Beet and cane sugar production processes are similar. Both involve reception, cleaning, extraction, juice clarification, evaporation, crystallization centrifugation, drying, storing, and packing stages as illustrated in Figure 3-9. Beet and cane sugar manufacturing are typically located adjacent to the sources of raw materials to reduce costs and transportation time, and to ensure fresh raw material.

A. Reception of beet and cane

Beet and cane are unloaded from the transportation vehicles after a sample has been taken for assessment of sugar and dirt content. The beet production line runs continuously at full capacity, whereas the sugarcane production line usually has to stop every 14 days (approximately) to facilitate removal of encrustations on heating surfaces. Cane and beet processing facilities typically have substantial areas to stock enough raw materials to facilitate continuous production.

B. Washing and extraction of cane

Traditionally, cane has been burned in the field before transport to processing facilities to remove any leaves from the cane stalk. The current trend is to harvest green unburned cane, returning leaves to the field where the crop residue promotes soil conservation.

Extraction of the sugar juice is achieved with roller mills which press out the juice. The remains of the cane stalk is called bagasse, which contains cellulose fiber. This is mostly used in the process facility as fuel for energy supply. Where fuel is available from another source, the bagasse may be used for further processing in the cellulose industry. Cane juice extraction may also be achieved by a diffusion leaching process, which can result in higher rates of extraction with 50% lesser energy consumption than a mechanical mill.

C. Washing and extraction of beet

Washing of sugar beet is water-intensive and washwater is typically recirculated. During washing, soil, stone and leaves are separated from the beet. Separated stone can be used, for example, as gravel for the construction industry. Disintegration of the beet is accomplished by cutting into slices (cossettes). The juice is extracted by a diffuser, where the slices are mixed with hot extraction water to form a sugar solution, known as 'diffusion juice'. The spent beet cossettes in the beet pulp are then pressed and dried to produce animal feed.

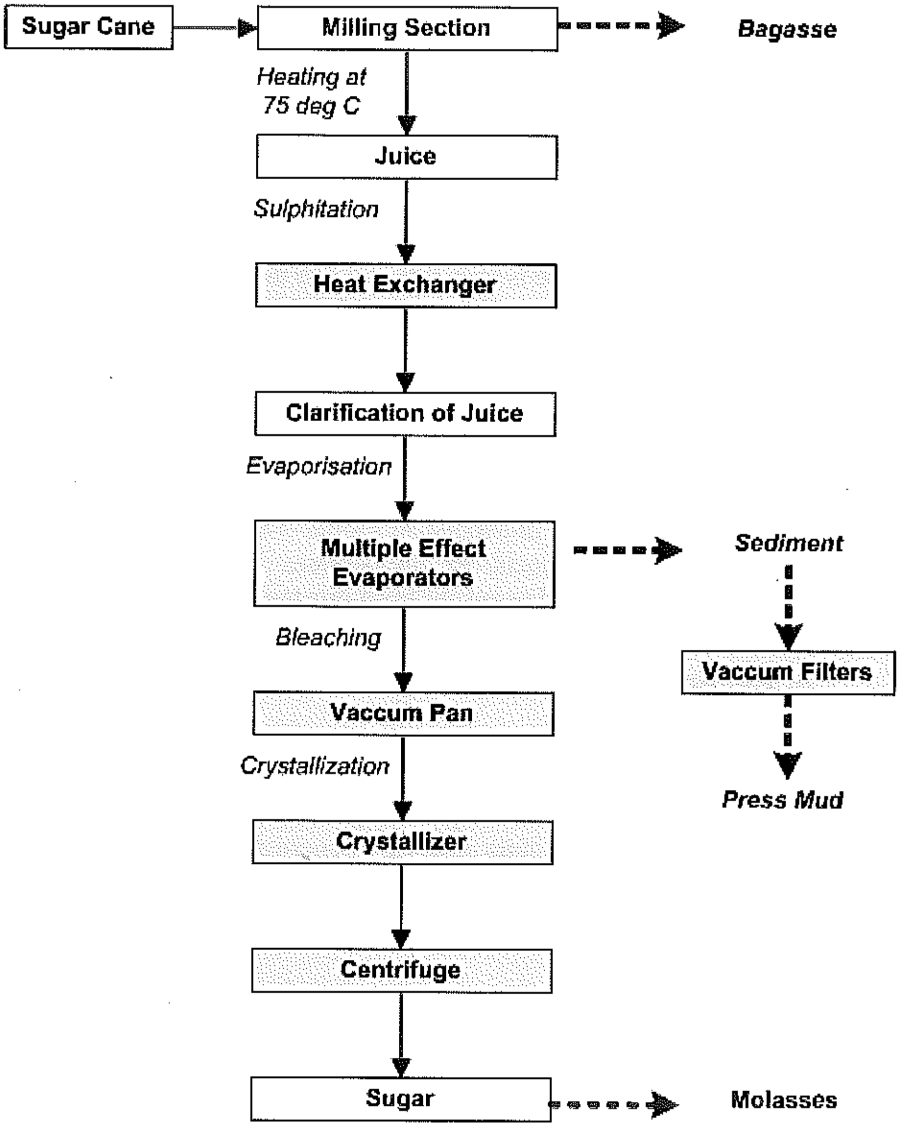
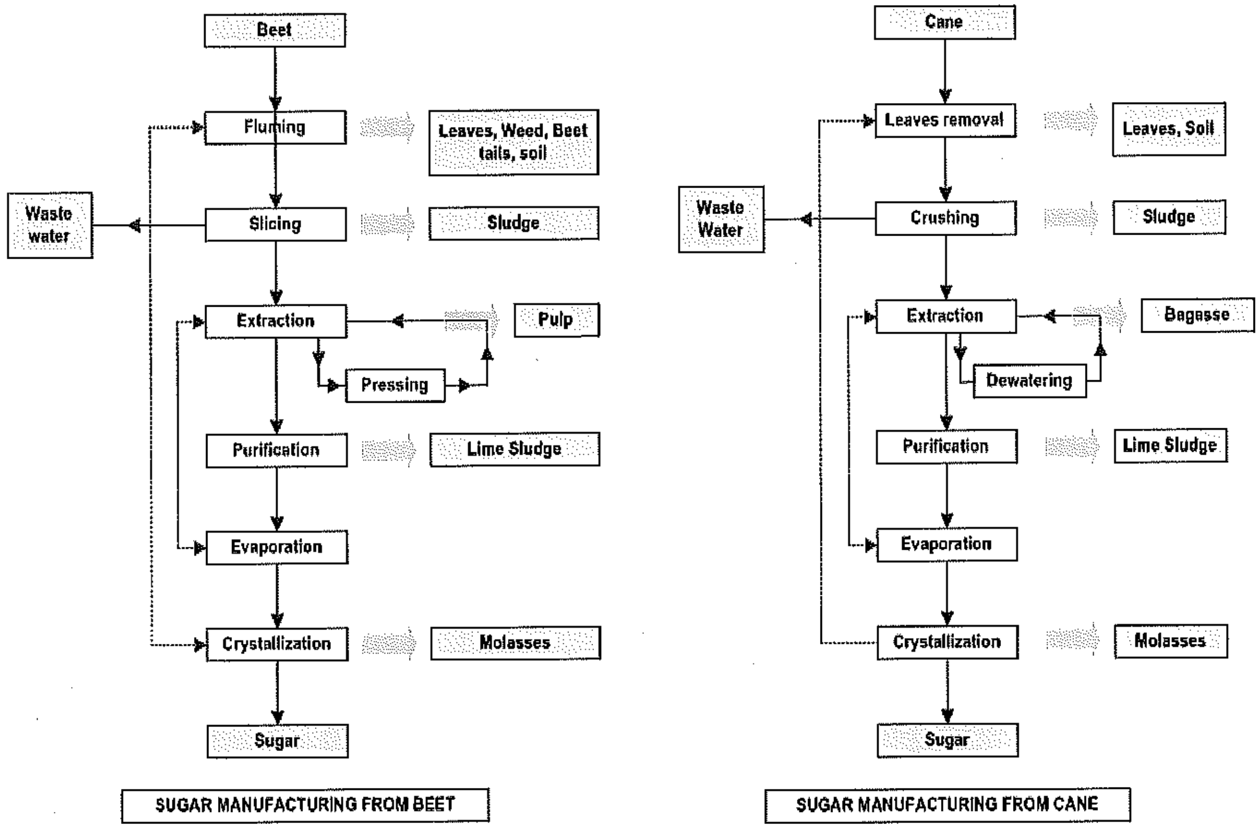


Figure 3-9: Sugar Manufacturing Process



Sonrce: IFC Environmental Health and Safety Guidelines

Figure 3-10: Comparison of Sugar Manufacture from Cane and Beet

D. Sugar refining

The refining of sugar involves affination (mingling and centrifugation), melting, clarification, decolorization, evaporation, crystallization, and finishing. Decolorization methods use granular activated carbon, powdered activated carbon, ion exchange resins, and other materials.

E. Clarification, evaporation, and crystallization

The juice resulting from the extraction process is clarified by mixing it with milk of lime, after which it is filtered to remove the mud. In beet-based sugar production, the lime is produced from limestone, which is combusted in a specially designed lime kiln. The main outputs are burnt limestone and carbon dioxide (CO_2). The burnt limestone is used to generate milk of lime and the CO_2 is also added to the liquid in a process called carbonation. Because large quantities of milk of lime and gas are needed, this is a continuous process. These substances are added to the juice and, in the process of carbonation, bind other components, such as protein, to the lime particles. The lime is then filtered, resulting in lime sludge, and dried for use as a soil conditioning agent in agriculture. The resultant clear solution of juice is called 'thin juice.'

Although the carbonation process gives good results, it is rarely used in the cane industry because of the investment required and a general lack of the main raw material, limestone. Cane processing facilities typically purchase ready-made burnt limestone powder and use this to generate milk of lime. After clarification, the thin juice has a sugar content of approximately 15%. Concentrations greater than 68% are needed to allow sugar crystallization, and this is achieved through evaporation. Water is removed from the thin juice in a series of evaporating vessels until syrup with a dry matter content of 68–72% is obtained. This thick juice is further evaporated until sugar crystals form, and the crystals and the accompanying syrup are then centrifuged to separate the two components. The final syrup, which contains 50% sugar, is called molasses.

Sugar crystals are then dried and stored (e.g. in silos). Molasses is the most important by-product of the sugar production. Molasses can be used as cattle fodder or as raw material in the fermentation industry. To facilitate the use of the molasses, which is generated in relatively high volumes, sugar factories may be combined with distillation plants (see below). The basis for the distillery can be sugar juice, molasses, or a combination of these products.

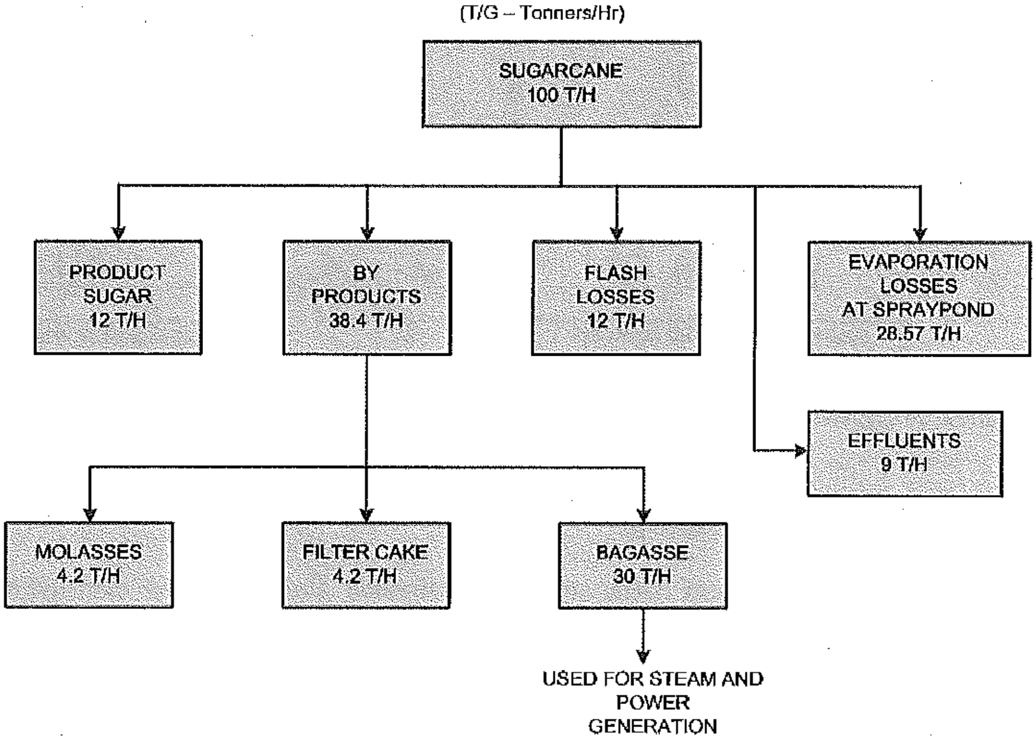


Figure 3-11: Material Balance for 100 Tonnes Sugar Unit

E. Distillery

An associated distillery may employ batch or continuous fermentation, followed by distillation, to produce ethanol with a purity of 95%. This ethanol can be used in other industries or further processed and blended with gasoline. Waste from the distillation process is known as vinasse or spent wash. Anaerobic digestion of this waste is used to produce biogas, which can be utilized for the production of boiler fuel for the distillery or to fuel combined heat and power engines. Remaining waste can be returned to agricultural fields and / or used in the composting of organic solids emanating from processing.

3.2.5 Cleaner technologies

Based on the site visits and study; the following technologies may be classified as cleaner technologies for sugar waste management.

- Segregation of concentrated and dilute waste streams and adopt
  - "Composting" for concentrated wastes and
  - Stabilization ponds for dilute wastes.
- Anaerobic Digestion/ Anaerobic lagoon/Anaerobic filter as primary treatment followed single stage aeration.
- Anaerobic pond + Facultative pond + aerobic pond
- Equalization tank + Monthly washing Holding Tank + Single/ two stage aeration + clarifier.

(NOTE: In all the above cases oil & grease trap (preferably mechanical), Screen and 'V' notch or continuous flow recorder is a must)

Table 3-7: Waste Minimization Options

S.No	Station	Pollutant	Preventive Measures		Waste management options	Cost
			Nature	Type		
1	Cane yard	Solid	Cane trash & dung	Collect as early as possible	Compost	Low
2	Bagasse storage yard	Solid	Bagasse	Collect at the end of the season	Compost	Low
3	Milling section	Liquid	Oil & grease	Collect in trays which can be easily lifted & stored in drum	Can be sold as low grade lubricants or burnt in boilers after mixing with bagasse	Low
		Liquid	Floor washings	Adopt dry cleaning, Give proper slope to floors	--------	Low
		Liquid	Leakages & spillovers	Use mechanical seals for all pump glands & alarms for overflow	Collect leakages & spillages in a pit and recycle into process	Low
		Liquid	Cooling waters	Collect desuperheater & mill bearing cooling water	Recycle	Low
4	Cane carrier	Solid	Bagasse	Use closed transfer system	Cover the drains so that bagasse do not enter into the drains	High
5	Sulphur burner	Gaseous	SO_2	Operate scrubbers efficiently	Provide mask to operators	Low
6	Lime station	Semi-solid	Lime solution	Provide proper slope to the drain	Allow it to mix with the effluent	Low

S.No	Station	Pollutant	Preventive Measures		Waste management options	Cost
			Nature	Type		
7	Clarification-on and vacuum filters	Liquid	Leakages from pumps, glands & pipes overflow	Install overflow alarms & provide mechanical seals	Recycle the cooling waters	Low
8	Boiler house	Liquid	Boiler blow down	Maintain boiler condition & also feed water quality	Use it for irrigation along with other effluents	Low
		Gaseous	Stack emissions	Adjust air fuel ratio for efficient combustion. Check the air pollution control equipment performance	Fly ash can be used as soil conditioner/brick manufacturing/composting	High
9	Crystallizer & pan boiling	Liquid	Leakages from pumps	Provide mechanical seals wherever it is appropriate Recycle all cooling waters	Recycle the cooling waters	Low
			Spillovers	Avoid overloading the equipment	Collect spillages & recycle in process	
10	Evaporator & juice heating	Liquid	Sugar entrainment	-Provide additional external catchers for the last body evaporators & all vacuum pans - use poly baffle stainless steel instead of umbrella type save alls - pump gland shall be provided with mechanical seals to prevent leakages	Recycle the water if there is no entrainment and in case there is entrainment use it for irrigation	High
11	Cleanings of vessels, boilers *etc.*, & laboratory washings	Liquid	High BOD & COD, chemicals as NaOH, Sulphamic Acid, lead	-Recycle NaOH for next cleaning -Provide standby units to have continuous operations -Store the effluent in a holding tank to avoid shock loads on ETP	Controlled loading in ETP from a storage tank Segregate laboratory effluents and join to storage tank	High
12	Press mud	Solid	Soil conditioner	Immediate disposal	Use as a filler material in "composting"	Low

S.No	Station	Pollutant	Preventive Measures		Waste management options	Cost
			Nature	Type		
13	Molasses	Semi-solid	By-product	Use only steel tanks	Provide mixing & cooling arrangements to avoid auto-combustion	High
14	Fugitive emission	Gaseous	Sugar Dust SO_2	Dust collectors Scrubbers	Recycle	High
15	Vibrating & heavy machinery	Noise	Sound	Use silencer pads & closed rooms	Provide earplugs & earmuffs to workers and also change the work environment frequently	Low
16	Bagasse	Solid	Dust & Fire	Provide proper ventilation for storage and also stand posts in case of fire	Store it far away from the industry	Low

*The fugitive emissions are mainly sugar dust emanating from sugar graders. The SO_2 emissions are from Sulphur Burner. The chimney height should be above the roof level. If there are leakages, the SO_2 gas may cause air pollution and hence, the provision for scrubbing of the SO_2 shall be made.

Source: Central Pollution Control Board

3.3 Significance of Pollutants Generated

Environmental issues in sugar manufacturing projects primarily include the following:

- Molasses
- Wastewater
- Solid waste and by-products
- Emissions to air

3.3.1 Molasses

Final molasses is produced in the last steps of operation of separation of sugar from the mother liquor in centrifuges. It has been found that average production of molasses is 4.2% of the cane crushed. But there is quite a large fluctuation in this. Molasses has very high pollution characteristics

Following table gives an idea about the pollution potential as compared to the permissible standards.

Table 3-8: Pollution Potential of Molasses

Parameters	Molasses	Admissible Effluent standards for Inland waterbodies
pH	3.5 – 4.1	5.5 – 9.0
Colour	Dark Brown	Colourless

Parameters	Molasses	Admissible Effluent standards for Inland waterbodies
Solids (mg/l) Total Dissolved	200000 to 320000	2100
BOD (mg/l)	440000	30
COD (mg/l)	960000	250
Chlorides (mg/l)	32000	600
Sulphates (mg/l)	15000	1000
DO (mg/l)	Nil	5
Source: COINDS, Minimum National Standards for Sugar industry, CPCB		

Even though molasses is a commodity under excise control, it is often observed that molasses gets spoiled due to improper storing facilities provided by the factory. Even with the excise regulations and the consent conditions given by the Pollution Control Boards (PCBs), many industries still follow the practice of strong molasses in unlined pits locally termed as *kutcha* pits. During rainy season and also owing to groundwater table conditions, molasses gets diluted and becomes unsuitable for fermentation. This diluted molasses has a BOD concentration varying between 50000 and 80000 mg/l, which are to be disposed off to factories conveniently, let it out to the natural water bodies thereby causing heavy pollution. However such molasses serves as the raw material for the distillery industry and is transported to the distilleries unit at frequent intervals.

3.3.2 Wastewater

3.3.2.1 Water consumption

The sugar industry consumes large quantity of water in manufacturing process and resulting in huge wastewater generation. Waste from the mill house includes the water used as splashes to extract maximum amount of juice and those used to cool the roller bearings.

The water used in sugar industry is of two types. One is Cold water and the other is Condense hot water. The cold water is used as make up water, injection water to the condenser, cooling water for various accessories such as engines, crystallizers, cold maceration, juice dilution, lime preparation, laboratory testing and factory equipment cleaning. The condense water is hot and it is used as boiler feedback water, maceration, juice dilution, lime and sulphate preparation, oliver wash, dilution, molasses conditioning, centrifugal, magma making, massecuite dilution, *etc.*

A large volume of water is required in the barometric condensers of the multiple effect evaporators and vacuum pans. The water is usually partially or fully recirculated after cooling through a spray pond. This cooling water gets polluted as it picks up some organic substances from the vapour of boiling syrup in evaporators and vacuum pan.

3.3.2.2 Water conservation techniques

It is generally observed that whenever water is available in plenty, such as from the river, the entire water is replaced everyday. To save the chemical cost on the neutralization of water restricted use of water should be practiced. Avoiding neutralization for saving chemicals is not desirable because if such water goes to irrigation fields, it will affect the crops adversely.

Table 3-9: Water Conservation Techniques in a 5500 TCD Plant

S.No	Station	Option Suggested	Savings of water in litre
1	Milling Plant	Use fully hot condensate instead of fresh water supplement	4,50,000
2	Boiler feed water	Overflow of all condensates from the vapour cells, first body evaporator and condensate pan shall be connected to a small storage tank instead of allowing to overflow into gutters	1,50,000
3	a) Clarification House Compressors b) Sulphur Burner	Recirculate the cooling waters Use treated effluent water for cooling purpose and connect it to spray pond to reduce the temperature	2,00,000 2,00,000
4	Oliver Filter	Instead of using fresh water spray pond water mat be used to create vacuum at vacuum pump and barometric condensers.	7,00,000
5	Boiling and Centrifuge section	Instead of allowing fresh water to go to spray pond after cooling at vertical crystallizers and massecuite allow it to go service tank	2,00,000
6	Preparation of seed and mixture	Use hot water instead of fresh water	50,000
7	Cooling waters	Mill drive, mill bearing, power house turbines, fiberisers, compressor, cooling waters and vertical crystallizers	Recirculated
8	Tap connections	Keep bear minimum	50,000
9	Excess Condensate	Mini cooling tower	3,50,000
10	Pipe connection	----------	-----
11	Total saving of fresh water	---	23,50,000
12	Total expenditure	---	------

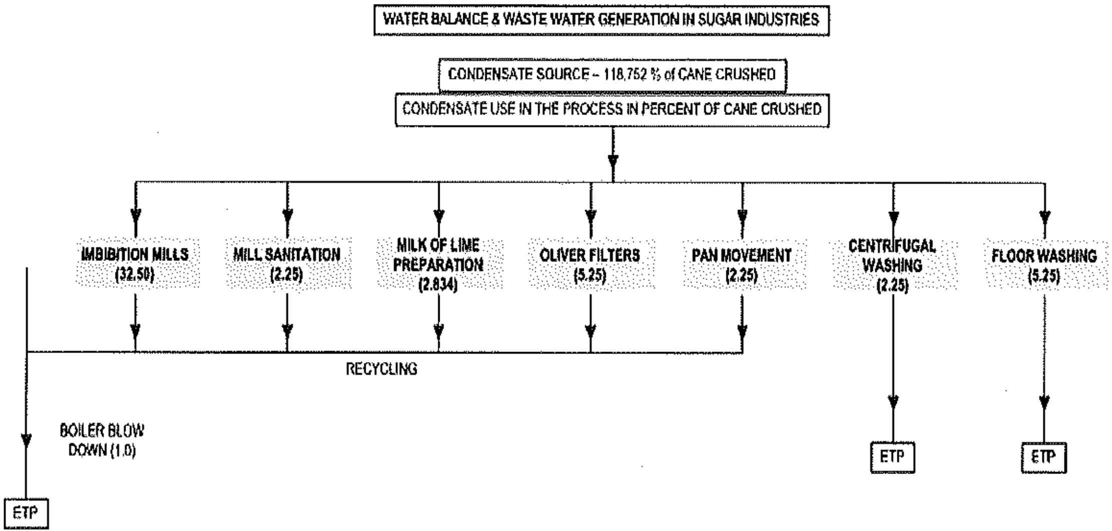
**The cost for implementation of water conservation is negligible as most of the options can be carried out with the waste materials available in the factory. The only major expenditure is Mini-cooling tower to reduce the temperature and pipe connections for recycling.*

Source: CPCB

3.3.2.3 Wastewater management

Water balance

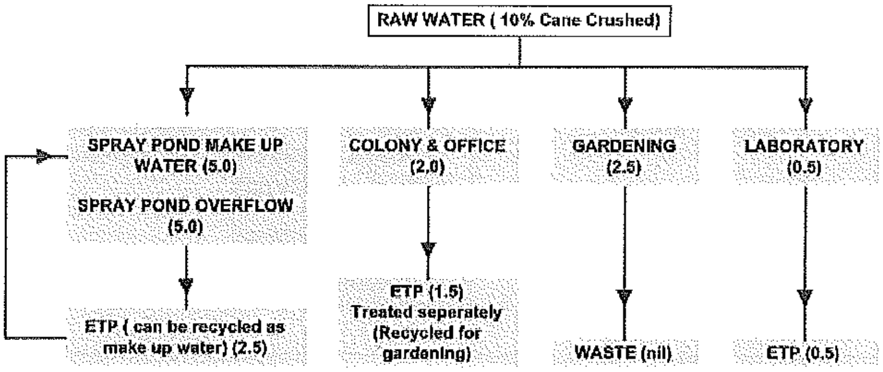
The water balance in sugar industry is given in Figure 3-12. Based on the water balance, it may be possible to completely eliminate the process water requirement and in fact, it can generate some excess water which can be stored and reused in the process. However, some water may be required as makeup water for spray pond and for drinking at the colonies, laboratories, hospitals, *etc.*, which may be around 10.0% of the cane crushed. It is also possible to reuse the treated effluent water as makeup water in spray pond, sulphur burner cooling water, wet-scrubber, *etc.*, and in which case the effluent quantity can be further reduced to 9.0% of the cane crushed.



EXCESS FOR STORAGE – 118.752 – 99.704 = 19.048 % OF CANE CRUSHED

TOTAL CONDENSATE USE = 99.704% OF CANE CRUSHED

Figure 3-12: Water Balance and Wastewater Generation in Sugar Industries (A)



NOTE:

The Effluent Quantity is 11.5% of the Cane crushed

If excess condensate is taken to Service Reservoir, the water requirement is nil

Figure 3-13: Water Balance and Wastewater Generation in Sugar Industries (B)

Source: CPCB

Wastewater generation

Sugar processing wastewater has high content of organic material and subsequently high biochemical oxygen demand (BOD), particularly because of the presence of sugars and organic material arriving with the beet or cane.

When the water from spray pond overflows, it becomes a part of the wastewater - usually of low BOD in a properly operating sugar mill. But because of poor maintenance and bad operating conditions, a substantial amount of sugar may enter in the condense water. This polluted water instead of being recirculated is discarded as excess condense water. These discharges contribute substantially to the waste volume and moderately to the BOD in many sugar mills. Additional waste originates due to the leakages and spillages of juice, syrup and molasses in different sections and also due to the handling of molasses. The periodical washings of the floor also contribute a great to the pollution load. Though these wastes are smaller in volume and are discharged intermittently, they have got a very high BOD. The periodic flowoff from the boilers produces another intermittent waste discharge. This waste is high is high in suspended solids, low in BOD, and is usually alkaline.

Prevention strategies for wastewater management

Recommended wastewater management includes the following prevention strategies:

- Segregate non-contaminated wastewater streams from contaminated streams
- Reduce the organic load of wastewater by preventing the entry of solid wastes and concentrated liquids into the wastewater stream
- Implement dry pre-cleaning of raw material, equipment, and production areas before wet cleaning
- Allow beet to dry on field if possible, and reduce breakage during collection and transport through use of rubber mats and lined containers. Use dry techniques to unload beet
- Fit and use floor drains and collection channels with grids and screens or traps to reduce the amount of solids (e.g., beet parts) entering the wastewater to prevent direct runoff to watercourses, especially from tank overflows.

3.3.2.4 Wastewater characteristics

Characteristics of wastewater generated from various sections of the sugar industry vary widely. The range of parameters in the wastewater from different sections of the industry is given in Table 3-10.

Table 3-10: Characteristics of Wastewater from Different Sections of Sugar Industry

S.No	Various Process/ Plant House	Range of Parameter						
		Temp °C	pH	TDS mg /l	SS mg /l	O&G mg/l	COD mg/l	BOD mg/l
1	Milling Plant	25-30	5-5.5	350-400	500-550	30-50	1000-1500	700-1000
2	Pump cooling at Milling Plant and at Boiler house	30-50	6-6.5	400-500	30-50	-	200-300	50-80`
3	Boiler Blow down	85-90	5.8-6.0	450-500	50-100	-	500-550	30-40

S.No	Various Process/ Plant House	Range of Parameter						
		Temp °C	pH	TDS mg /l	SS mg /l	O&G mg/l	COD mg/l	BOD mg/l
4	Boiling House	40-60	4.5-5.0	400-450	400-600	5.0-1.0	2000-3000	1500-2000
5	Excess condensate	60-70	6.0-6.2	80-1000	5-10	-	250-300	100-150
6	Sulphate House	30-35	-	-	-	-	-	-
7	Lime House	25-30	9.0-10	1400-1500	3500-4000	4.0-6.0	200-250	100-150
Source: CPCB								

Water requirement, raw material consumption and waste water generation in sugar industry is summarized in Table 3-11.

Table 3-11: National Average for Water Requirement, Raw Material Consumption and Effluent generation

S.No	Particulars		< 2500		2500 – 5000		5000 - 7500		Suggested norms irrespective of the capacity
			Avg	SD	Avg	SD	Avg	SD	
1.	Water Requirement (Lit/MT)	Process	268	80	236	63	250	90	50
		Cooling	147	150	161	71	130	70	50
		Domestic (m^3/day)	109	105	193	234	250	130	100
2.	Raw material consumption (Kg/quintal of sugar produced)	Bagasse	314	30	276	39	233	40	250
		Lubricants	0.116	0.068	0.123	0.085	0.105	0.049	0.050
		Lime	1.60	0.50	1.50	0.30	0.90	0.48	1.000
		Sulphur	0.460	0.150	0.430	0.14	0.40	0.16	0.350
		Caustic soda	0.053	0.029	0.027	0.015	0.024	0.012	0.015
		Coagulants	0.0059	0.0082	0.0095	0.011	0.0048	0.0050	0.010
		HCL	0.08	0.08	0.18	0.189	0.10	0.105	
		O.P. Acid	0.073	0.043	0.20	0.274	0.090	0.080	0.050
3.	Bye products Kg per tonne of cane crushed	Bagasse	313.46	11.41	291.22	44.56	300	30.0	260-300
		Molasses	43.58	3.17	41.00	1.89	40.00	1.90	38-42
		Press mud	33.00	4.01	35.12	3.52	38.00	2.00	35-40

S.No	Particulars		< 2500		2500 – 5000		5000 - 7500		Suggested norms irrespective of the capacity
			Avg	SD	Avg	SD	Avg	SD	
4.	Effluent generated	(Lit/TCD)	230	145	250	132	233	83	100
5.	Capital and recurring cost of ETP in Rs/TCD	Capital cost	1236	620	1180	890	1000	333	3000-4000
		Recurring cost	460	312	525	480	466	200	1200-1500
6.	Steam	Kg/T of cane crushed	490.00	30.0	500.00	20.00	480	15.0	460-480
7.	Power	kW/MT cane crushed	22.00	3.00	20.00	2.00	24	5.00	19-28

Avg. – Average value

S.D. – Standard Deviation

Lit/MT – Liters per Metric tonne

TCD – Tonnes of Cane crushed per day

NOTE:

The water consumption, effluent generated, capital and recurring expenditure appears to be highly unreliable as there are no proper cross-checks. Most of the industries have not provided the water meters to calculate the exact quantity of water used for various operations (Process, Cooling, and Domestic). In many cases, the effluent quantity measurements are not made with calibrated 'V' notches and not a single unit has provided continuous flow recording device. There are no standard flow sheets and as such the capital cost of ETPs vary widely. There is no proper documentation to calculate the O&M cost. Therefore, the standard deviation is very high. The power consumption is high in case of higher crushing capacity due to the installation of Co-generation units.

Source: CPCB & CREP guidelines

3.3.2.5 Process wastewater treatment

Techniques for treating industrial process wastewater in sugar industries include:

- preliminary treatment for separating floating, settleable solids, oil & grease
- flow & load equalization
- sedimentation for suspended solids reduction using clarifiers
- biological treatment, typically anaerobic followed by aerobic treatment, for reduction of soluble organic matter (BOD)
- biological nutrient removal for reduction in nitrogen & phosphorus
- chlorination of effluent when disinfection is required
- dewatering and disposal of residuals; in some instances composting or land application of wastewater treatment residuals of acceptable quality may be possible

- Additional engineering controls may be required to contain and neutralize nuisance odors

There are mainly two effluent streams emanating from a sugar factory, namely, process house effluent and cooling water and excess condensate.

The cooling water and excess condensate practically do not contribute any pollution load. It is therefore, suggested that these two streams should be segregated and treatment units may be installed for process house effluent only, while cooling water and excess condensate may be let out directly for irrigation or can be used for dilution purpose, after checking for quality.

A separate holding tank of one day capacity should be provided for soda waste, acid waste and boiler blowdown water and this may be discharged gradually within a fortnight into treatment plant.

In the process house effluents, the floor washings and mill house washings are the major sources of effluent to be treated. Suggested methods for the treatment of these wastes are:

- Preliminary treatment
- Biological treatment, either by lagoons or extended aeration or activated sludge and Trickling filters

A. Preliminary treatment

Inorder to remove the inorganic settleable solids and oil & grease matter, a catch pit, oil & grease trap, respectively should be provided

B. Biological treatment

Lagoons

If land is available and the soil possesses impermeable characteristics, lagoons may be used. Lagoons may be constructed in series and should preferably be operated on the principle of anaerobic and aerobic action. It is found by experience that the anaerobic lagoons should have 15 days detention time and a 3-metre liquid depth, whereas anaerobic lagoons must have a depth of 1 metre with a detention time of 15 days.

Operation and maintenance (O&M)

The sugar factories operate crushing and sugar production units for a six-moth period *i.e.*, November to April. The effluent produced being seasonal if treated biologically, the biological systems should remain dormant during the period when crushing is over. As such, the seeding of the lagoon before the commencement of every season is essential. About 5-10% 'weight to weight' (w/w) seed material from domestic effluent is found to be satisfactory for anaerobic lagoon operation. If the residential colony effluent is allowed to get mixed with industrial effluent, this would be most ideal condition to maintain the necessary seed.

C. Extended aeration

Where lagoons are not suitable, extended aeration is recommended which is cheap and economical. For extended aeration treatment, a lined aeration reactor of 24-48 hr holding capacity is to be constructed. The food to micro organisms (F/M) ratio of 0.05 is to be maintained. A part of sludge is to be recirculated inorder to maintain the required mixed liquor suspended solids (MLSS) concentration. The excess sludge from a secondary setting tank can be directly dried on sludge drying beds.

Operation and maintenance

Aeration process is very sensitive, depends on the influent BOD load and MLSS concentration in the system. Any variation in either of the parameters would change the F/M ratio and would seriously affect the efficiency of the process. In the wastewater from a sugar factory, the variation of BOD concentration is very wide and thus the process efficiency varies considerably. As described earlier, the preservation of microbial culture and the maintenance of the desired concentration of MLSS are difficult tasks for a seasonal industry.

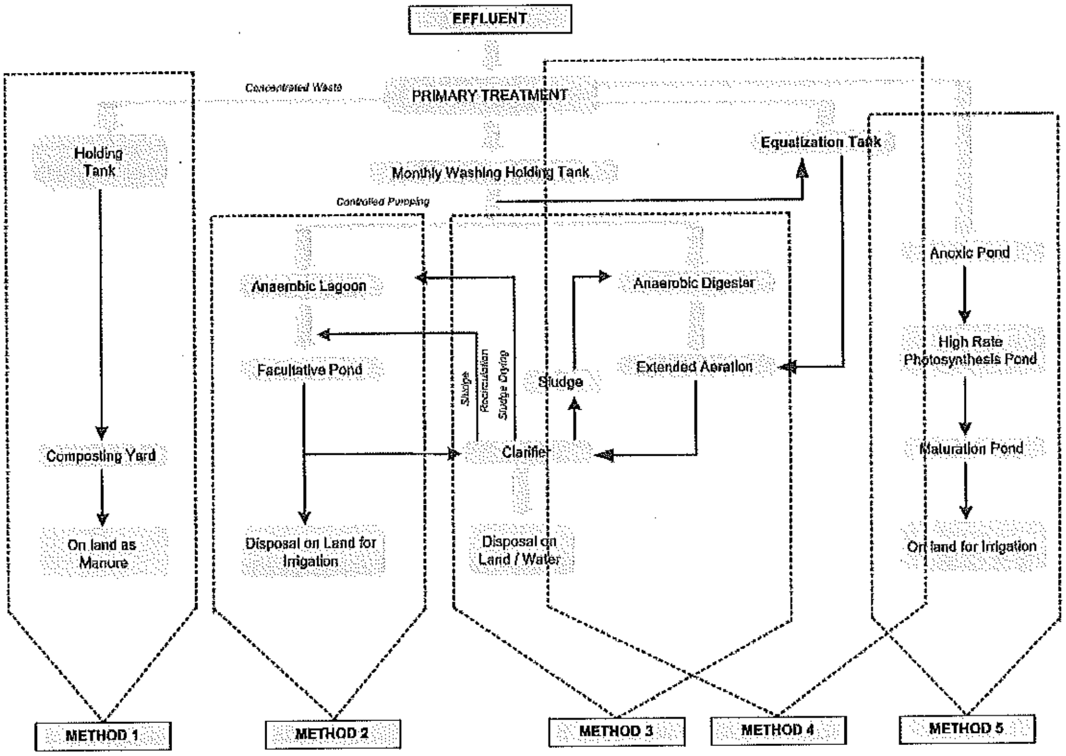


Figure 3-14: Various Methods of Effluent Treatment

D. Activated sludge and trickling filters

These methods can also be used but have been found to be expensive in view of greater controls and operational costs. They are recommended for sugar factories having an installed capacity of more than 5000 tonnes daily.

Operation and maintenance

- Activated Sludge Process: Controls involved in activated sludge process are many and as such, this process, unless judiciously used, may not perform reliably. The factors mentioned in extended aeration systems are also applicable to this process

- Trickling Filters: Here operational problems are not as many as that are faced in the activated sludge and extended aeration system, but the maintenance of rotary distributors may give rise to a number of difficulties as the floating and suspended materials in the effluent are very high, which result in the clogging up of nozzles.

The guideline values of the effluent after the treatment are given in the following Table:

Table 3-12: Treated Effluent Levels for Sugar Industries

Pollutants	**Units**	**Guideline Value**
pH	pH	6-9
BODs	mg/l	< 30
COD	mg/l	< 250
Total Kjeldhal Nitrogen	mg/l	100
Phosphates	mg/l	2
Oil & Grease	mg/l	< 10
Total Suspended Solids	mg/l	30 for disposal in Surface Water 100 for disposal on land
Temperature increase	Deg C	< 3b
Total Coliform bacteria	MPN/ 100 ml	Not applicable

MPN – Most Portable Number

b – at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving, receiving water use, potential receptors and assimilative capacity.

Source: CPCB

3.3.2.6 Effects of the wastewater on receiving water

The fresh effluent from the sugar mill decomposes rapidly after few hours of stagnation. It has been to cause considerable difficulties when this effluent gets an access to the water courses, particularly the annual and non-perennial streams in the rural areas. The rapid depletion of oxygen due to biological oxidation followed by anaerobic stabilization of the waste causes a secondary pollution of offensive odours and black colour.

The concentrated boiled juice is converted into the consistency of syrup. Sugar is separated by crystallization and centrifuging and bottom liquor is molasses or mother liquor. The quantity of molasses averages about 4.45% of the cane crushed. Molasses is the basic raw material from the production of alcohol and many other organic compounds. Even though molasses is stored in unlined pits, which lead to a serious groundwater contamination as it contains a high BOD.

The characteristics of combined wastewater before treatment and after treatment are given in Table 3-13 below.

Table 3-13: Characteristics of Combined Wastewater before and after Treatment

S.No	Parameters	Concentration before treatment (mg/l)	Concentration after treatment (mg/l)
1	SS	250-300	50-100
2	BOD	500-800	<30
3	O&G	5-10	<5
4	COD	1000-1600	<250
5	TDS	1000-1200	800-1000

Source: Comprehensive Industry document on Sugar Industry, Comprehensive Industry Document Series COINDS /8/1980-81, CPCB, Delhi.

It is considered that all the sugar industries in India comply with the prescribed standards for wastewater generation. Wastewater generation shall not exceed 0.10 cubic metre per tonne (m^3/tonne) of cane crushed for calculation purposes.

Additional industry-specific measures applicable to sugar manufacturing include:

- Recycle process water and apply to the washing of incoming raw material
- Use closed loops for intensive solid generating washings (e.g., cane and beet wash) and flue gas scrubbers
- Recommended methods for the treatment of sludge from wastewater treatment include the following:
  - Aerobic stabilization or anaerobic digestion. Anaerobic stabilization improves the sludge applicability to agriculture
  - Gravity thickening
  - Sludge dewatering on drying beds for small-scale facilities and dewatering using belt presses and decanter centrifuges for medium- and large-scale facilities
  - Using sludge from concentrated sugar juice prior to evaporation and crystallization (known as cane mud or cachaza) to produce organic manure and soil amendment for agricultural applications

3.3.2.7 Odor management

Recommended measures to prevent or control odour in beet processing facilities include the following:

- Keep beet processing and storage facilities clean to avoid the accumulation and fermentation of juice
- Use wet scrubbers to remove odors with a high affinity to water(e.g. the ammonia emitted from the drying of beet pulp)
- Consider use of bio-treatments

3.3.3 Solid waste and by-product management

Sugar industry activities generate large quantities of organic solid waste and by-products (e.g., leaves from cane or beet, molasses from the final crystallization, press mud or cachaza, bagasse fiber from the cane, mud and soil arriving at the plant with the raw material, and lime solids from the juice clarification). Generated mainly from the primary treatment of raw materials, these waste materials may also present a risk from pesticide residues. The amount of waste generated depends on the quality of the raw materials themselves and on the initial cleaning in the field.

The generation of higher quality waste can provide opportunities for reprocessing of otherwise discarded raw materials into commercially viable by-products (e.g. paper making and particle board manufacturing)., Other solid wastes from the sugar manufacturing process include spent filter material (e.g., active carbon, resins from the ion exchange process, acids from chemical cleaning of equipment, vinasse or spent wash from the distillation of fermented molasses-sugar juice, and ashes from the steam boiler plant).

Generally the solid waste generated in sugar factory can be broadly categorized as Bagasse and Press mud.

Bagasse has a calorific value of 2100 kilocalories per kilogram (kCal/kg) at 50% moisture which is used as a fuel in boilers for steam and power generation. Where high pressure boilers are used, the saving of bagasse can be as high as 30% of the daily production which can be used for power generation during off season. About 90 – 96% of bagasse is consumed in this way and the rest of it is either sold to paper mills or hands pressing paper mills and card board manufacturing units.

Press mud originates from the settled sludge in the juice clarification process. The quantity of press mud varies with the process used for clarification and is in the range of 8 – 9.9% in the carbonation process. It contains all non-sucrose impurities in the juice along with the $CaCO_3$ precipitate and sulphates. As the press mud of double sulphitation process contains valuable nutrients like nitrogen, phosphorous, potassium, *etc.*, it is used mainly as organic manure and does not pose any problem of disposal. The press mud from the units using double carbonation process is used for land filling and is not used as manure.

Press mud contains non-sucrose impurities along with $CaCO_3$ precipitates. It has got a huge fertilizer value. The characteristics of press mud are listed in Table 3-14. It is seen from the Table that the wax from the press mud can be extracted and recovered as a byproduct.

Table 3-14: Press Mud Characteristics

S.No	Nutrients	Mg/l
1	Phosphorous as (P_2O_3)	4470
2	Potassium as (K_2O)	4500
3	Calcium as (CaO)	10500
4	Magnesium (MgO)	9450
5	Available Nitrogen	50
6	Moisture	76%
7	Wax	9%

S.No	Nutrients	Mg/l
Source: COINDS, Minimum National Standards Sugar Industry, CPCB		

3.3.4 Emissions to air

Air emissions in sugar manufacturing are primarily related to particulate matter generated from bagasse-fired steam boilers, dust from unpaved access roads and areas, and sugar drying or packing activities. In addition, odour emissions are generated from beet processing activities and storage facilities. Beet juice clarification produces a sweet odour, which can be irritating. Inadequate cleaning of the raw material may result in fermented juice, which also creates a foul smell.

3.3.4.1 Particulate matter and dust

Recommended measures to prevent or control particulate matter include the following:

- Operate bagasse-fired steam boilers while targeting emission guidelines applicable to the combustion of solid fuels. Typical control methods include boiler modifications or add-on controls, (e.g., flue gas cyclones, fabric filters, or electrostatic precipitators, wet scrubbers and local recirculation systems) to capture ash and recycle water to prevent particulate emission
- Use wet scrubbers to remove dust from drying and cooling of sugar
- Reduce fugitive dust from roads and areas by cleaning and maintaining a sufficient level of humidity
- Install ventilation systems with filters on transport systems for dry sugar and on sugar packing equipment
- Add on controls such as wet scrubbers / bag filters / ESP
- Use Dust catchers to collect Sugar dust from sugar graders

3.3.4.2 Exhaust gases

Exhaust gas emissions produced by the combustion of organic materials in boilers for power and heat generation can be the most significant source of air emissions in sugar processing activities. Air emission specifications should be considered during all equipment selection and procurement.

3.3.4.3 Air pollution from sugar industries

The burning of bagasse produces particulate like unburnt fibers, carbon particles, and ash and gaseous pollutants like oxides of nitrogen, water vapour and other compounds of the particulate waste, the heavier particles slowly settle down in the surrounding area. Such dust fall leads to the problem of cleaning, reduction in property value, effect on vegetation, *etc.* The main gaseous pollutant is carobon monoxide (CO) which is altogether not measured by any unit and CO_2 is reported to be 12-14%. It is recommended to take some immediate steps to control these emissions. It is also essential to monitor the pollutant concentrations in the ambient air, surrounding the factory area to assess the extent of air pollution cansed by the factory. Ensure that vapor from the carbonation section is emitted from a stack of sufficient height.

3.3.4.4 Air pollution control equipment

At present; most of the industries have installed multicyclones. These equipment may not satisfy the emission standards prescribed by the State Boards as 150 mg/Nm^3 to 350 mg/Nm^3. It is therefore suggested to replace the Multicyclones with

1. Wet-Scrubbers (Sugar Units without Co-generation)

2. Electrostatic Precipitator (Sugar Units with co-generation

3.4 Summary of Applicable National Regulations

There are well-defined regulatory requirements which imply that the government must regulate various aspects of the operations and construction of sugar industries to reduce their environmental and social impacts.

3.4.1 General description of major statutes

A comprehensive list of all the laws, rules, regulations, decrees and other legal instruments applicable to sugar industries is annexed as **Annexure I.**

3.4.2 Industry-specific requirements

The sector-specific standards for sugar industry as regularized by the CPCB are given below.

A) Effluent standards for liquid effluent in sugar industry

Table 3-15: Standards for Liquid Effluent

S.No	Parameter	Concentration not to exceed, mg/l
1	Bio-Chemical oxygen Demand, 3 days at 25^{0}C	100 for disposal on land
2	Suspended Solids	30 for disposal in surface waters 100 for disposal on land
Source: EPA Notification [S.O.844 (E), dt. 19th No.1986]		

B) Wastewater generation standards

Table 3-16: Wastewater Generation Standards

S.No	Industry	Quantum
1	Sugar	0.10 m^3 / tonne of cane crushed

C) Additional recommendations for sugar industry

- Install steam turbine-based combined heat and power technology, enabling the facility to generate its own process steam and electricity requirements and sell excess electricity
- Use waste fiber or bagasse from the cane as fuel for steam and power generation. Ensure that the bagasse moisture level is below 50 % before it is used as boiler fuel to improve its calorific value and overall efficiency for steam generation and avoid the need for supplemental fuels
- Anaerobically digest high-strength organic wastes (e.g. vinasse or spent wash from distillery and organic chemical manufacturing) to produce biogas. Use biogas to fire distillery boilers or to operate combined heat and power systems generating electric energy and hot water/steam
- Keep heating surfaces clean by adding chemicals to prevent incrustations. Incrustations are generated by mineral salts that are not removed during clarification and may be prevented or reduced by adding special polymers to the thin juice
- Ensure even energy consumption by management of batch processes (e.g. centrifuges, vacuum pans) to schedule energy demand and equalize steam demand on the boilers
- Reuse vapor from vacuum pans for heating juice or water
- Use an evaporator with at least five effects
- Combine drying of beet pulp with the main energy system in the facility
- Select the operating conditions of the boiler and steam turbine system to match the heat-power ratio of the utility system to that of the facility. If, despite selection of a high pressure boiler, the facility needs to pass more steam through the turbine than it uses in the process to generate sufficient electricity, then it should condense rather than vent this steam

3.4.3 Pending & proposed regulatory requirements

Following is the Charter on Corporate Responsibility for Environmental Protection (CREP) action points which needs to be implemented.

1. Sugar industry operates for six to ten months and as such the effluent treatment plant (ETP) is also not operated for rest of the period thus bacterial life does not survive. At the time of resuming crushing seasons ETP needs to be restarted which takes one to two months for its stabilization. During the period of stabilization effluent is not treated up to desired level, which causes water pollution. The biomass needs to be kept alive by operating ETP throughout the year from the colony wastewater and washing of mills so that sufficient biomass is available at the time of start of ETP.

2. The sugar industry uses bagasse as fuel in old boilers, which generates significant amount of particulate matter, causing air pollution. With installation of multi-cyclones, the emissions range from 250 mg/Nm^3 to 800 mg/Nm^3 is required to install wet scrubber and also switch over to new boilers so as to achieve particulate emission < 150 mg/Nm^3.

3. Adequate storage capacity of molasses should be provided and molasses should not be stored in *kutcha* lagoon to avoid groundwater pollution.

4. Anaerobic digester for methane recovery followed by aerobic treatment is an option, which needs to be considered.

5. Priority should be given to distilleries for lifting of press-mud for compost making with the spent wash.

6. Fly ash may be utilized for brick making, as soil conditioner and other uses. Else fly ash may be properly disposed off at a particular site with proper care.

7. Since, sugar mills consume large quantity of water, the water consumption should be brought down to 100 litres per tonne (L/T) of cane crushed. Water discharged from cooling and condensate should be recycled.

The earlier action points as per the MINAS for sugar industry as per the Comprehensive Industry Document Series (COINDS) include:

- Consumption of fresh water shall be reduced to 100 L/T of cane crushed
- Cooling of water and spray pond over flow volume shall be reduced to 50 L/T of cane crushed
- Wastewater volume from mill house, boiling house, filter cloth washing, equipment washing and floor washing shall be reduced to 100 L/T of cane crushed
- Following other minor controls shall be attained
  - Oil and grease leakages shall be trapped
  - All gutters within the factory building shall be covered
  - Floors shall be given adequate slope towards gutters
  - Leakage of molasses in the factory shall be totally stopped
- Cooling water shall be reused for processing
- After cleaning the evaporators, the used water shall be settled and reused for washing purposes
- If disposal of wastes is to be made on land for irrigation, the BOD and suspended solid concentration shall be brought down to less than 100 mg/l
- Molasses shall be stored in steel tanks and on no account shall it be stored in unlined pits. Disposal of molasses in the environment shall be done only after prior approval of and according to the methods as may be prescribed by the concerned State Water Pollution Control Board, which must give its decision within five days from the date of receipt of request from the industry regarding the needs for molasses disposal.

4.
OPERATIONAL ASPECTS OF EIA

Prior environmental clearance process has been revised in the Notification issued on 14th September, 2006, into following four major stages *i.e.*, screening, scoping, public consultation and appraisal. Each stage has certain procedures to be followed. This section deals with all the procedural and technical guidance, for conducting objective-oriented EIA studies, their review and decision-making. Besides, the Notification classified projects into Category A, which requires prior environmental clearance from MoEF and Category B from SEIAA/UTEIAA.

Consistency with Other Requirements

- Clearance from other regulatory bodies is not a pre-requisite for obtaining the prior environmental clearance and all such clearances will be treated as parallel statutory requirements.
- Consent for Establishment (CFE) and Prior Environmental Clearance are two different legal requirements a project proponent is required to be taken. Therefore, these two activities can be initiated and proceeded with simultaneously.
- If a project is covered by the provisions of CRZ and EIA Notifications, then the project proponent is required to take separate clearances from the concerned Authorities.
- Rehabilitation and Resettlement issues need not be dealt under the EIA Notification as other statutory bodies deal with these issues. However, socio-economic studies be considered while taking environmental decisions.

4.1 Coverage of Sugar Industry Under the Purview of Notification

All the sugar industrial projects including expansion and modernization require prior environmental clearance. Based on pollution potential, these projects are classified in to Category A and Category B *i.e.*,

- Category A: All the projects if general conditions are applicable.
- Category B: All the projects having ≥ 5000 TCD cane crushing capacity.

Besides the general conditions, when it applies, a Category B project will be treated as Category A project. These conditions are discussed in subsequent sections.

The sequence of steps in the process of prior environmental clearance for Category A and the Category B projects are shown in Figure 4.1 and Figure 4.2 respectively. Each stage in the process of prior environmental clearance for the sugar industries are discussed in subsequent sections.

In case of Expansion or Modernization of the developmental Activity:

- Any developmental activity, which was issued EIA clearance (existing project), when undergoes expansion or modernization (change in process or technology) with increase in production capacity or any change in product mix beyond the list of products cleared in the issued clearance is required to submit new application of EIA clearance.

- Any developmental activity, which is listed in Schedule of the EIA Notification and after expansion due to its total capacity, if falls under the purview of either Category B or Category A, then such developmental activities requires clearance from respective authorities.

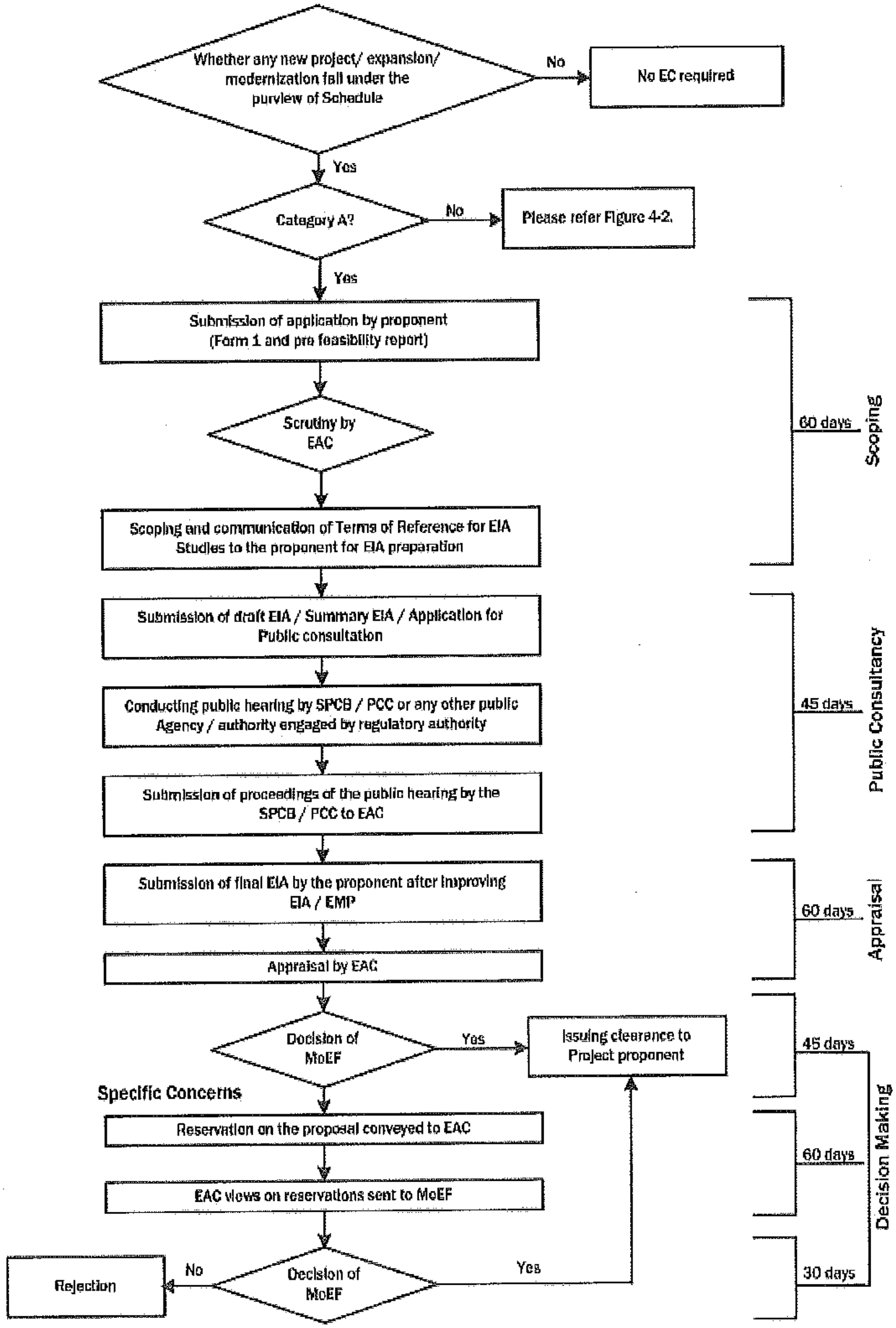


Figure 4-1: Prior Environmental Clearance Process for Activities Falling Under Category A

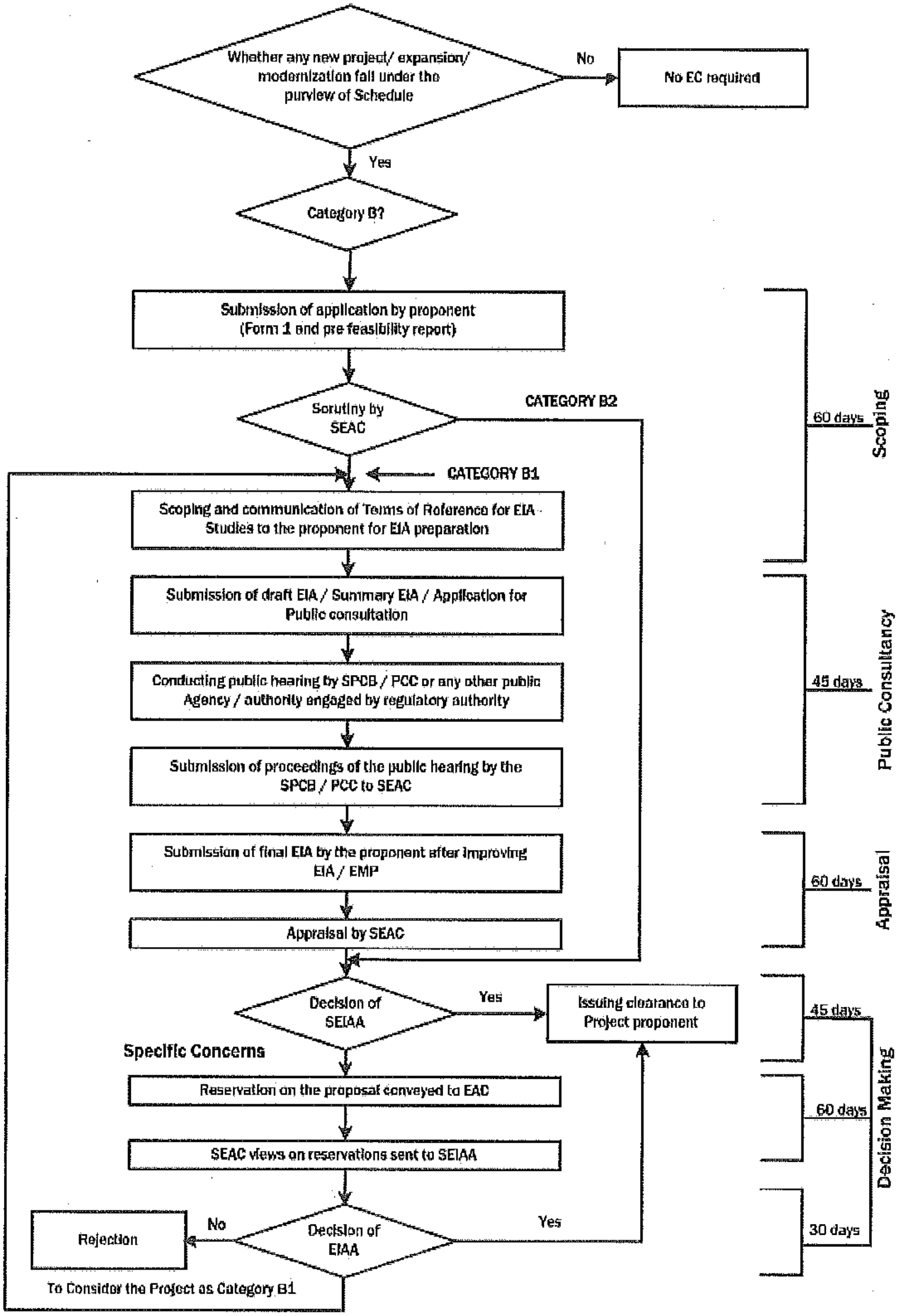


Figure 4-2: Prior Environmental Clearance Process for Activities Falling Under Category B

4.2 Screening

Screening of the project shall be performed at the initial stage of the project development so that proponents are aware of their obligations before deciding on the budget, project design and execution plan.

This stage is applicable only for Category 'B' developmental activity *i.e.,* if general conditions are applicable for a Category B project, then it will be treated as Category A project. Besides, screening is also refers to the classification of Category B projects into either Category B1 or Category B2. Category B1 projects require to follow all the stages that are applicable for a Category A project, but are processed at the state level environmental impact assessment authorities. Whereas, the Category B2 do not require either EIA or public consultation.

As per the Notification, classification of the Category B projects falls under the purview of the state level expert appraisal committee (SEAC). This manual provides certain guidelines to the stakeholders for classification of category B1 and Category B2.

4.2.1 Applicable conditions for Category B projects

Generic condition:

- Any sugar project that has a cane crushing capacity of ≥ 5000 TCD (usually falling under Category B) will be treated as Category A, if located in whole or in part within 10 km from the boundary of:
  - Protected Areas notified under the Wild Life (Protection) Act, 1972,
  - Critically Polluted areas as notified by the CPCB from time to time
  - Notified Eco-sensitive areas
  - Inter-State boundaries and international boundaries. Provided that the requirement regarding distance of 10 km of the inter-state boundaries can be reduced or completely done away with by an agreement between the respective States or UTs sharing the common boundary.
- If any of the conditions listed in above general condition applies, then a Category B project will be treated as Category A.
- The SEIAA shall base its decision on the recommendations of a State/UT level EAC for the purpose of Environmental Clearance.
- In absence of a duly constituted SEIAA or SEAC, a Category B project shall be treated as a Category 'A' project.
- The EAC at the State/UT level shall screen the projects or activities in Category B. SEAC shall meet at least once every month.
- If any Category B cement plant project/activity, after proposed expansion of capacity/production or fuel change, falls under the purview of Category A in terms of production capacity, then clearance is required from the Central Government.

4.2.2 Criteria for classification of Category B1 and B2 projects

The classification of Category B projects or activities into B1 or B2 (except the project or activities listed in item 8(b) in the schedule to the EIA Notification, 2006) will be determined based on whether or not the project or activity requires further environmental studies for preparation of an EIA for its appraisal prior to the grant of environmental clearance. The necessity of which will be decided, depending upon the nature and location specificity of the project, by SEAC after scrutiny of the applications seeking environmental clearance for Category B projects or activities.

The projects requiring an EIA report shall be included in Category B1 and remaining projects will fall under Category B2 and will not require an EIA report and public consultation.

Situations which could be considered for Category B2 are:

- Captive power plants based on Bagasse as fuel irrespective of the capacity shall be considered under Category B2.
- Bagasse and bio-fuel based power plants up to a capacity of 50 MW
- Pressmud Compost plants are to be fully exempted

4.2.3 Application for prior screening for environmental clearance

- The project proponent, after identifying the site and pre-feasibility study, is required to apply for the prior environmental clearance in Form 1 given in **Annexure II**. The proponent has to submit the filled in Form 1 along with the pre-feasibility report and draft ToR for EIA studies to the concerned Authority *i.e.,* MoEF, Government of India for Category A projects and SEIAA in case of Category B projects. Please refer subsequent sections for the information on how to fill the Form 1, contents of pre-feasibility report and sector-specific ToRs.
- Prior environmental clearance is required before any construction work, or preparation of land is started on the identified site / project or activity by the project management, except for securing the land.
- If the application is made for a specific developmental activity, which has an inherent area development component as a part of its project proposal and the same project also attract the construction and area development provisions under 8a and 8b of the Schedule, then the project will be seen as a developmental activity other than 8a and 8b of the Schedule.

4.2.4 Siting guidelines

These are the guidelines, stake holders may consider while siting the developmental projects, to minimize the associated possible environmental impacts. While in some situations, completely sticking to these guidelines is difficult and unwarranted, therefore these guidelines may be kept in the background, as far as possible, while taking the decisions.

Sites not suitable

Sites preferably located 3 km away from the municipal limits due to vehicular movements of raw material Sugar cane. The availability of sugar cane shall be within 10 km radius of the factory.

Areas preferably be avoided

In siting industries, care should be taken to minimize the adverse impact of the industries on the immediate neighborhood as well as distant places. Some of the natural life sustaining systems and some specific land uses are sensitive to industrial impacts because of the nature and extent of fragility. With a view to protect such sites, the industries may maintain the following distances, as far as possible, from the specific from the areas listed:

- Ecologically and/or otherwise sensitive areas: Preferably 5 km; depending on the geo-climatic conditions the requisite distance may be decided appropriately by the agency.
- Coastal Areas: Preferably ½ km away from high tide line.
- Flood Plain of the Riverine System: Preferably ½ km away from flood plain or modified flood plain affected by dam in the upstream or by flood control systems.
- Transport/Communication System: Preferably ½ km. away from highway and railway line.
- Major Settlements (3,00,000 population) : Distance from major settlements is difficult to maintain because of urban sprawl. At the time of siting of the industry if any major settlements notified limit as within 50 km., the spatial direction of growth of the settlement for at least a decade must be assessed and the industry shall be sited at least 25 km. from the projected growth boundary of the settlement.

NOTE: Ecological and/or otherwise sensitive areas include (i) Religious and Historic Places; (ii) Archaeological Monuments (e.g. identified zone around Taj Mahal); (iii) Scenic Areas; (iv) Hill Resorts; (v) Beach Resorts; (vi) Health Resorts; (vii) Coastal Areas rich in Corals, Mangroves, Breeding Grounds of Specific Species; (viii) Estuaries rich in Mangroves, Breeding grounds of Specific Species; (ix) Gulf Areas; (x) Biosphere Reserves; (xi) National Parks and Sanctuaries; (xii) Natural lakes, Swamps; (xiii) Seismic Zones; (xiv) Tribal Settlements; (xv) Areas of Scientific and Geological Interest; (xvi) Defence Installations, specially those of security importance and sensitive to pollution; (xvii) Border Areas (International) and (xviii) Air Ports.

Pre-requisite: State and Central Governments are required to identify such areas on a priority basis

General siting factors

In any particular selected site, the following factors must also be recognized.

- No forest land shall be converted into non-forest activity for the sustenance of the industry (Ref: Forest Conversation Act, 1980).
- No prime agricultural land shall be converted into industrial site.
- Land acquired shall be sufficiently large to provide space for appropriate green cover including green belt, around the battery limit of the industry.
- Lay out of the industry that may come up in the area must conform to the landscape of the area without affecting the scenic features of that place.
- Associated township of the industry may be created at a space having physiographic barrier between the industry and the township.

4.3 Scoping for EIA studies

Scoping exercise is the first step in the project assessment phase of the EIA process, and should be carried out soon after the project contours are defined. The primary purpose of scoping is to identify concerns and issues which are important to project decisions. Scoping also serves to define EIA study requirements and boundaries. The results of the scoping exercise form the basis for the rest of the EIA process. Scoping helps to center efforts on whole EIA process including the assessment of significant environmental attributes. The end result will be a work program, which is well focused and cost-effective.

Scoping refers to the process by which the EAC in the case of Category 'A' projects or activities, and SEAC in the case of Category 'B1' projects, including applications for expansion and/or modernization (e.g. fuel change) of existing projects, determine detailed and comprehensive ToR for EIA studies addressing all relevant environmental concerns for the preparation of an EIA Report in respect of the project for which prior environmental clearance is sought.

- Project proponent shall submit the application to the concerned authority. The application (Form 1 as given in **Annexure II**) shall be attached with pre-feasibility report and proposed ToR for EIA Studies. The proposed sequence to arrive at the draft ToR is discussed below:.
  - Precisely, the pre-feasibility report summarizes the project details and also the likely environmental concerns based on the secondary information, which will be availed for filling the Form 1.
  - From the pre-feasibility report and the Form 1, valued environmental components (VECs) may be identified for a given project (the receiving environment/social components, which are likely to get effected due to the project operations/activities).
  - Once the project details from the pre-feasibility report & Form 1; and VECs are identified, a matrix establishing the interactions which can lead to the effects/impacts could be developed (Qualitative analysis).
  - For each identified possible effect in the matrix, significance analysis could be conducted to identify the impacts, which needs to be further studied (quantitative analysis) in the subsequent EIA studies. All such points will become the part of the draft ToR to be proposed by the project proponent along with the application form.
  - The information to be provided in pre-feasibility report, guidelines for filling Form 1 and guidelines for developing draft ToR is summarized in the subsequent sections.
  - Authority consults the respective EAC/SEAC to reply to the proponent. The EAC/SEAC concerned reviews the application form, pre-feasibility report and proposed draft ToR by the proponent and make necessary additions/deletions to make it a comprehensive ToR that suits the statutory requirements for conducting the EIA studies.
- All Category B projects are exempted from scoping till 18th January, 2012.
- A site visit by a sub-group of EAC/SEAC concerned will be planned, only if considered necessary by the EAC/SEAC concerned. Project proponent will facilitate such site-visits of the sub-committees
- EAC/SEAC shall provide an opportunity to the project proponent for presentation and discussions on the proposed project and related issues as well as the proposed ToR for EIA studies. If the State Government desires to present their views on any specific project, they can depute an officer for the same in the scoping stage to EAC, as an invitee but not as a member of EAC. However, non-appearance of the project proponent before EAC/SEAC at any stage will not be a ground for rejection of the application for the prior environmental clearance.

- In case of a new or expansion project in an identified problem area by the CPCB, then the Ministry may invite representative SEIAA to present their views, if any at the stage of scoping, to the EAC.
- The final set of ToRs for EIA studies shall be conveyed to the proponent by the EAC/SEAC within sixty days of the receipt of Form 1 and Pre-feasibility report. If the finalized ToR for EIA studies are not conveyed to the proponent within sixty days of the receipt of Form 1, the ToR for EIA studies suggested by the proponent shall be deemed as the final and will be approved for the EIA studies.
- The final ToR for EIA studies shall be displayed on the websites of the MoEF/ SEIAA.
- Applications for prior environmental clearance may be rejected by the concerned Authority based on the recommendation of the EAC or SEAC concerned at this stage itself. In case of such rejection, the decision together with reasons for the same shall be communicated to the proponent in writing within sixty days of the receipt of the application.
- The final EIA report and the other relevant documents submitted by the applicant shall be scrutinized by the concerned Authority strictly with reference to the approved ToR for EIA studies.

4.3.1 Pre-feasibility report

The pre-feasibility report should include, but not limited to highlight the proposed project information, keeping in view of the environmental sensitivities of the selected site, raw material, technology options (based on alternative analysis), efficiency, availability, *etc.*

The general structure of the pre-feasibility report for the sugar industries is listed as under

- Background of the project proponent
- Details of location of site, layout and geo-hydrological eonditions
- Brief description of the manufacturing process
- Water budget and material balance
- Raw material requirements and availability
- Land requirement and its availability
- Air, water & Noise Pollution Control Measures
- Disposal arrangements for wastewater & air emissions.
- Anticipated environmental impacts and mitigation measures

The information required in pre-feasibility report varies from case to case even in the same sector depending upon the local environmental setting within which the plant is located. However, the environmental information required in the Feasibility Report for finalizing the ToR is discussed below.

- Description of the project , including in particular:
  - a description of the physical characteristics of the whole project and the land use requirements during the construction and operational phases
  - a description of the main characteristics of the production process, for instance the nature and the quantity of the materials used
  - an estimate , by type and quantity of expected residues and emissions (water, air and soil pollution, noise, vibration, *etc.*) resulting from the operation of the proposed project.

- An outline of the main alternatives studied by the developer and an indication of the main reasons for this choice, taking into account the environmental effects.
- A description of the aspects of the environment likely to be significantly affected by the propose project, including in particular population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and the inter-relationship between the above factors.
- A description of the likely significant effects of the proposed project on the environment resulting from:
  - the existence of the project
  - the use of natural resources - Specific consumptions
  - the emission of pollutants, the creation of nuisances and the elimination of waste and the description by the developer of the forecasting methods used to assess the effects of the environment
- A description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment.
- A non technical summary of the information, provide under the above headings.
- An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the developer in completing the required information.

Besides, depending on the scope defined in the pre-feasibility report some pre-feasibility reports are based on various studies and data collection and addresses in detail the concern as technical & economical analysis and the detailed feasibility level design of equipment, process, optimization, economic, financial, social and environmental investigations, cost estimates with detailed bill of quantities (BOQ). The components identified here focuses on the requirements of Scoping for EIA study. **Annexure III** can be referred for preferable structure of the pre-feasibility report.

4.3.2 Guidance for filling information in Form 1

The information given in specifically designed pre-feasibility report for this developmental activity may also be availed for filling Form 1.

Form 1 is designed to help users identify the likely significant environmental effects of proposed projects during scoping. There are two stages for providing information under two columns:

- First - identifying the relevant project activities from the list given in column 2 of Form 1. Start with the checklist of questions set out below and complete Column 3 by answering:
  - Yes - if the activity is likely to occur during implementation of the project;
  - No - if it is not expected to occur;
  - May be - if it is uncertain at this stage whether it will occur or not.
- Second – For each activity for which the answer in Column 3 is "Yes" the next step is to refer to the fourth column which quantifies the volume of activity which could be judged as significant impact on the local environmental characteristics, and identify the areas that could be affected by that activity during construction /operation / decommissioning of the project. The Form 1 requires information within 15 km around the project, whereas actual study area for EIA studies will be as prescribed by

respective EAC/SEAC. Information will be needed about the surrounding VECs in order to complete this Form 1.

4.3.3 Identification of appropriate valued environmental components

VECs are components of the natural resources and human world that are considered valuable and are likely to be affected by the project activities. Value may be attributed for economic, social, environmental, aesthetic or ethical reasons. VECs represent the investigative focal point for further EIA process. The indirect and/or cumulative effects can be concerned with indirect, additive or even synergistic effects due to other projects or activities or even induced developments on the same environmental components as would be considered direct effects. But such impacts tend to involve larger scale VECs such as within entire region, river basins or watersheds; and, broad social and economic VECs such as quality of life and the provincial economy. Once VECs are identified then appropriate indicators are selected for impact assessments on the respective VECs.

4.3.4 Methods for identification of impacts

There are number of factors which will influence the approach adopted for the assessment of direct, indirect, cumulative impacts, *etc.*, for a particular project. The method should be practical and suitable for the project given the data, time and financial resources available. However, the method adopted should be able to provide a meaningful conclusion from which it would be possible to develop, where necessary, mitigation measures and monitoring. Key points to consider when choosing the method(s) include:

- Nature of the impact(s)
- Availability and quality of data
- Availability of resources (time, finance and staff)

The method chosen should not be complex, but should aim at presenting the results in a way that can be easily understood by the developer, decision maker and the public. A comparative analysis of major impact identification methods is given in the following Table 4-1.

Table 4-1: Advantages and Disadvantages of Impact Identification Methods

Methods	Description	Advantages	Disadvantages
Checklists	▪ Annotate the environmental features that need to be addressed when identifying the impacts of activities in the project	▪ Simple to understand and use ▪ Good for site selection and priority setting ▪ Simple ranking and weighting	▪ Do not distinguish between direct and indirect impacts ▪ Do not link action and impact ▪ The process of incorporating values can be controversial
Matrices	▪ Grid like table that identify the interaction between project activities (along one axis) and environmental characteristics (along other axis)	▪ Link action to impact ▪ Good method for displaying EIA results	▪ Difficult to distinguish direct and indirect impacts ▪ Significant potential for double-counting

	- Entries are made in the cells which highlights impact severity in the form of symbols or numbers or descriptive comments		of impacts
Networks	- Illustrate cause effect relationship of project activities and environmental characteristics - Useful in identifying secondary impacts - Useful for establishing impact hypothesis and other structured science based approaches to EIA	- Link action to impact - Useful in simplified form for checking for second order impacts - Handles direct and indirect impacts	- Can become very complex if used beyond simplified version
Overlays	- Maps the impacts spatially and display them pictorially - Useful for comparing site and planning alternatives for routing linear developments - Can address cumulative effects - Information incentive	- Easy to understand - Good to display method - Good siting tool	- Address only direct impacts - Do not address impact duration or probability
GIS	- Maps the impacts spatially and display them pictorially - Useful for comparing site and planning alternatives for routing linear developments - Can address cumulative effects - Information incentive	- Easy to understand - Good to display method - Good siting tool - Excellent for impact identification and analysis	- Do not address impact duration or probability - Heavy reliance on knowledge and data - Often complex and expensive
Networks	- Illustrate cause effect relationship of project activities and environmental characteristics - Useful in identifying secondary impacts - Useful for establishing impact hypothesis and other structured science based approaches to EIA	- Link action to impact - Useful in simplified form for checking for second order impacts - Handles direct and indirect impacts	- Can become very complex if used beyond simplified version
Overlays	- Maps the impacts spatially and display them pictorially - Useful for comparing site and planning alternatives for routing linear developments - Can address cumulative	- Easy to understand - Good to display method - Good siting tool	- Address only direct impacts - Do not address impact duration or probability

	effects ▪ Information incentive		
GIS	▪ Maps the impacts spatially and display them pictorially ▪ Useful for comparing site and planning alternatives for routing linear developments ▪ Can address cumulative effects ▪ Information incentive	▪ Easy to understand ▪ Good to display method ▪ Good siting tool ▪ Excellent for impact identification and analysis	▪ Do not address impact duration or probability ▪ Heavy reliance on knowledge and data ▪ Often complex and expensive
Expert System	▪ Assist diagnosis, problem solving and decision making ▪ Needs inputs from user by answering systematically developed questions to identify impacts and determine their mitigability and significance ▪ Information intensive, high investment methods of analysis	▪ Excellent for impact identification and analysis ▪ Good for experimenting	▪ Heavy reliance on knowledge and data ▪ Often complex and expensive

The project team made an attempt to construct an impact matrix considering major project activities (generic operations) and stage-specific likely impacts which is given in Table 4-2.

While the impact matrix is each project-specific, Table 4-2 may facilitate the stakeholders in identifying a set of components and phase-specific project activities for determination of likely impacts. However, the location-specific concerns may vary from case to case, therefore, the components even without likely impacts are also retained in the matrix for the location-specific reference.

Table 4-2: Matrix of Impacts

								PHASE II						PHASE III						
			Pre Construction					Construction/ Establishment						Operation and Maintenance						
ENVIRONMENT	COMPONENT	Project Activity / Parameter/ Factor	Land Acquirement	Site Clearing	Burning of wastes, refuse and cleared vegetation	Site Preparation / Leveling	Traffic movement	Civil works such as earth moving and building of structures including temporary structures	Heavy Equipment operations	Disposal of construction wastes	Generation of sewage	Influx of construction workers	Transportation of material	Sugar Cane Farming	Storage ,slicing, Juice extraction, purification,	Molasses management	By-products (Bagasse, press mud, cane wax, ,,)management	Waste water management	Solid Waste management	Health and safety management
Physical	Soil	Erosion Risks												*						
		Contamination						*							*			*	*	
		Soil Quality		*				*		*						*		*		
	Resources	Fuels/ Electricity					*													
		Construction material- stone, aggregates						*												
		Land especially undeveloped or agricultural land		*																
	Water	Interception or Alteration of River Beds				*														
		Alteration of surface run-off and interflow				*		*						*						
		Alteration of aquifers				*		*												
		Water quality						*						*				*	*	
	Air	Air quality			*		*	*	*				*		*	*	*			
		Noise		*			*	*	*				*							
Biological	Terrestrial Flora	Effect on grass & flowers		*																
		Effect on trees & shrubs		*																

								PHASE II						PHASE III						
			Pre Construction					Construction/ Establishment						Operation and Maintenance						
		Effect on farmland		*												*		*		
		Endangered species		*																
		Reduction of aquatic biota																*		
		Reduction of Biodiversity												*						
Social	Economy	Creation of new economic activities	*																	
		Commercial value of properties	*											*						
		Conflict due to negotiation and/ compensation payments	*																	
		Generation of temporary and permanent jobs								*		*	*							
		Effect on crops		*				*						*				*		
		Reduction of farmland productivity		*														*		
		Income for the state and private sector	*											*						
	Education	Training in new technologies																*	*	*
	Public Order	Political Conflicts	*								*	*								
		Unrest, Demonstrations & Social conflicts	*				*				*	*	*			*	*	*	*	
	Infrastructure and Services	Conflicts with projects of urban, commercial or Industrial development	*					*	*			*	*							
	Security and Safety	Increase in Crime													*					
		Accidents caused by					*													
	Health	Temporary									*					*	*			
		Chronic																		*
		Acute	*	*	*													*		
	Cultural	Land use		*	*					*				*						
		Recreation										*								
		Aesthetics and human interest									*				*	*	*	*		

NOTE:

1. The above table represents a model for likely impacts, which will have to be arrived case-to-case basis considering VECs and significance analysis (Ref Section 2.9).

2. Project activities are shown as indicative for a given sector. However, in Form 1 (application for EIA Clearance), for any question for which answer is 'Yes', then the corresponding activity shall reflect in project activities. Similarly 'parameters'/'factors' will also be changed within a component in order to reflect the target species of prime concern .

4.3.5 Testing the significance of impacts

The following set of conditions may be used as the checklist for testing the significance of the impacts and also to provide information in Column IV of Form 1.

- Will there be a large change in environmental conditions?
- Will new features be out-of-scale with the existing environment?
- Will the effect be unusual in the area or particularly complex?
- Will the effect extend over a large area?
- Will there be any potential for trans-frontier impact?
- Will many people be affected?
- Will many receptors of other types (fauna and flora, businesses, facilities) be affected?
- Will valuable or scarce features or resources be affected?
- Is there a risk that environmental standards will be breached?
- Is there a risk that protected sites, areas, features will be affected?
- Is there a high probability of the effect occurring?
- Will the effect continue for a long time?
- Will the effect be permanent rather than temporary?
- Will the impact be continuous rather than intermittent?
- If it is intermittent will it be frequent rather than rare?
- Will the impact be irreversible?
- Will it be difficult to avoid, or reduce or repair or compensate for the effect?

For each "Yes" answer in column 3, the nature of effects and reasons for it should be recorded in column 4. The questions are designed so that an "Yes" answer in column 3, will generally point towards the need for analyzing for the significance and requirement for conducting impact assessment for the effect.

4.3.6 Terms of reference for EIA studies

ToR for EIA studies in respect of the proposed Sugar industry may include, but not limited to the following:

1. Executive summary of the project – giving a *prima facie* idea of the objectives of the proposal, use of resources, justification, *etc* In addition, it should provide a compilation of EIA report, EMP and the post-project plan in brief.

Project description

2. Justification for selecting the proposed unit size.
3. Land requirement for the project including its optimization, break up of land requirement and its availability
4. Complete process flow diagram describing each unit, its processes and operations in production of sugar, along with material and energy inputs and outputs (material and energy balance).
5. Number of working days of the sugar production unit.
6. Source of water and its availability. Proof regarding the availability of requisite quantity of water from the competent authority.

7. Details of water balance (water intake, use, wastewater generation) taking into account reuse and re-circulation of effluents. Additional water conservation measures, if any, proposed for the project.
8. Details of the use of steam from the boiler.
9. Information on the following is necessary:
   - Sugar cane sourcing, transportation and storage (issues of traffic congestion)
   - Water sourcing and use for sugarcane plantation
   - Land use pattern and cropping, if sugarcane plantations are owned by the mill
   - Bagasse quantity generated, its storage, internal use and external disposal
   - Use of Pith
   - Bagasse drying
   - Use of fossil fuels
   - Fire hazards
10. Proposed effluent treatment system and scheme for achieving zero discharge
11. Any litigation pending against the project and /or any direction /order passed by any Court of Law against the project, if so, details thereof.

Description of the environment

12. Toposheet with all the coordinates of the plant site demarcated (1:50000 scale).
13. The study area shall be up to a distance of 5 km from the boundary of the proposed project site.
14. Topography of the area clearly indicating the presence of pits deeper than one metre, if any. If these pits require to be filled in, details of filling material to be used, quantity required, its source, mode of transport, *etc.*, shall be provided.
15. Details of site and information related to environmental setting within a 5 km radius of the project site.
16. Land use of study area should include data about the residential/ institutional/nearest village/ township/ locality/ housing society, *etc.*, based on the satellite imagery.
17. Information regarding eco-sensitive areas such as National parks / Wildlife Sanctuaries / Biosphere reserves within the study area.
18. Information regarding surface hydrology and water regime and impact due to the project, if any, on the same.
19. Site-specific meteorological data of one season.
20. Ambient Air Quality (AAQ) data (except monsoon) of one complete season along with the monitoring dates. The parameters to be covered shall include SPM, RSPM, SO_2, NOx (ground level). The location of the monitoring stations should be decided in such a way that the pre-dominant downwind direction, population zone and sensitive receptors including reserved forests, if any are considered. There should be at least one monitoring station in the upwind direction and one in down-wind direction where maximum GLC is likely to fall.
21. Noise level monitoring data from at least five locations within the study area.
22. Details of groundwater quality around the unit and molasses storage area.
23. Details of traffic density vis-à-vis impact on the ambient air.

24. Details of flora and fauna. In case of any scheduled fauna, conservation plan should be provided.

25. The name of the laboratory recognized by the MoEF / CPCB / NBA, *etc.*, through which the monitoring / analysis shall be carried out.

26. If any incompatible land use attributes fall within a 5 km radius of the project boundary, proponent shall describe the sensitivity (distance, area and significance) and propose the additional points based on significance for review and acceptance by the EAC/SEAC. Incompatible land use attributes include:

    - Public water supply areas from rivers/surface water bodies, from groundwater
    - Scenic areas/tourism areas/hill resorts
    - Religious places, pilgrim centers that attract over 10 lakh pilgrims a year
    - Protected tribal settlements (notified tribal areas where industrial activity is not permitted); CRZ
    - Monuments of national significance, World Heritage Sites
    - Cyclone, Tsunami prone areas (based on last 25 years);
    - Airport areas
    - Any other feature as specified by the State or local government and other features as locally applicable, including prime agricultural lands, pastures, migratory corridors, *etc.*
    -

27. If ecologically sensitive attributes fall with in a 5 km radius of the project boundary, proponent shall describe the sensitivity (distance, area and significance) and propose the additional points based on significance for review and acceptance by the EAC / SEAC. Ecological sensitive attributes include:

    - National parks
    - Wild life sanctuaries Game reserve
    - Tiger reserve/elephant reserve/turtle nesting ground
    - Breeding grounds
    - Core zone of biosphere reserve
    - Habitat for migratory birds
    - Mangrove area; Areas with threatened (rare, vulnerable, endangered) flora/fauna
    - Protected corals
    - Wetlands
    - Zoological gardens
    - Gene Banks
    - Reserved forests
    - Protected forests
    - Any other closed/protected area under the Wild Life (Protection) Act, 1972, any other area locally applicable

28. If the location falls in a valley, specific issues connected to the management of natural resources shall be studied and presented.

Anticipated environmental impacts and mitigation measures

29. Impact on drainage of the area and the surroundings.

30. Mathematical modeling for calculating the dispersion of air pollutants and ground level concentration along with emissions.

31. Typical measures that could be considered for the mitigation of impacts as given in this manual may be referred.

32. Details regarding infrastructure facilities such as sanitation, fuel, restroom, *etc.*, to the workers during construction as well as to the casual workers including truck drivers during the operational phase.

33. Impact of the project on local infrastructure of the study area such as road network, *etc.* In case if the study area requires any additional infrastructure, details of the agency responsible for the same should be included along with the time frame. Details of the permission from Competent Authority for conveyor belt crossing the village road.

34. Remediation measures adopted to restore the environmental quality if the groundwater, soil, crop, air *etc.*, are affected.

35. Proposed measures for occupational safety and health of the workers.

36. Details of solid waste management including management of boiler ash.

37. Details of rainwater harvesting and its proposed usage in the plant.

38. Details of greenbelt giving details of species, width of plantation, planning schedule, *etc.*

39. Anticipated environmental impacts that require specific studies for significance are given in Impact matrix of the TGM. Tools as given in the Manual shall be used for the assessment of environmental impacts.

Analysis of alternative resources and technologies

40. Justification for selecting the proposed unit size.

41. Comparison of alternate sites considered and the reasons for selecting the proposed site. Conformity of the site with the prescribed guidelines in terms of Coastal Regulatory Zone (CRZ), river, highways, railways *etc.*

42. Details on improved technologies.

Environmental monitoring program

43. Appropriate monitoring network has to be designed and proposed for regulatory compliance and to assess the residual impacts, if any.

Additional studies

44. Detailed compensation package for the people affected by the project shall be prepared, considering the socio-economic status of the area, homestead oustees, land oustees, and landless labourers.

45. Points identified in public hearing (if applicable) and commitment of the project proponent to the same. Detailed action plan addressing the issues raised, and the details of necessary allocation of funds.

46. Proposed plan to handle the socio-economic influence on the local community. The plan should include quantitative dimension as far as possible.

47. Details on risk assessment and proposed safeguard measures.

Environmental management plan

48. EMP devised to mitigate the adverse impacts of the project should be provided along with item-wise cost of its implementation.
49. Proposed post project monitoring programme to ensure compliance to the approved Management Plan including administrative and technical organizational structure.

Note:

Above points shall be adequately addressed in the EIA report at corresponding chapters, in addition to the contents given in the reporting structure (Table: 4-7).

4.4 Environmental Impact Assessment

The approach for accomplishing EIA studies is shown in figure 4.3. Each stage is discussed, in detail in subsequent sections.

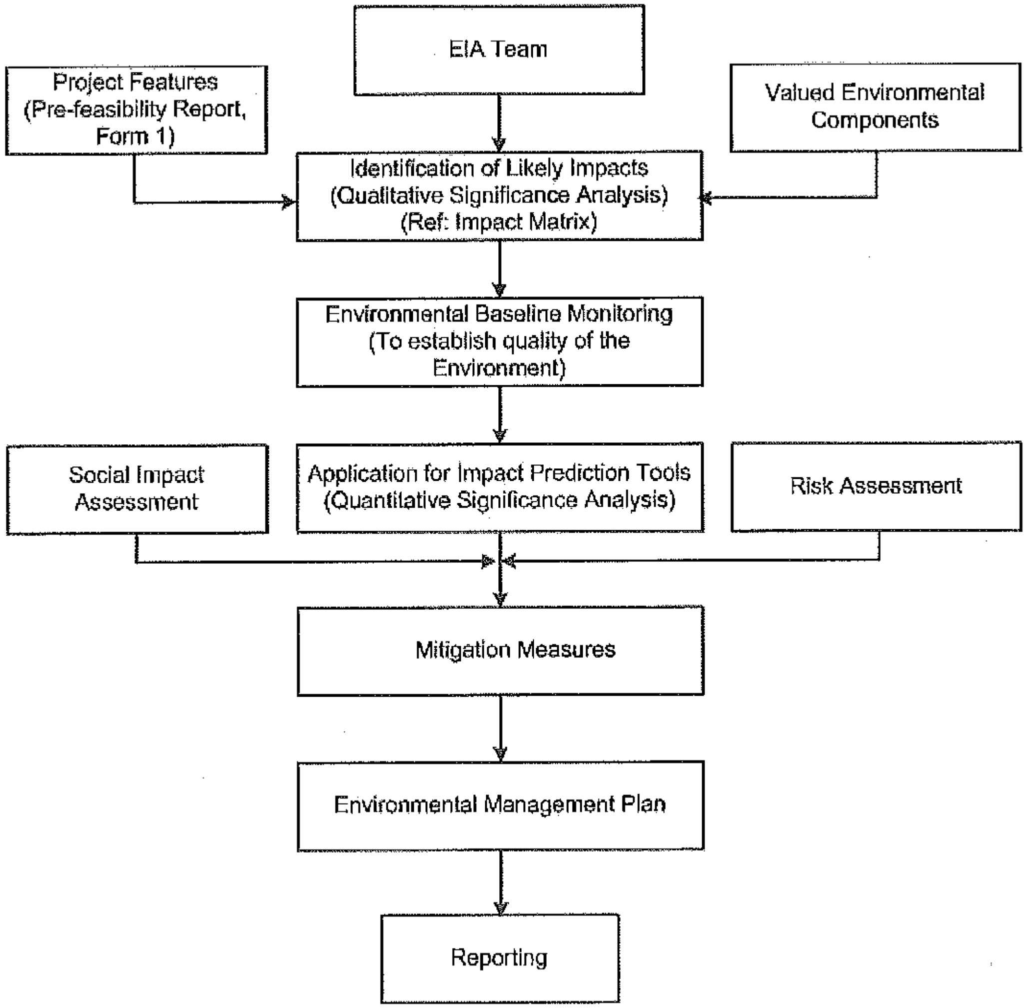


Figure 4-3: Approach for EIA Studies

4.4.1 EIA Team

The success of a multi-functional activity like an EIA primarily depends on constitution of a right team at the right time (preferable at the initial stages of an EIA) inorder to assess the significant impacts (direct, indirect as well as cumulative impacts).

The professional Team identified for a specific EIA study should consist of qualified and experienced professionals from various disciplines, inorder to address the critical aspects identified for the specific project. Based on the nature and the environmental setting, following professionals may be identified for EIA studies:

- Environmental management specialist/ environmental regulator
- Air and Noise quality
- Occupational health
- Geology/geo-hydrology
- Ecologist
- Transportation specialist
- Safety and health specialist
- Social scientist
- Organic Chemistry specialist, *etc.*

4.4.2 Baseline Quality of the Environment

EIA Notification 2006 typically specifies that an EIA Report should contain a description of the existing environment that would be or might be affected directly or indirectly by the proposed project. Environmental Baseline Monitoring (EBM) is a very important stage of EIA. In fact, one can say that for an EIA in India the EBM is the center of gravity. On one hand EBM plays a very vital role in EIA and on the other hand it provides feedback about the actual environmental impacts of a project. EBM during the operational phase helps in judging the success of mitigation measures in protecting the environment. Mitigation measures, in turn are used to ensure compliance with environmental standards, and to facilitate any needed project design or operational changes.

The existing environment is broadly defined to include the natural, cultural, socio-economic systems and their interrelationships. The intention is not to describe all baseline conditions, but to focus the collection and description of baseline data on those VECs that are important and are likely to be affected by the proposed Sugar industrial activities and should be included for further impact assessments and lead to appropriate decision-making.

4.4.2.1 Objective of EBM in the EIA Context

The term 'baseline' refers to conditions existing before development against which subsequent changes can be referenced. EBM studies are carried out to:

- identify environmental conditions which might influence project design decisions (e.g., site layout, structural or operational characteristics);
- identify sensitive issues or areas requiring mitigation or compensation;
- provide input data to analytical models used for predicting effects;
- provide baseline data against which the results of future monitoring programs can be compared.

At this stage of EIA process, the EBM is primarily discussed in the context of first purpose wherein the feedback from EBM programs may be used to:

- determine the available assimilative capacity of different environmental components within the designated impact zone and whether more or less stringent mitigation measures are needed; and
- improve the predictive capability of EIAs.

There are many institutional, scientific, quality control, and fiscal issues that must be addressed in the implementation of an environmental monitoring program. Careful consideration of these issues in the design and planning stages will help avoid many of the pitfalls associated with environmental monitoring programs.

4.4.2.2 Environmental Monitoring Network Design

Monitoring refers to the collection of data through a series of repetitive measurements of environmental parameters (or, more generally, to a process of systematic observation). The environmental quality monitoring programme design will be dependent upon the monitoring objectives specified for the selected area of interest. Types of monitoring and network design considerations are discussed in **Annexure IV**.

4.4.2.3 Baseline Data Generation

List of important physical environmental components and indicators of EBM are given in Table 4-3.

Table 4-3: List of Important Physical Environmental Components and Indicators of EBM

Environmental Component	Environmental Indicators
Climatic variables	▪ Rainfall patterns – mean, mode, seasonality ▪ Temperature patterns ▪ Extreme events ▪ Climate change projections ▪ Prevailing wind - direction, speed, anomalies ▪ Stability conditions and mixing height
Geology	▪ Underlying rock type ▪ Surgical material ▪ Geologic structures (faults *etc.*) ▪ Geologic resources (minerals, *etc.*)
Topography	▪ Slope form ▪ Landform and terrain analysis ▪ Specific landform types
Coastal dynamics and morphology	▪ Wave patterns ▪ Currents ▪ Shoreline morphology – near shore, foreshore ▪ Sediment – characteristics and transport
Soil	▪ Type and characteristics ▪ Porosity and permeability ▪ Sub-soil permeability ▪ Run-off rate ▪ Effective depth (inches/centimetres)

Environmental Component	Environmental Indicators
	- Inherent fertility - Suitability for method of sewage disposal
Drainage	- Surface hydrology - Drainage network - Rainfall runoff relationships - Hydrogeology - Groundwater characteristics – springs, *etc.*
Water quality	- Terrestrial - rivers, lakes, ponds, gullies - Coastal
Air quality	- Ambient - Respirable - Air shed importance - Odour levels
Noise	
Hazardous waste	

Guidance for assessment of baseline components and attributes describing sampling network, sampling frequency, method of measurement is given in **Annexure V**.

Infrastructure Requirements for EBM

In addition to devising a monitoring network design and monitoring plans/program, it is also necessary to ensure adequate resources in terms of staffing and skills, equipment, training, budget, *etc.,* for its implementation. Besides assigning institutional responsibility, reporting requirements, QA/QC plans and its enforcement capability are essential. A monitoring program that does not have an infrastructural support and QA/QC component will have little chance of success.

Defining Data Statistics/Analyses Requirements

The data analyses to be conducted are dictated by the objectives of the environmental monitoring program. The statistical methods used to analyze the data should be described in detail prior to data collection. This is important because repetitive observations are recorded in time and space. Besides, the statistical methods could also be chosen so that uncertainty or error estimates in the data can be quantified. For e.g., statistical methods useful in an environmental monitoring program include: 1) frequency distribution analysis; 2) analysis of variance; 3) analysis of covariance; 4) cluster analysis; 5) multiple regression analysis; 6) time series analysis; 7) the application of statistical models (ADB-Green, 1979).

Use of Secondary Data

The EBM program for EIA can at best address temporal and/or spatial variations limited to a limited extent because of cost implications and time limitations. Therefore analysis of all available information or data is essential to establish the regional profiles. So all the relevant secondary data available for different environmental components should be collated and analyzed.

To facilitate stake-holders, IL&FS Ecosmart Ltd. made an attempt to compile the list of information required for EIA studies and the sources of secondary data, which are given in **Annexure VIA** and **Annexure VIB.**

4.4.3 Impact Prediction Tools

The scientific and technical credibility of an EIA relies on the ability of the EIA practitioners to estimate the nature, extent, and magnitude of change in environmental components that may result from project activities. Information about predicted changes is needed for assigning impact significance, prescribing mitigation measures, and designing and developing EMPs and monitoring programs. The more accurate the predictions, the more confident the EIA practitioner will be in prescribing specific measures to eliminate or minimize the adverse impacts of development project.

Choice of models/methods for impact predictions in respect of each of air, noise, water, land and biological environment are precisely tabulated in **Annexure VII.**

4.4.4 Significance of the Impacts

Evaluating the significance of environmental effects is perhaps the most critical component of impact analysis. More than other components, however, the interpretation of significance is also a contentious process. The interpretation of significance bears directly on the subsequent EIA process and also during Environmental Clearance on project approvals and condition setting. At an early stage, it also enters into screening and scoping decisions on what level of assessment is required and which impacts and issues will be addressed.

Impact significance is also a key to choosing among alternatives. In total, the attribution of significance continues throughout the EIA process, from scoping to EIS review, in a gradually narrowing "cone of resolution" in which one stage sets up the next. But at this stage it is the most important as better understanding and quantification of impact significance is required.

One common approach is based on determination of the significance of predicted changes in the baseline environmental characteristics and compares these with reference to regulatory standards, objective criteria and similar 'thresholds' as eco-sensitivity, cultural /religious values. Often, these are outlined in guidance. A better test proposed by the CEAA (1995) is to determine if 'residual' environmental effects are adverse, significant, and likely (given under). But at this stage, the practice of formally evaluating significance of residual impacts, *i.e.,* after predicting the nature and magnitude of impacts based on before-versus-after-project comparisons, and identifying measures to mitigate these effects is not being followed in a systematic way.

Step 1: Are the environmental effects adverse?

- Criteria for determining if effects are "adverse" include:
- Effects on biota health
- Effects on rare or endangered species
- Reductions in species diversity
- Habitat loss
- Transformation of natural landscapes
- Effects on human health

- Effects on current use of lands and resources for traditional purposes by aboriginal persons; and
- Foreclosure of future resource use or production

Step 2: Are the adverse environmental effects significant?

- Criteria for determining 'significance' is to judge that the impacts:
- Are extensive over space or time
- Are intensive in concentration or proportion to assimilative capacity
- Exceed environmental standards or thresholds
- Do not comply with environmental policies, land use plans, sustainability strategy
- Adversely and seriously affect ecologically sensitive areas
- Adversely and seriously affect heritage resources, other land uses, community lifestyle and/or indigenous peoples traditions and values

Step 3: Are the significant adverse environmental effects likely?

Criteria for determining 'likelihood' include:

- Probability of occurrence, and
- Scientific uncertainty

4.5 Social Impact Assessment

Social Impact Assessment (SIA) is an instrument used to analyze social issues and solicit stakeholder views for the design of projects. SIA helps in making the project responsive to social development concerns, including the options that enhance benefits for poor and vulnerable people while mitigating risk and adverse impacts. It analyzes distributional impacts of intended project benefits on different stakeholder groups, and identifies differences in assets and capabilities to access the project benefits.

The scope and depth of the SIA should be determined by the complexity and importance of the issues studied, taking into account the skills and resources available. However, SIA may include following:

Description of the Socio-economic, Cultural and Institutional Profile

Conduct a rapid review of available sources of information to describe the socio-economic, cultural and institutional interface in which the project operates.

Socio-economic and cultural profile: Describe the most significant social, economic and cultural features that differentiate social groups in the project area. Describe their different interests in the project, and their levels of influence. In particular, explain any particular effects the project may have on the poor and underprivileged. Identify any known conflicts among groups that may affect project implementation.

Institutional profile: Describe the institutional environment; consider both the presence and function of public, private and civil society institutions relevant to the operation. Are there important constraints within existing institutions e.g., disconnect between institutional responsibilities and the interests and behaviors of personnel within those institutions? Or are there opportunities to utilize the potential of existing institutions, e.g., private or civil society institutions, to strengthen implementation capacity.

Legislative and Regulatory Considerations

To review laws and regulations governing the project's implementation and the access of poor and excluded groups to goods, services and opportunities provided by the project. In addition, review the enabling environment for public participation and development planning. SIA should build on strong aspects of the legal and regulatory systems to facilitate program implementation and identify weak aspects while recommending alternative arrangements.

Key Social Issues

SIA provides the baseline information for designing the social development strategy. The analysis should determine what the key social and Institutional issues are in relation to project objectives; identify the key stakeholder groups in this context and determine how relationships between stakeholder groups will affect or be affected by the project; and identify expected social development outcomes and actions proposed to achieve those outcomes.

Data Collection and Methodology

Describe the design and methodology for the social analysis. In this regard:

- Build on existing data;
- Clarify the units of analysis for the SIA: intra-household, household level, as well as communities/settlements and other relevant social aggregations on which data is available or will be collected for analysis;
- Choose appropriate data collection and analytical tools and methods, employing mixed methods wherever possible; mixed methods include a mix of quantitative and qualitative methods.

Strategy to Achieve Social Development Outcomes

Identify the likely social development outcomes of the project and propose a Social development strategy, including recommendations for institutional arrangements to achieve them, based on the findings of the social assessment. The social development strategy could include measures:

- that strengthen social inclusion by ensuring that both poor and excluded groups and intended beneficiaries are included in the benefit stream and in access to opportunities created by the project
- that empower stakeholders through their participation in the design and implementation of the project, their access to information, and their increased voice and accountability (*i.e.,* a participation framework); and
- that enhance security by minimizing and managing likely social risks and increasing the resilience of intended beneficiaries and affected persons to socioeconomic shocks

Implications for Analysis of Alternatives

Review the proposed approaches for the project, and compare them in terms of their relative impacts and social development outcomes. Consider what implications the findings of the social assessment might have on those approaches. Should some new components be added to the approach, or other components reconsidered or modified?

If the SIA and consultation process indicate that alternative approaches are likely to have better development outcomes, such alternatives should be described and considered, along with the likely budgetary and administrative effects these changes might have.

Recommendations for Project Design and Implementation Arrangements

Provide guidance to project management and other stakeholders on how to integrate social development issues into project design and implementation arrangements. As much as possible, suggest specific action plans or implementation mechanisms to address relevant social issues and potential impacts. These can be developed as integrated or separate action plans, for example, as Resettlement Action Plans, Indigenous Peoples Development Plans, Community Development Plans, *etc.*

Developing a Monitoring Plan

Through the SIA process, a framework for monitoring and evaluation should be developed. To the extent possible, this should be done in consultation with key stakeholders, especially beneficiaries and affected people.

The framework shall identify expected social development indicators, establish benchmarks, and design systems and mechanisms for measuring progress and results related to social development objectives. The framework shall identify organizational responsibilities in terms of monitoring, supervision, and evaluation procedures. Wherever possible, participatory monitoring mechanisms shall be incorporated. The framework should establish:

- a set of monitoring indicators to track the progress achieved. The benchmarks and indicators should be limited in number, and should combine both quantitative and qualitative types of data. The indicators should include outputs to be achieved by the social development strategy; indicators to monitor the process of stakeholder participation, implementation and institutional reform;
- indicators to monitor social risk and social development outcomes; and indicators to monitor impacts of the project's social development strategy. It is important to suggest mechanisms through which lessons learned from monitoring and stakeholder feedback can result in changes to improve the operation of the project. Indicators should be of such a nature that results and impacts can be disaggregated by gender and other relevant social groups;

Define transparent evaluation procedures. Depending on context, these may include a combination of methods, such as participant observation, key informant interviews, focus group discussions, census and socio-economic surveys, gender analysis, Participatory Rural Appraisal (PRA), Participatory Poverty Assessment (PPA) methodologies, and other tools. Such procedures should be tailored to the special conditions of the project and to the different groups living in the project area; Estimate resource and budget requirements for monitoring and evaluation activities, and a description of other inputs (such as institutional strengthening and capacity building) needed to carry it out.

4.6 Risk Assessment

Industrial accidents results in great personal and financial loss. Managing these accidental risks in today's environment is the concern of every industry including sugar industries, because either real or perceived incidents can quickly jeopardize the financial viability of a business. Many facilities involve various manufacturing processes that have the potential for accidents which may be catastrophic to the plant, work force, environment, or public.

The main objective of the risk assessment study is to propose a comprehensive but simple approach to carry out risk analysis and conducting feasibility studies for industries and planning and management of industrial prototype hazard analysis study in Indian context.

Risk analysis and risk assessment should provide details on Quantitative Risk Assessment (QRA) techniques used world-over to determine risk posed to people who work inside or live near hazardous facilities, and to aid in preparing effective emergency response plans by delineating a Disaster Management Plan (DMP) to handle onsite and offsite emergencies. Hence, QRA is an invaluable method for making informed risk-based process safety and environmental impact planning decisions, as well as being fundamental to any facility-siting decision-making. QRA whether, site-specific or risk-specific for any plant is complex and needs extensive study that involves process understanding, hazard identification, consequence modeling, probability data, vulnerability models/data, local weather and terrain conditions and local population data. QRA may be carried out to serve the following objectives.

- Identification of safety areas
- Identification of hazard sources
- Generation of accidental release scenarios for escape of hazardous materials from the facility
- Identification of vulnerable units with recourse to hazard indices
- Estimation of damage distances for the accidental release scenarios with recourse to Maximum Credible Accident (MCA) analysis
- Hazard and Operability studies (HAZOP) inorder to identify potential failure cases of significant consequences
- Estimation of probability of occurrences of hazardous event through fault tree analysis and computation of reliability of various control paths
- Assessment of risk on the basis of above evaluation against the risk acceptability criteria relevant to the situation
- Suggest risk mitigation measures based on engineering judgement, reliability and risk analysis approaches
- Delineation / up-gradation of Disaster Management Plan (DMP).
- Safety Reports: with external safety report/ occupational safety report.

The risk assessment (Figure 4-4) report may cover the following in terms of the extent of damage with resource to MCA analysis and delineation of risk mitigations measures with an approach to DMP.

- Hazard identification – identification of hazardous activities, hazardous materials, past accident records, *etc.*
- Hazard quantification – consequence analysis to assess the impacts
- Risk Presentation
- Risk Mitigation Measures
- Disaster Management Plans

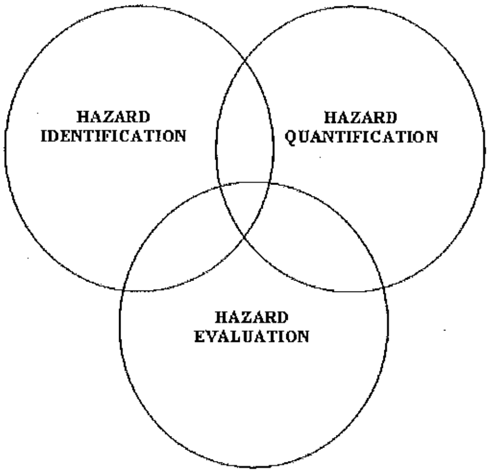


Figure 4-4: Risk Assessment – Conceptual Framework

Predictive methods for estimating risk should cover all the design intentions and operating parameters to quantify risk in terms of probability of occurrence of hazardous events and magnitude of its consequence. Table 4-4 shows the predicted models for risk assessment.

Table 4-4: Guidance for Accidental Risk Assessment

Relevance		
EFFECT	Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence	Heat load, press wave & toxic release exposure neutral gas dispersion
WHAZAN	Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence	
EGADIS	Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence	Dense gas dispersion
HAZOP and Fault Tree Assessment	For estimating top event probability	Failure frequency data is required
Pathways reliability and protective system hazard analysis	For estimating reliability of equipments and protective systems	Markov models
Vulnerability Exposure models	Estimation of population exposure	Uses probit equation for population exposure
F-X and F-N curves	Individual / Societal risks	Graphical Representation

4.7 Mitigation Measures

The purpose of mitigation is to identify measures that safeguard the environment and the community affected by the proposal. Mitigation is both a creative and practical phase of the EIA process. It seeks to find the best ways and means of avoiding, minimizing and remedying impacts. Mitigation measures must be translated into action in the correct way and at the right time, if they are to be successful. This process is referred to as impact management and takes place during project implementation. A written plan should be prepared for this purpose, and includes a schedule of agreed actions. Opportunities for impact mitigation will occur throughout the project cycle.

4.7.1 Important Considerations for Mitigation Methods

The responsibility of project proponents to 'internalize' the full environmental costs of development proposals is now widely accepted under "Polluter Pay" principle. In addition, many proponents have found that good design and impact management can result in significant savings applying the principles of cleaner production to improve their environmental performance.

- The predicted adverse environmental as well as social impacts for which mitigation measures are required should be identified and briefly summarized along with cross referencing them to the significance, prediction components of the EIA report or other documentation.
- Each mitigation measure should be briefly described with reference to the impact of significances to which it relates and the conditions under which it is required (for example, continuously or in the event of contingencies). These should also be cross-referenced to the project design and operating procedures which elaborate on the technical aspects of implementing the various measures.
- Cost and responsibilities for mitigation and monitoring should be clearly defined, including arrangements for co-ordination between the various authorities responsible for mitigation.
- The proponent can use the EMP to develop environmental performance standards and requirements for the project site as well as supply chain. An EMP can be implemented through EMS for the operational phase of the project.

Prior to selecting mitigation plans it is appropriate to study the mitigation alternatives for cost-effectivity, technical and socio-political feasibility. Such Mitigation measures could include:

- avoiding sensitive areas such as eco-sensitive area e.g., fish spawning areas, dense mangrove areas or areas known to contain rare or endangered species
- adjusting work schedules to minimize disturbance
- engineered structures such as berms and noise attenuation barriers
- pollution control devices, such as scrubbers and electrostatic precipitators
- changes in fuel feed, manufacturing, process, technology use, or waste management practices, such as substituting a hazardous chemical with a non-hazardous one, or the re-cycling or re-use of waste materials, *etc.*

Other Generic Measures

- Extend education facility and vocational training to the children of the neighbouring villages.
- Extend hospital facilities for adjacent villages and provide community with water supply.
- Develop community projects to improve rural economy, health and sanitation standards, animal husbandry, *etc.*

- Conduct mass awareness programmes for villagers, township residents and employees about the chemicals / raw materials being used in the plant, emergency preparedness of the industry, *etc.*
- Develop green belt / greenery in and around the plant.
- Develop infrastructure like roads, power supply, transport, *etc.*
- Adopt rainwater harvesting to recharge the ground water.
- Adopt accredited Environment Management Systems: ISO 14001, OHSAS – 18001

4.7.2 Hierarchy of Elements of Mitigation Plan

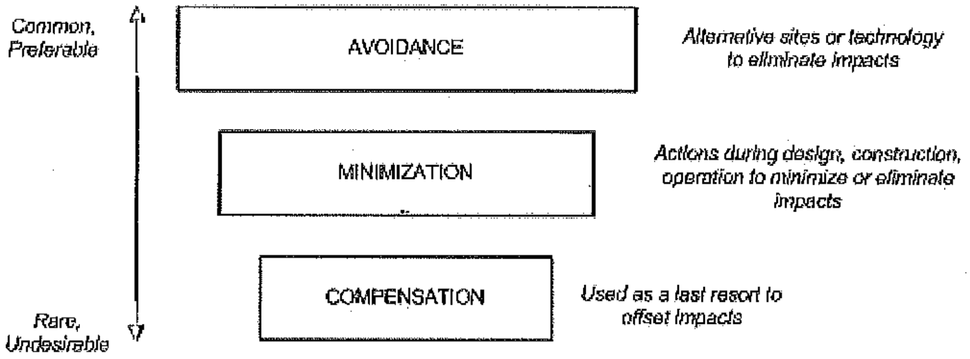


Figure 4-5: Hierarchy of Elements of Mitigation Plan

Good EIA practice requires a relevant technical understanding of the issues and the measures that work in the circumstances: The priority of selection of mitigation measures should be in the order:

Step One: Impact Avoidance

This step is most effective when applied at an early stage of project planning. It can be achieved by:

- Not undertaking certain projects or elements that could result in adverse impacts
- Avoiding areas that are environmentally sensitive; and
- Putting in place the preventative measures to stop adverse impacts from occurring, for example, release of water from a reservoir to maintain a fisheries regime.

Step Two: Impact Minimization

This step is usually taken during impact identification and prediction to limit or reduce the degree, extent, magnitude, or duration of adverse impacts. It can be achieved by:

- Scaling down or relocating the proposal
- Redesigning elements of the project; and
- Taking supplementary measures to manage the impacts

Step Three: Impact Compensation

This step is usually applied to remedy unavoidable residual adverse impacts. It can be achieved by:

- Rehabilitation of the affected site or environment, for example, by habitat enhancement and restocking fish;
- Restoration of the affected site or environment to its previous state or better, as typically required for mine sites, forestry roads and seismic lines; and
- Replacement of the same resource values at another location, for example, by wetland engineering to provide an equivalent area to that lost to drainage or infill.

Important Compensation Elements

Resettlement Plans: Special considerations apply to mitigation of proposals that displace or disrupt people. Certain types of projects, such as reservoirs and irrigation schemes and public works, are known to cause involuntary resettlement. This is a contentious issue because it involves far more than re-housing people; in addition, income sources and access to common property resources are likely to be lost. Almost certainly, a resettlement plan will be required to ensure that no one is worse off than before, which may not be possible for indigenous people whose culture and lifestyle is tied to a locality. This plan must include the means for those displaced to reconstruct their economies and communities and should include an EIA of the receiving areas. Particular attention should be given to indigenous, minority and vulnerable groups who are at higher risk from resettlement.

In-kind Compensation

When significant or net residual loss or damage to the environment is likely, in kind compensation is appropriate. As noted earlier, environmental rehabilitation, restoration or replacement have become standard practices for many proponents. Now, increasing emphasis is given to a broader range of compensation measures to offset impacts and assure the sustainability of development proposals. These include impact compensation 'trading', such as offsetting CO2 emissions by planting forests to sequester carbon.

4.7.3 Typical Mitigation Measures

Table 4-5: Mitigation Measures for Construction Phase

Impacts	Mitigation Steps
Erosion	▫ Windscreens, Maintenance, And Installation Of Ground Cover ▫ Installation Of Drainage Ditches ▫ Runoff And Retention Ponds ▫ Minimize Disturbances And Scarification Of The Surface.
Deforestation	▫ Plant Or Create Similar Areas ▫ Initiate A Tree Planning Program In Other Areas ▫ Donate Land To Conservationalist Groups

Table 4-6: Mitigation Measures for Operation Phase

Impacts	Mitigation steps
Dust pollution	▪ Wetting of roadways to reduce traffic dust and reentrained particles ▪ Installation of windscreens to breakup the wind flow
Noise pollution	▪ Heavy duty muffler systems on heavy equipment ▪ Limit certain activities ▪ Provide enclosures and silencer pad
Water pollution and issues	▪ Channeling and retention of water to reduce erosion and situation ▪ Collection and treatment of sewage and organic waste ▪ Increased recycling and reuse of water ▪ Use of biodegradable or otherwise readily treatable additives ▪ Cooling ponds, towers and canals to reduce temperatures of cooling water discharge ▪ Neutralization and sedimentation of wastewater ▪ Dewatering of sludges and appropriate disposal of solids ▪ Use deep well injection below potable levels ▪ Construct liners of ponds and solids waste disposal ▪ Dilute water at point of discharge ▪ Stormwater management
Chemical discharges and spills	▪ Develop spill prevention plans ▪ Develop traps and containment system and chemically treat discharges on site
Biological	▪ Installation of systems to discourage nesting or perching of birds in dangerous environments ▪ Increased employee awareness to sensitive areas
Disruption of traffic	▪ Develop traffic plan that minimizes road use by workers ▪ Upgrade roads and intersections
Worker exposure to dust from Process	▪ Provide dust collector equipment ▪ Maintain dust levels less than 10 mg/m^3 ▪ Monitor for free silica content ▪ Provide dust masks when levels are exceeded
Worker exposure to toxic gases leaking from the boilers	▪ Maintain boilers properly ▪ Monitor concentrations with levels not to exceed ▪ SO_2 – 5 ppm ▪ CO – 5 ppm ▪ NO_2 – 5 ppm
Worker exposure to excessive noise	▪ Maintain noise levels from below 90 dba ▪ Provide ear protection if in excess
Induced secondary development puts increased demand on infrastructure	▪ Provide infrastructure plan and financial support for increased demands ▪ Construct facilities to reduce demands

4.7.4 Environmental Management Plan

A typical EMP shall be composed of the following:

1. summary of the potential impacts of the proposal ;
2. description of the recommended mitigation measures ;
3. statement of their compliance with relevant standards ;

4. allocation of resources and responsibilities for plan implementation ;
5. schedule of the actions to be taken ;
6. programme for surveillance, monitoring and auditing ; and
7. contingency plan when impacts are greater than expected

Each of the above components are precisely discussed below:

Summary of impacts: The predicted adverse environmental and social impacts for which mitigation measures are identified in the earlier sections to be briefly summarized with cross referencing to the corresponding sections in the EIA report.

Description of mitigation measures: Each mitigation measure should be briefly described with reference to the impact to which it relates and the conditions under which it is required. These should be accompanied by, or referenced to, project design and operating procedures which elaborate on the technical aspects of implementing the various measures.

Description of monitoring programme: Environmental monitoring refers to compliance monitoring and residual impact monitoring. Compliance monitoring refers to meeting the industry-specific statutory compliance requirements (Ref. Applicable National regulations as detailed in Chapter 3).

Residual impact monitoring refers to monitoring of identified sensitive locations with adequate number of samples and frequency. The monitoring programme should clearly indicate the linkages between impacts identified in the EIA report, measurement indicators, detection limits (where appropriate), and definition of thresholds that will signal the need for corrective actions.

Institutional arrangements: Responsibilities for mitigation and monitoring should be clearly defined, including arrangements for co-ordination between the various actors responsible for mitigation. Details should be provided w.r.t the deployment of staff (detailed organogram), monitoring network design, parameters to be monitored, analysis methods, associated equipments etc.

Implementation schedule and reporting procedures: The timing, frequency and duration of mitigation measure should be specified in an implementation schedule, showing links with overall project implementation. Procedures to provide information on the progress and results of mitigation and monitoring measures should also be clearly specified.

Cost estimates and sources of funds: These should be specified for both the initial investment and recurring expenses for implementing all measures contained in the EMP, integrated into the total project costs, and factored into loan negotiation.

The EMP should contain commitments that are binding on the proponent in different phases of project implementation i.e. pre-construction or site clearance, construction, operation, decommissioning.

4.8 Reporting

Structure of the EIA report is given in the following Table 4-7. Each task prescribed in ToR shall be incorporated appropriately in the contents in addition to the described in the Table.

Table 4-7: Structure of EIA Report

S.NO	EIA STRUCTURE	CONTENTS
1.	Introduction	▪ Purpose of the report ▪ Identification of project & project proponent ▪ Brief description of nature, size, location of the project and its importance to the country, region ▪ Scope of the study – details of regulatory scoping carried out (As per ToR EIA studies)
2.	Project Description	▪ Condensed description of those aspects of the project (based on project feasibility study), likely to cause environmental effects. Details should be provided to give clear picture of the following: ▪ Type of project ▪ Need for the project ▪ Location (maps showing general location, specific location, project boundary & project site layout) ▪ Size or magnitude of operation (incl. Associated activities required by or for the project) ▪ Proposed schedule for approval and implementation ▪ Technology and process description ▪ Project description including drawings showing project layout, components of project *etc.* Schematic representations of the feasibility drawings which give information important for EIA purpose ▪ Description of mitigation measures incorporated into the project to meet environmental standards, environmental operating conditions, or other EIA requirements (as required by the scope) ▪ Assessment of New & untested technology for the risk of technological failure
3.	Description of the Environment	▪ Study area, period, components & methodology ▪ Establishment of baseline for VECs, as identified in the scope ▪ Base maps of all environmental components
4.	Anticipated Environmental Impacts & Mitigation Measures	▪ Details of Investigated Environmental impacts due to project location, possible accidents, project design, project construction, regular operations, final decommissioning or rehabilitation of a completed project ▪ Measures for minimizing and / or offsetting adverse impacts identified ▪ Irreversible and Irretrievable commitments of environmental components ▪ Assessment of significance of impacts (Criteria for determining significance, Assigning significance) ▪ Mitigation measures
5.	Analysis of Alternatives (Technology & Site)	▪ Incase, the scoping exercise results in need for alternatives: ▪ Description of each alternative ▪ Summary of adverse impacts of each alternative ▪ Mitigation measures proposed for each alternative and selection of alternative
6.	Environmental Monitoring Program	▪ Technical aspects of monitoring the effectiveness of mitigation measures (incl. Measurement methodologies, frequency, location, data analysis, reporting schedules, emergency procedures, detailed budget &

S.NO	EIA STRUCTURE	CONTENTS
		procurement schedules)
7.	Additional Studies	- Public Consultation - Risk assessment - Social Impact Assessment, R&R Action Plans
8.	Project Benefits	- Improvements in the physical infrastructure - Improvements in the social infrastructure - Employment potential –skilled; semi-skilled and unskilled - Other tangible benefits
9.	Environmental Cost Benefit Analysis	- If recommended at the Scoping stage
10.	EMP	- Description of the administrative aspects of ensuring that the measures of mitigation are implemented and their effectiveness monitored, after approval of the EIA
11.	Summary & Conclusion (This will constitute the summary of the EIA Report)	- Overall justification for implementation of the project - Explanation of how, adverse effects have been mitigated - Implementation of Clean Development Mechanism to conserve natural resources
12.	Disclosure of Consultants engaged	- The names of the Consultants engaged with their brief resume and nature of Consultancy rendered

4.9 Public Consultation

Public consultation refers to the process by which the concerns of local affected people and others who have plausible stake in the environmental impacts of the project or activity are ascertained.

- Public consultation is not a decision taking process, but is a process to collect views of the people having plausible stake. If the SPCB/Public agency conducting public hearing is not convinced with the plausible stake, then such expressed views need not be considered.
- All Category A and Category B1 projects require public hearing except the following:
  - Modernization of irrigation projects
  - Once environmental clearance is granted to an industrial estates/SEZs/EPZs *etc.*, for a given composition (type and capacity) of industries, then individual units will not require public hearing Expansion of roads and highways, which do not involve any further acquisition of land.
  - All building/ construction projects/ area development projects/townships
  - All Category B2 projects
  - All projects concerning national defense and security or involving other strategic considerations as determined by the Central Government
- Public consultation involves two components, one is public hearing, and other one is inviting written responses/objections through Internet/by post, *etc.*, by placing the summary of EIA report on the web site.
- Public hearing shall be carried out at the site or in its close proximity, district-wise, for ascertaining concerns of local affected people.

- Project proponent shall make a request through a simple letter to the Member—Secretary of the SPCB or UTPCC to arrange public hearing.
- Project proponent shall enclose with the letter of request, at least 10 hard copies and 10 soft copies of the draft EIA report including the summary EIA report in English and local language prepared as per the approved scope of work, to the concerned Authority.
- Simultaneously, project proponent shall arrange to send, one hard copy and one soft copy, of the above draft EIA report along with the summary EIA report to the following Authorities within whose jurisdiction the project will be located:
  - District magistrate(s)
  - Zilla parishad and municipal corporation
  - District industries office
  - Concerned regional office of the MoEF/SPCB
- Above mentioned Authorities except concerned prior environmental clearance Authority (MoEF/SEIAA) shall arrange to widely publicize the draft EIA report within their respective jurisdictions. They shall also make draft EIA report for inspection electronically or otherwise to the public during normal hours till the public hearing is over.
- Concerned regulatory Authority (MoEF/SEIAA/UTEIA) shall display the summary of EIA report on its website and also make full draft EIA report available for reference at a notified place during normal office hours at their head office.
- SPCB or UTPCC concerned shall make arrangements for giving publicity about the project within the State/UT and make available the summary of draft EIA report for inspection in select offices, public libraries. They shall also additionally make available a copy of the draft EIA report to the above five authorities/offices as mentioned above.
- The Member—Secretary of the concerned SPCB or UTPCC shall finalize the date, time and exact venue for the conduct of public hearing within seven days of the date of the receipt of the draft EIA report from the project proponent and advertise the same in one major National Daily and one Regional vernacular Daily.
- A minimum notice period of 30 (thirty) days shall be provided to the public for furnishing their responses.
- No postponement of the date, time, venue of the public hearing shall be undertaken, unless some untoward emergency situation occurs and only then on the recommendation of the concerned District Magistrate the postponement shall be notified to the public through the same National and Regional vernacular dailies and also prominently displayed at all the identified offices by the concerned SPCB or UTPCC.
- In the above exceptional circumstances fresh date, time and venue for the public consultation shall be decided by the Member—Secretary of the concerned SPCB or UTPCC only in consultation with the District Magistrate and notified afresh as per the procedure.
- The District Magistrate or his or her representative not below the rank of an Additional District Magistrate assisted by a representative of SPCB or UTPCC, shall supervise and preside over the entire public hearing process.

- The SPCB or UTPCC shall arrange to video film the entire proceedings. A copy of the videotape or a CD shall be enclosed with the public hearing proceedings while forwarding it to the Regulatory Authority concerned.
- The attendance of all those who are present at the venue shall be noted and annexed with the final proceedings.
- There shall be *no quorum* required for attendance for starting the proceedings.
- Every person present at the venue shall be granted the opportunity to seek information or clarifications on the project from the Applicant. The summary of the public hearing proceedings accurately reflecting all the views and concerns expressed shall be recorded by the representative of the SPCB or UTPCC and read over to the audience at the end of the proceedings explaining the contents in the vernacular language and the agreed minutes shall be signed by the District Magistrate or his or her representative on the same day and forwarded to the SPCB/UTPCC concerned.
- A statement of the issues raised by the public and the comments of the proponent shall also be prepared in the local language and in English and annexed to the proceedings.
- The proceedings of the public hearing shall be conspicuously displayed at the office of the Panchayats within whose jurisdiction the project is located, office of the concerned Zilla Parishad, District Magistrate, and the SPCB or UTPCC. The SPCB or UTPCC shall also display the proceedings on its website for general information. Comments, if any, on the proceedings, may be sent directly to the concerned regulatory authorities and the Applicant concerned.
- The public hearing shall be completed within a period of 45 (forty five) days from date of receipt of the request letter from the Applicant. Therefore the SPCB or UTPCC concerned shall send the public hearing proceedings to the concerned regulatory authority within 8(eight) days of the completion of the public hearing. The proponent may also directly forward a copy of the approved public hearing proceedings to the regulatory authority concerned along with the final EIA report or supplementary report to the draft EIA report prepared after the public hearing and public consultations.
- Upon receipt of the same, the Authority will place executive summary of the report on the website to invite responses from other concerned persons having a plausible stake in the environmental aspects of the project or activity.
- If SPCB/UTPCC is unable to conduct the public hearing in the prescribed time, the Central Government incase of Category A projects and State Government in case of Category B projects at the request of the SEIAA or project proponent can engage a public agency for conducting the public hearing process within a further period of 45 days. The respective governments shall pay the appropriate fee to the public agency for conducting public hearing.
- A public agency means a non-profit making institution/ body such as technical/academic institutions, government bodies not subordinate to the concerned Authority.
- If SPCB/Public Agency authorized for conducting public hearing informs the Authority, stating that it is not possible to conduct the public hearing in a manner, which will enable the views of the concerned local persons to be freely expressed, then Authority may consider such report to take a decision that in such particular case, public consultation may not have the component of public hearing.

- Often restricting the public hearing to the specific district may not serve the entire purpose, therefore, NGOs who are local and registered under the Societies Act in the adjacent districts may also be allowed to participate in public hearing, if they so desire.
- Confidential information including non-disclosable or legally privileged information involving intellectual property right, source specified in the application shall not be placed on the website.
- The Authority shall make available on a written request from any concerned person the draft EIA report for inspection at a notified place during normal office hours till the date of the public hearing.
- While mandatory requirements will have to be adhered to, utmost attention shall be given to the issues raised in the public hearing for determining the modifications needed in the project proposal and the EMP to address such issues.
- Final EIA report after making needed amendments, as aforesaid, shall be submitted by the applicant to the concerned Authority for prior environmental clearance. Alternatively, a supplementary report to draft EIA and EMP addressing all concerns expressed during the public consultation may be submitted.

4.10 Appraisal

Appraisal means the detailed scrutiny by the EAC or SEAC of the application and the other documents like the final EIA report, outcome of the public consultation including public hearing proceedings submitted by the applicant for grant of environmental clearance.

- The appraisal shall be made by EAC to the Central Government or SEAC to SEIAA.
- Project proponent either personally or through consultant can make a presentation to EAC/SEAC for the purpose of appraising the features of the project proposal and also to clarify the issues raised by the members of the EAC/SEAC.
- On completion of these proceedings, concerned EAC/SEAC shall make categorical recommendations to the respective Authority, either for grant of prior environmental clearance on stipulated terms & conditions, if any, or rejection of the application with reasons.
- In case EAC/SEAC needs to visit the site or obtain further information before being able to make categorical recommendations, EAC/SEAC may inform the project proponent accordingly. In such an event, it should be ensured that the process of environmental clearance is not unduly delayed to go beyond the prescribed timeframe.
- Upon the scrutiny of the final report, if EAC/SEAC opines that ToR for EIA studies finalized at the scoping stage are not covered by the proponent, then the project proponent may be asked to provide such information. If such information is declined by the project proponent or is unlikely to be provided early enough so as to complete the environmental appraisal within prescribed time of 60 days, the EAC/SEAC may recommend for rejection of the proposal with the same reason.
- Appraisal shall be strictly in terms of ToR for EIA studies finalized at the scoping stage and the concerns expressed during public consultation.
- This process of appraisal shall be completed within 60 days from the receipt of the updated EIA report and EMP report, after completing public consultation.

- The EIA report will be typically examined for following:
  1. Project site description supported by topographic maps & photographs – detailed description of topography, land use and activities at the proposed project site and its surroundings (buffer zone) supported by photographic evidence.
  2. Clarity in description of drainage pattern, location of eco sensitive areas, vegetation characteristics, wildlife status - highlighting significant environmental attributes such as feeding, breeding and nesting grounds of wildlife species, migratory corridor, wetland, erosion and neighboring issues.
  3. Description of the project site – how well the interfaces between the project related activities and the environment have been identified for the entire project cycle *i.e.,* construction, operation and decommissioning at the end of the project life.
  4. How complete and authentic are the baseline data pertaining to flora and fauna and socio economic aspects?
  5. Citing of proper references, with regard to the source(s) of baseline data as well as the name of the investigators/ investigating agency responsible for collecting the primary data.
  6. How consistent are the various values of environmental parameters w.r.t. each other?
  7. Is a reasonable assessment of the environmental and social impact made for the identified environmental issues including project affected people?
  8. To what extent the proposed environmental plan will mitigate the environmental impact and at what estimated cost, shown separately for construction, operation and closure stages and also separately in terms of capital and recurring expenses along with details of agencies that will be responsible for the implementation of environmental plan/ conservation plan.
  9. How well the concerns expressed/highlighted during the Public hearing have been addressed and incorporated in the EMP giving item wise financial provisions and commitments (in quantified terms)?
  10. How far the proposed environmental monitoring plan will effectively evaluate the performance of the EMP? Are details for environmental monitoring plan provided in the same manner as the EMP?
  11. Identification of hazard and quantification of risk assessment and whether appropriate mitigation plan has been included in the EMP?
  12. Does the proposal include a well formulated time bound green belt development plan for mitigating environmental problems such as fugitive emission of dust, gaseous pollutants, noise, odour, *etc.*
  13. Does EIA makes a serious attempt to guide the project proponent for minimizing the requirement of natural resources including land, water energy and other non renewable resources?
  14. How well the EIA statement has been organized and presented so that the issues, their impact and environmental management strategies emerge clearly from it and how well organized was the power point presentation made before the expert committee?
  15. Is the information presented in the EIA adequately and appropriately supported by maps, imageries and photographs highlighting site features and environmental attributes?

4.11 Decision-Making

The Chairperson reads the sense of the Committee and finalizes the draft minutes of the meeting, which are circulated by the Secretary to all the core members and sectoral experts invited to the meeting. Based on the response from the members, the minutes are finalized and signed by the Chairperson. This process for finalization of the minutes should be so organized that the time prescribed for various stages is not exceeded.

Approval / Rejection / Reconsideration

- The Authority shall consider the recommendations of concerned appraisal Committee and convey its decision within 45 days of the receipt of recommendations.
- If the Authority disagrees with the recommendations of the Appraisal Committee, then reasons shall be communicated to concerned Appraisal Committee and applicant with in 45 days from the receipt of the recommendations. The Appraisal Committee concerned shall consider the observations of the Authority and furnish its views on the observations within further period of 60 days. The Authority shall take a decision with in the next 30 days based on the views of appraisal Committee.
- If the decision of the Authority is not conveyed within the time, then the proponent may proceed as if the environmental clearance sought has been granted or denied by the regulatory authority in terms of the final recommendation of the concerned appraisal Committee. For this purpose, the decision of the Appraisal Committee will be public document, once the period specified above for taking the decision by the Authority is over.
- Incase of the Category B projects, application shall be received by the Member—Secretary of the SEIAA and clearance shall also be issued by the same SEIAA.

If approved

- The concerned authority (MoEF/SEIAA) will issue an Environmental Clearance for the project.
- The project proponent should make sure that the award of Environment Clearance is properly publicized in at least two local newspapers of the district or state where the proposed project is located. For instance, the executive summary of the Environmental Clearance may be published in the newspaper along with the information about the location (website/office where it is displayed for public) where the detailed Environmental Clearance is made available. The MoEF and the SEIAA/UTEIAA, as the case may be, shall also place the Environmental Clearance in the public domain on Government Portal. Further copies of the environmental clearance shall be endorsed to the Heads of local bodies, Panchayats and Municipal bodies in addition to the relevant offices of the Government
- The environmental clearance will be valid from the start date to actual commencement of the production of the developmental activity.

4.12 Post-Clearance Monitoring Protocol

The MoEF, Government of India shall entrust the post monitoring clearance to the laboratories recognized under the Environment (Protection) Act, 1986/ the laboratories recognized by the Central Pollution Control Board

The project proponent must submit half-yearly compliance reports in respect of the stipulated prior environmental clearance terms and conditions in hard and soft copies to the regulatory authority concerned, on 1st June and 1st December of each calendar year.

All such compliance reports submitted by the project management shall be public documents. Copies of the same shall be given to any person on application to the concerned regulatory authority. The latest such compliance report shall also be displayed on the web site of the concerned regulatory authority

The SPCB shall incorporate EIA clearance conditions into consent conditions in respect of Category A and Category B projects and in parallel monitor and enforce the same.

5.
STAKEHOLDERS' ROLES AND RESPONSIBILITIES

Prior environmental clearance process involves many stakeholders *i.e.*, Central Government, State Government, SEIAA, EAC at the National Level, SEAC, the public agency, SPCB, the project proponent, and the public.

- The roles and responsibilities of the organizations involved in different stages of prior environmental clearance are given in Table 5-1.
- Organization-specific functions are listed in Table 5-2.

In this Chapter, constitution, composition, functions, *etc.*, of the Authorities and the Committees are discussed in detail.

Table 5-1: Roles and Responsibilities of Stakeholders Involved in Prior Environmental Clearance

Stage	MoEF/ SEIAA	EAC/ SEAC	Project Proponent	EIA consultant	SPCB/ Public Agency	Public and Interest Group
Screening	Receives application and takes advise of EAC/ SEAC	Advises the MoEF/ SEIAA	Submits application (Form 1) and provides necessary information	Advises and assists the proponent by providing technical information		
Scoping	Approves the ToR, communicates the same to the project proponent and places the same in the website	Reviews the ToR, visits the proposed site, if required and recommends the ToR to the MoEF/ SEIAA	Submits the draft ToR to SEIAA and facilitates the visit of the EIA/SEAC members to the project site	Prepares ToR		
EIA Report & Public Hearing	Reviews and forwards copies of the EIA report to SPCB /public agency for conducting public hearing		Submits detailed EIA report as per the finalized ToR Facilitates the public hearing by arranging presentation on the project, EIA and EMP – takes note of	Prepares the EIA report Presents and appraises the likely impacts and pollution control measures proposed in the public hearing	Reviews EIA report and conducts public hearing in the manner prescribed Submits proceedings and views of	Participates in public hearings and offers comments and observations. Comments can be sent directly to SEIAA

	Places the summary of EIA report in the website Conveys objections to the project proponent for update		objections and updates the EMP accordingly		SPCB, to the Authority and the project proponent as well	through Internet in response to the summary placed in the website
Appraisal and Clearance	Receives updated EIA Takes advise of SEAC, approves EIA and attaches the terms and conditions	Critically examines the reports, presentation of the proponent and appraises EIA/ SEIAA (recommendations are forwarded to MoEF/ SEIAA)	Submits updated EIA , EMP reports to SEIAA. Presents the overall EIA and EMP including public concerns to SEAC	Provides technical advise to the project proponent and if necessary presents the proposed measures for mitigation of likely impacts (terms and conditions of clearance)		
Post-clearance Monitoring			Implements environmental protection measures prescribed and submits periodic monitoring results	Conducts periodic monitoring	Incorporates the clearance conditions into appropriate consent conditions and ensures implementation	

Table 5-2: Organization-specific Functions

ORGANIZATION	FUNCTIONS
Central Government	▫ Constitutes the EAC ▫ Considering recommendations of the State Government, constitutes the SEIAA & SEAC ▫ Receives application from the project proponent in case of Category A projects or Category B projects attracting general condition ▫ Communicated the ToR finalized by the EAC to the project proponent. ▫ Receives EIA report from the project proponent and soft copy of summary of the report for placing in the website ▫ Summary of EIA report will be placed in website. Forwards the received responses to the project proponent

	▪ Engages other public agency for conducting public hearings in cases where the SPCB does not respond within time ▪ Receives updated EIA report from project proponent incorporating the considerations from the proceedings of public hearing and responses received through other media ▪ Forwards updated EIA report to the EAC for appraisal ▪ Either accepts the recommendations of EAC or asks for reconsideration of specific issues for review by the EAC. ▪ Takes the final decision – acceptance/ rejection – of the project proposal and communicates the same to the project proponent
State Government	▪ Identifies experts as per the composition specified in the Notification and subsequent guidelines to recommend to the Central Government. ▪ Extends funding support to fulfill the functions of SEIAA/SEAC ▪ Engages other public agency for conducting public hearings in cases where the SPCB does not respond within time ▪ State Governments will suitably pay the public agency for conducting such activity
EAC	▪ Reviews Form 1 and its attachments ▪ Visits site(s), if necessary ▪ Finalizes ToR and recommends to the Central Government, which in turn communicates the finalized ToR to the project proponent, if not exempted by the Notification ▪ Reviews EIA report, proceedings and appraises their views to the Central government ▪ If the Central Government has any specific views, then the EAC reviews again for appraisal
SEIAA	▪ Receives application from the project proponent ▪ Considers SEAC's views for finalization of ToR ▪ Communicates the finalized ToR to the project proponent ▪ Receives EIA report from project proponent ▪ Uploads the summary of EIA report in the website in cases of Category B projects ▪ Forwards the responses received to the project proponent ▪ Receives updated EIA report from project proponent incorporating the considerations from the proceedings of public hearing and responses received through other media ▪ Forwards updated EIA report to SEAC for appraisal ▪ Either accepts the recommendations of SEAC or asks for reconsideration of specific issues for review by SEAC. ▪ Takes the final decision and communicates the same to the project proponent
SEAC	▪ Reviews Form 1 ▪ If necessary visits, site(s) for finalizing the ToR ▪ Reviews updated EIA - EMP report and ▪ Appraises the SEIAA
SPCB	▪ Receives request from project proponent and conducts public hearing in the manner prescribed. ▪ Conveys proceedings to concerned authority and project proponent
Public Agency	▪ Receives request from the respective Governments to conduct public hearing ▪ Conducts public hearing in the manner prescribed. ▪ Conveys proceedings to the concerned Authority/EAC /Project proponent

5.1 SEIAA

- SEIAA is constituted by the MoEF to take final decision regarding the acceptance/rejection of prior environmental clearance to the project proposal for all Category 'B' projects.
- The state government may decide whether to house them at the Department of Environment or at any other Board for effective operational support.
- State Governments can decide whether the positions are permanent or part-time. The Central Government (MoEF) continues to follow the model of paying fee (TA/DA, accommodation, sitting fee) to the Chairperson and the members of EAC. As such, the State Government is to fund SEIAA & SEAC and decide the appropriate institutional support for them.

A. Constitution

- SEIAA is constituted by the Central Government comprising of three members including a Chairperson and Member—Secretary to be nominated by the State Government or UT Administration concerned.
- The Central Government will notify as and when the nominations (in order) are received from the State Governments, within 30 days from the date of receipt.
- The Chairperson and the non-official member shall have a fixed term of three years, from the date of Notification by the Central Government constituting the Authority.

The form used by the State Governments to submit nominations for Notification by the Central Government is provided in **Annexure VIII**.

B. Composition

- Chairperson shall be an expert in the EIA process
- Member—Secretary shall be a serving officer of the concerned State Government/UT Administration familiar with the environmental laws.
- Member—Secretary may be of a level equivalent to the Director, Dept. of Environment or above – a full time member.
- All the members including the Chairperson shall be the experts as per the criteria set in the Notification.
- The Government servants can only serve as the Member—Secretary to SEIAA and the Secretary to SEAC. All other members including Chairperson of the SEIAA and SEAC shall not be comprised of serving Government Officers; industry representatives; and the activists.
- Serving faculty (academicians) is eligible for the membership in the Authority and/or the Committees, if they fulfill the criteria given in Appendix VI to the Notification.
- This is to clarify that the serving Government officers shall not be nominated as professional/expert member of SEIAA/SEAC/EAC.
- Professionals/Experts in the SEIAA and SEAC shall be different.

Summary regarding the eligibility criteria for Chairperson and Members of the SEIAA is given in Table 5-3.

C. Decision-making process

- The decision of the Authority shall be arrived through consensus.
- If there is no consensus, the Authority may either ask SEAC for reconsideration or may reject the approval.
- All decisions of the SEIAA shall be taken in a meeting, considering the majority

Table 5-3: SEIAA: Eligibility Criteria for Chairperson / Members / Secretary

S. No.	Attribute	Requirement			
			Members	**Member–Secretary**	**Chairperson**
1	Professional qualification as per the Notification		Compulsory	Compulsory	Compulsory
2	Experience (Fulfilling any one of a, b, c)	a	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI
		b	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI
		c	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	-------------
3	Test of independence (conflict of interest) and minimum grade of the Secretary of the Authority		Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism	Only serving officer from the State Government (DoE) familiar with environmental laws not below the level of Director	Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism

S. No.	Attribute	Requirement			
			Members	**Member—Secretary**	**Chairperson**
4	Age		Below 67 years at the time of Notification of the Authority	As per State Government Service Rules	Below 72 Years at the time of the Notification of the Authority
5	Other memberships in Core Committees and/or as Sectoral expert		Shall not be a member in any SEIAA/EAC/SEAC	Shall not be a member in any SEIAA/EAC/SEAC	Shall not be a member in any SEIAA/EAC/SEAC
6	Tenure of earlier appointment (continuous)		Only one term before this in continuity is permitted	Not applicable	Only one term before this in continuity is permitted
7	Eminent environmental expertise with understanding on environmental aspects and impacts		Desirable	Desirable	Compulsory
8	Expertise in the environmental clearance process		Desirable	Desirable	Compulsory

NOTE:

1. A member after continuous membership in two terms (six years) shall not be considered for further continuation. His/her nomination may be considered after a gap of one term (three years), if other criteria meet.

2. Chairperson/Member (core or sectoral expert) once notified may not be removed prior to the tenure of three years without cause and proper enquiry.

5.2 EAC and SEAC

EAC and SEAC are independent Committees to review each developmental activity and offer its recommendations for consideration of the Central Government and SEIAA respectively.

A. Constitution

- EAC and SEAC shall be constituted by the Central Government comprising a maximum of 15 members including a Chairperson and Secretary. In case of SEAC, the State Government/UT Administration is required to nominate the professionals/ experts for consideration and Notification by the Central Government.
- The Central Government will notify as and when the nominations (in order) are received from the State Governments, within 30 days from the date of receipt.
- The Chairperson and the non-official member shall have a fixed term of three years, from the date of Notification by the Central Government.

- The Chairperson shall be an eminent environmental expert with understanding on environmental aspects and environmental impacts. The Secretary of the SEAC shall be a State Government officer, not below the level of a Director/Chief Engineer.
- The members of the SEAC need not be from the same State/UT.
- In case the State Governments/UTs so desire, the MoEF can form regional EAC to serve the concerned States/Union Territories.
- State Governments may decide to their convenience to house SEAC at the Department of Environment or at SPCB or at any other department, to extend support to the SEAC activities.

B. Composition

- Secretary to EAC/SEAC shall invite a maximum of two sectoral professionals/experts with the prior approval of the Chairperson, if desired.
- The Secretary of each EAC shall be an officer of the level equivalent to or above the level of Director, the MoEF, GoI.
- The suggested model for appraisal committees is a composition of Core expert members and joined by sectoral experts. This means, core group expert members will be common to all the developmental projects in a group, whereas the sectoral experts join the core group when specific sectoral project is being appraised.
- The desired composition of state or central appraisal committee for this industry includes the following:
    - Environmental management specialist/ environmental regulator/ environmental Planner
    - Air and Noise quality expert
    - Occupational health
    - Geology/geo-hydrology
    - Ecologist
    - Transportation specialist
    - Safety and health specialist
    - Social scientist, *etc.*

C. Decision-making

The EAC and SEAC shall function on the principle of collective responsibility. The Chairperson shall endeavor to reach a consensus in each case, and if consensus cannot be reached, the view of the majority shall prevail.

D. Operational issues

- Secretary may deal with all correspondence, formulate agenda and prepare agenda notes. Chairperson and other members may act only for the meetings.
- Chairperson of EAC/SEAC shall be one among the core group having considerable professional experience with proven credentials.
- EAC/SEAC shall meet at least once every month or more frequently, if so needed, to review project proposals and to offer recommendations for the consideration of the Authority.

- EAC/SEAC members may inspect the site at various stages *i.e.,* during screening, scoping and appraisal, as per the need felt and decided by the Chairperson of the Committee.
- The respective Governments through the Secretary of the Committee may pay/reimburse the participation expenses, honorarium *etc.*, to the Chairperson and members.

i. Tenure of EAC/SEIAA/SEAC

The tenure of Authority/Committee(s) shall be for a fixed period of three years. At the end of the three years period, the Authority and the committees need to be re-constituted. However, staggered appointment dates may be adopted to maintain continuity of members at a given point of time.

ii. Qualifying criteria for nomination of a member to EAC/SEIAA/SEAC

While recommending nominations and while notifying the members of the Authority and Expert Committees, it shall be ensured that all the members meet the following three criteria:

- Professional qualification
- Relevant experience/Experience interfacing with environmental management
- Absence of conflict of interest

These are elaborated subsequently.

a) Professional qualification

The person should have at least

- 5 years of formal University training in the concerned discipline leading to a MA/MSc Degree, or
- In case of Engineering/Technology/Architecture disciplines, 4 years formal training in a professional training course together with prescribed practical training in the field leading to a B.Tech/B.E./B.Arch. Degree, or
- Other professional degree (e.g., Law) involving a total of 5 years of formal University training and prescribed practical training, or
- Prescribed apprenticeship/articleship and pass examinations conducted by the concerned professional association (e.g., MBA/IAS/IFS). In selecting the individual professionals, experience gained by them in their respective fields will be taken note of.

b) Relevant experience

- Experience shall be related to professional qualification acquired by the person and be related to one or more of the expertise mentioned for the members of the Core group or the Sectoral Experts. Such experience should be a minimum of 15 years.
- When the experience mentioned in the foregoing sub-paragraph interfaces with environmental issues, problems and their management, the requirement for the length of the experience can be reduced to a minimum of 10 years.

c) Absence of conflict of interest

For the deliberations of the EAC/SEAC to be independent and unbiased, all possibilities of potential conflict of interests have to be eliminated. Therefore, serving government officers; persons engaged in industry and their associations; persons associated with the formulation of development projects requiring environmental clearance, and persons associated with environmental activism shall not be considered for membership of SEIAA/ SEAC/ EAC.

iii. Age

Below 70 years for the members and below 72 years for the Chairperson of the SEIAA/SEAC/EAC. The applicability of the age is at the time of the Notification of the SEIAA/SEAC/EAC by the Central Government.

Summary regarding the eligibility criteria for Chairperson and Members of the EAC/SEAC are given in Table 5-4.

Table 5-4: EAC/SEAC: Eligibility Criteria for Chairperson / Members / Secretary

S. No.	Attribute		Requirement		
			Core Members/Sectoral Expert members	**Secretary**	**Chairperson**
1	Professional qualification as per the Notification		Compulsory	Compulsory	Compulsory
2	Experience (Fulfilling any one of a, b, c)	a	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI
		b	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in Appendix VI
		c	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	-------------

S. No.	Attribute	Requirement		
		Core Members/Sectoral Expert members	**Secretary**	**Chairperson**
3	Test of independence (conflict of interest) and minimum grade of the Secretary of the Committees	Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism	In case of EAC, not less than a Director from the MoEF, Government of India Incase of SEAC, not below the level of Director/Chief Engineer from the State Government (DoE)	Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism
4	Age	Below 67 years at the time of Notification of the Committee	As per state Government Service Rules	Below 72 Years at the time of the Notification of the Committee
5	Membership in Core committees	Only one other than this nomination is permitted	Shall not be a member in other SEIAA/EAC/SEAC	Shall not be a member in any other SEIAA/EAC/SEAC
6	Membership of Sectoral Experts	Only three other than this nomination is permitted	Shall not be a member in other SEIAA/EAC/SEAC	
7	Tenure of earlier appointment (continuous)	Only one term before this in continuity is permitted	Not applicable	Only one term before this in continuity is permitted
8	Eminent environmental expertise with understanding on environmental aspects and impacts	Desirable	Not applicable	Compulsory

NOTES:

1. Core members are the members in EAC/SEAC, who are common for all the types of developmental activities, whereas, sectoral expert members will join for the specific developmental sectors. Core members may be limited to about 12.

2. Sectoral expert members: Sectoral Expert members are the members who join the EAC/SEAC, when corresponding sector is being reviewed/appraised. At a given sectoral review, a maximum of three sectoral expert members may join. Therefore the total number of expert members in EAC/SEAC does not exceed 15.

3. A member after continuous membership in two terms (six years) shall not be considered for further continuation. His/her nomination may be reconsidered after a gap of one term (three years), if other criteria meet.

4. Chairperson/Member (core or sectoral expert) once notified may not be removed prior to the tenure of 3 years with out cause and proper enquiry. A member after continuous membership in two terms (6 years) shall not be considered for further continuation. The same profile may be considered for nomination after a gap of three years, i.e., one term, if other criteria are meeting.

E. Other conditions

- An expert Core Committee member of one State/UT, can have at the most another State/UT Committee membership (core or sectoral expert member), but in no case more than two Committees at a given point of time.
- Sectoral experts (not being a member in a Core Committee) can have membership in not more than four states.
- An expert member of a Committee (core or sectoral expert) shall not have membership continuously in the same committee for more than two terms, *i.e.,* six years. They can be nominated after a gap of three years, *i.e.*, one term. When a member of Committee has been associated with any development project, which comes for environmental clearance, he/she may not participate in the deliberations and the decisions in respect to that particular project.
- At least four members shall be present in each meeting to fulfill the quorum.
- If a member does not consecutively attend six meetings, without prior intimation to the Committee his/her membership may be terminated by the Notifying Authority. Prior information for absence due to academic pursuits, career development and national/state-endorsed programmes may be considered as genuine grounds for retention of membership.

Annexure I
A Compilation of Legal Instruments

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
1	Air (Prevention and Control of Pollution) Act, 1981 amended 1987	Central Pollution Control Board and State Pollution Control Boards	Air pollutants from chemical industries	The prevention, control and abatement of air pollution	Section 2: Definitions Section 21: Consent from State Boards Section 22: Not to allow emissions exceeding prescribed limits Section 24: Power of Entry and Inspection Section 25: Power to Obtain Information Section 26: Power to Take Samples Section 37-43: Penalties and Procedures
2	Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983	Central Pollution Control Board and State Pollution Control Boards	Air pollutants from chemical industries	The prevention, control and abatement of air pollution	Rule 2: Definitions Rule 9: Consent Applications
3	Water (Prevention and Control of Pollution) Act, 1974 amended 1988	Central Pollution Control Board and State Pollution Control Boards	Water Pollutants from water polluting industries	The prevention and control of water pollution and also maintaining or restoring the wholesomeness of water	Section 2: Definitions Section 20: Power to Obtain Information Section 21: Power to Take Samples Section 23: Power of Entry and Inspection Section 24: Prohibition on Disposal Section 25: Restriction on New Outlet and New Discharge Section 26: Provision regarding existing discharge of sewage or trade effluent Section 27: Refusal or withdrawal of consent by state boards Section 41-49: Penalties and Procedures

4	Water (Prevention and Control of Pollution) Rules, 1975	Central Pollution Control Board and State Pollution Control Boards	Water Pollutants from water polluting industries	The prevention and control of water pollution and also maintaining or restoring the wholesomeness of water	Rule 2: Definitions Rule 30: Power to take samples Rule 32: Consent Applications
5	The Environment (Protection) Act, 1986, amended 1991	Ministry of Environment & Forests, Central Pollution Control Board and State Pollution Control Boards	All types of environmental pollutants	Protection and Improvement of the Environment	Section 2: Definitions Section 7: Not to allow emission or discharge of environmental pollutants in excess of prescribed standards Section 8: Handing of Hazardous Substances Section 10: Power of Entry and Inspection Section 11: Power to take samples Section 15-19: Penalties and Procedures
6	Environmental (Protection) Rules, 1986 (Amendments in 1999, 2001, 2002, 2002, 2002, 2003, 2004)	Ministry of Environment & Forests, Central Pollution Control Board and State Pollution Control Boards	All types of environmental pollutants	Protection and Improvement of the Environment	Rule 2: Definitions Rule 3: Standards for emission or discharge of environmental pollutants Rule 5: Prohibition and restriction on the location of industries and the carrying on process and operations in different areas Rule 13: Prohibition and restriction on the handling of hazardous substances in different areas Rule 14: Submission of environmental statement

7	Hazardous Waste (Management and Handling) Rules, 1989 amended 2000 and 2003	MoEF, CPCB, SPCB, DGFT, Port Authority and Customs Authority	Hazardous Wastes generated from industries using hazardous chemicals	Management & Handling of hazardous wastes in line with the Basel convention	Rule 2: Application Rule 3: Definitions Rule 4: Responsibility of the occupier and operator of a facility for handling of wastes Rule 4A: Duties of the occupier and operator of a facility Rule 4B: Duties of the authority Rule 5: Grant of authorization for handling hazardous wastes Rule 6: Power to suspend or cancel authorization Rule 7: Packaging, labeling and transport of hazardous wastes Rule 8: Disposal sites Rule 9: Record and returns Rule 10: Accident reporting and follow up Rule 11: Import and export of hazardous waste for dumping and disposal Rule 12: Import and export of hazardous waste for recycling and reuse Rule 13: Import of hazardous wastes Rule 14: Export of hazardous waste Rule 15: Illegal traffic Rule 16: Liability of the occupier, transporter and operator of a facility Rule 19: Procedure for registration and renewal of registration of recyclers and re-refiners Rule 20: Responsibility of waste generator

8	Manufacture Storage and Import of Hazardous Chemicals Rules, 1989 amended 2000	Ministry of Environment & Forests, Chief Controller of Imports and Exports, CPCB, SPCB, Chief Inspector of Factories, Chief Inspector of Dock Safety, Chief Inspector of Mines, AERB, Chief Controller of Explosives, District Collector or District Emergency Authority, CEES under DRDO	Hazardous Chemicals - Toxic, Explosive, Flammable, Reactive	Regulate the manufacture, storage and import of Hazardous Chemicals	Rule 2: Definitions Rule 4: responsibility of the Occupier Rule 5: Notification of Major Accidents Rule 7-8: Approval and notification of site and updating Rule 10-11: Safety Reports and Safety Audit reports and updating Rule 13: Preparation of Onsite Emergency Plan Rule 14: Preparation of Offsite Emergency Plan Rule 15: Information to persons likely to get affected Rule 16: Proprietary Information Rule 17: Material Safety Data Sheets Rule 18: Import of Hazardous Chemicals
9	Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	CCG, SCG, DCG, LCG and MAH Units	Hazardous Chemicals - Toxic, Explosive, Flammable, Reactive	Emergency Planning Preparedness and Response to chemical accidents	Rule 2: Definitions Rule 5: Functions of CCG Rule 7: Functions of SCG Rule 9: Functions of DCG Rule 10: Functions of LCG
10	EIA Notification, 1994	MoEF, SPCB	Chemicals/pollutants expected to be generated from industrial activities	Requirement of environmental clearance before establishment of or modernization / expansion of certain type of industries/ projects.	Rule 2: Requirements and procedure for seeking environmental clearance of projects

11	Batteries (Management and Handling) Rules, 2001.	SPCB, CPCB and MoEF	Lead Acid Batteries	To control the hazardous waste generation (lead waste) from used lead acid batteries	Rule 2: Application Rule 3: Definitions Rule 4: Responsibilities of manufacturer, importer, assembler and re-conditioner Rule 5: Registration of Importers Rule 7: Responsibilities of dealer Rule 8: Responsibilities of recycler Rule 9: Procedure for registration / renewal of registration of recyclers Rule 10: Responsibilities of consumer or bulk consumer Rule 11: Responsibilities of auctioneer Rule 14: Computerization of Records and Returns
12	Public Liability Insurance Act, 1991 amended 1992	Ministry of Environment & Forests, District Collector	Hazardous Substances	To provide immediate relief to persons affected by accident involving hazardous substances	Section 2: Definitions Section 3: Liability to give relief in certain cases on principle of no fault Section 4: Duty of owner to take out insurance policy Section 7A: Establishment of Environmental Relief Fund Section 14-18: Penalties and Offences
13	Public Liability Insurance Rules, 1991 amended 1993	Ministry of Environment & Forests, District Collector	Hazardous Substances	To provide immediate relief to persons affected by accident involving hazardous substances and also for Establishing an Environmental Relief fund	Rule 2: Definitions Rule 6: Establishment of administration of fund Rule 10: Extent of liability Rule 11: Contribution of the owner to environmental relief fund

14	Factories Act, 1948	Ministry of Labour, DGFASLI and Directorate of Industrial Safety and Health/Factories Inspectorate	Chemicals as specified in the Table	Control of workplace environment, and providing for good health and safety of workers	Section 2: Interpretation Section 6: Approval, licensing and registration of factories Section 7A: General duties of the occupier Section 7B: General duties of manufacturers etc., as regards articles and substances for use in factories Section 12: Disposal of wastes and effluents Section 14: Dust and fume Section 36: Precautions against dangerous fumes, gases, etc. Section 37: Explosion or inflammable dust, gas, etc. Chapter IVA: Provisions relating to Hazardous processes Section 87: Dangerous operations Section 87A: Power to prohibit employment on account of serious hazard Section 88: Notice of certain accident Section 88A: Notice of certain dangerous occurrences Chapter X: Penalties and procedures
15	The Petroleum Act, 1934	Ministry of Petroleum and Natural Gas	Petroleum (Class A, B and C - as defined in the rules)	Regulate the import, transport, storage, production, refining and blending of petroleum	Section 2: Definitions Section 3: Import, transport and storage of petroleum Section 5: Production, refining and blending of petroleum Section 6: Receptacles of dangerous petroleum to show a warning Section 23-28 Penalties and Procedure

16	The Petroleum Rules, 2002	Ministry of Petroleum and Natural Gas, Ministry of Shipping (for notification of authorized ports for import), Ministry of Environment & Forests or SPCB (for clearance of establishment of loading/unloading facilities at ports) Chief Controller of Explosives, district authority, Commissioner of Customs, Port Conservator, State Maritime Board (Import)	Petroleum (Class A, B and C - as defined in the rules)	Regulate the import, transport, storage, production, refining and blending of petroleum	Rule 2: Definition Chapter I part II: General Provision Chapter II: Importation of Petroleum Chapter III: Transport of Petroleum Chapter VII: Licenses
17	The Explosives Act, 1884	Ministry of Commerce and Industry (Department of Explosives)	Explosive substances as defined under the Act	To regulate the manufacture, possession, use, sale, transport, export and import of explosives with a view to prevent accidents	Section 4: Definition Section 6: Power for Central government to prohibit the manufacture, possession or importation of especially dangerous explosives Section 6B: Grant of Licenses

18	The Explosive Rules, 1983	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, railway administration	Explosive substances as defined under the Act	To regulate the manufacture, possession, use, sale, transport, export and import of explosives with a view to prevent accidents	Rule 2: Definition Chapter II: General Provisions Chapter III: Import and Export Chapter IV: Transport Chapter V: Manufacture of explosives Chapter VI: Possession sale and use Chapter VII: Licenses
19	The Gas Cylinder Rules, 2004	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, DGCA, DC, DM, Police (sub inspector to commissioner)	Gases (Toxic, non toxic and non flammable, non toxic and flammable, Dissolved Acetylene Gas, Non toxic and flammable liquefiable gas other than LPG, LPG	Regulate the import, storage, handling and transportation of gas cylinders with a view to prevent accidents	Rule 2: Definition Chapter II: General Provisions Chapter III: Importation of Cylinder Chapter IV: Transport of Cylinder Chapter VII: Filling and Possession
20	The Static and Mobile Pressure Vessels (Unfired) Rules, 1981	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, DGCA, DC, DM, Police (sub inspector to commissioner)	Gases (Toxic, non toxic and non flammable, non toxic and flammable, Dissolved Acetylene Gas, Non toxic and flammable liquefiable gas other than LPG, LPG	Regulate the import, manufacture, design, installation, transportation, handling, use and testing of mobile and static pressure vessels (unfired) with a view to prevent accidents	Rule 2: Definition Chapter III: Storage Chapter IV: Transport Chapter V: Licenses

21	The Motor Vehicle Act, 1988	Ministry of Shipping, Road Transport and Highways	Hazardous and Dangerous Goods	To consolidate and amend the law relating to motor vehicles	Section 2: Definition Chapter II: Licensing of drivers of motor vehicle Chapter VII: Construction equipment and maintenance of motor vehicles
22	The Central Motor Vehicle Rules, 1989	Ministry of Shipping, Road Transport and Highways	Hazardous and Dangerous Goods	To consolidate and amend the law relating to motor vehicles including to regulate the transportation of dangerous goods with a view to prevent loss of life or damage to the environment	Rule 2: Definition Rule 9: Educational qualification for driver's of goods carriages carrying dangerous or hazardous goods Rule 129: Transportation of goods of dangerous or hazardous nature to human life Rule 129A: Spark arrestors Rule 130: Manner of display of class labels Rule 131: Responsibility of the consignor for safe transport of dangerous or hazardous goods Rule 132: Responsibility of the transporter or owner of goods carriage Rule 133: Responsibility of the driver Rule 134: Emergency Information Panel Rule 135: Driver to be instructed Rule 136: Driver to report to the police station about accident Rule 137: Class labels
23	The Mines Act 1952	Ministry of Coal and Mines	Use of toxic and inflammable gases, dust or mixtures	Safety of the mine workers	Section 2: Definitions Chapter IV: Mining operations and management of mines Chapter V: Provisions as to health and safety Chapter IX: Penalties and procedure

24	The Custom Act, 1962	CBEC, Ministry of Finance	Hazardous Goods	To prevent entry of illegal hazardous goods or banned goods including hazardous or banned chemicals	Section 2: definitions Section 11: Power to Prohibit Importation or Exportation of Goods
25	The Merchant Shipping Act, 1958 amended in 2002 and 2003	Ministry of Shipping, Road Transport and Highways	All packaged cargo including Dangerous and hazardous goods as defined in the rules	For safe handling and transportation of cargo including dangerous goods to prevent accident	Section 3: Definitions Section 331: Carriage of Dangerous Goods
26	Merchant Shipping (carriage of Cargo) Rules 1995	Ministry of Shipping, Road Transport and Highways	All packaged cargo including Dangerous and hazardous goods as defined in the rules	For safe handling and transportation of cargo including dangerous goods to prevent accident	
27	The Indian Port Act, 1908	Ministry of Shipping, Road Transport and Highways	All Chemicals - handling and storage	For control of activities on ports including safety of shipping and conservation of ports	Section 2: Definitions Chapter IV: Rules for the safety of shipping and the conservation of ports Chapter VII: Provisions with respect to penalties
28	The Dock Workers, (Safety, Health and Welfare) Act, 1986	Ministry of Labour, DGFASLI and Directorate of Dock Safety	All Chemicals termed as dangerous goods	Safety of Dock workers including handling of dangerous goods	
29	The Dock Workers, (Safety, Health and Welfare) Rules, 1990	Ministry of Labour, DGFASLI and Directorate of Dock Safety	All Chemicals termed as dangerous goods	Safety of Dock workers including handling of dangerous goods	

30	Drug and Cosmetics Act, 1940	Ministry of Health and Family Welfare	To all types of drugs and cosmetics	To regulate the import, manufacture, distribution and sale of drugs	Section 2: Definitions Chapter III: Import of Drugs and Cosmetics Chapter IV: Manufacture, Sale and Distribution of Drugs and Cosmetics

Annexure II
Form 1 (Application Form for Obtaining EIA Clearance)

FORM 1

(I) Basic Information

Name of the Project:

Location / site alternatives under consideration:

Size of the Project: *

Expected cost of the project:

Contact Information:

Screening Category:

- *Capacity corresponding to sectoral activity (such as production capacity for manufacturing, mining lease area and production capacity for mineral production, area for mineral exploration, length for linear transport infrastructure, generation capacity for power generation etc.,)*

(II) Activity

1. Construction, operation or decommissioning of the Project involving actions, which will cause physical changes in the locality (topography, land use, changes in water bodies, etc.)

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quautities /rates, wherever possible) with source of information data
1.1	Permanent or temporary change in land use, land cover or topography including increase in intensity of land use (with respect to local land use plan)		
1.2	Clearance of existing land, vegetation and buildings?		
1.3	Creation of new land uses?		
1.4	Pre-construction investigations e.g. bore houses, soil testing?		
1.5	Construction works?		

1.6	Demolition works?		
1.7	Temporary sites used for construction works or housing of construction workers?		
1.8	Above ground buildings, structures or earthworks including linear structures, cut and fill or excavations		
1.9	Underground works including mining or tunneling?		
1.10	Reclamation works?		
1.11	Dredging?		
1.12	Offshore structures?		
1.13	Production and manufacturing processes?		
1.14	Facilities for storage of goods or materials?		
1.15	Facilities for treatment or disposal of solid waste or liquid effluents?		
1.16	Facilities for long term housing of operational workers?		
1.17	New road, rail or sea traffic during construction or operation?		
1.18	New road, rail, air waterborne or other transport infrastructure including new or altered routes and stations, ports, airports etc?		
1.19	Closure or diversion of existing transport routes or infrastructure leading to changes in traffic movements?		
1.20	New or diverted transmission lines or pipelines?		
1.21	Impoundment, damming, culverting, realignment or other changes to the hydrology of watercourses or aquifers?		
1.22	Stream crossings?		
1.23	Abstraction or transfers of water form ground or surface waters?		
1.24	Changes in water bodies or the land surface affecting drainage or run-off?		

1.25	Transport of personnel or materials for construction, operation or decommissioning?		
1.26	Long-term dismantling or decommissioning or restoration works?		
1.27	Ongoing activity during decommissioning which could have an impact on the environment?		
1.28	Influx of people to an area in either temporarily or permanently?		
1.29	Introduction of alien species?		
1.30	Loss of native species or genetic diversity?		
1.31	Any other actions?		

2. **Use of Natural resources for construction or operation of the Project (such as land, water, materials or energy, especially any resources which are non-renewable or in short supply):**

S.No.	**Information/checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities /rates, wherever possible) with source of information data**
2.1	Land especially undeveloped or agricultural land (ha)		
2.2	Water (expected source & competing users) unit: KLD		
2.3	Minerals (MT)		
2.4	Construction material – stone, aggregates, and / soil (expected source – MT)		
2.5	Forests and timber (source – MT)		
2.6	Energy including electricity and fuels (source, competing users) Unit: fuel (MT), energy (MW)		
2.7	Any other natural resources (use appropriate standard units)		

3. Use, storage, transport, handling or production of substances or materials, which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health.

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
3.1	Use of substances or materials, which are hazardous (as per MSIHC rules) to human health or the environment (flora, fauna, and water supplies)		
3.2	Changes in occurrence of disease or affect disease vectors (e.g. insect or water borne diseases)		
3.3	Affect the welfare of people e.g. by changing living conditions?		
3.4	Vulnerable groups of people who could be affected by the project e.g. hospital patients, children, the elderly etc.,		
3.5	Any other causes		

4. Production of solid wastes during construction or operation or decommissioning (MT/month)

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
4.1	Spoil, overburden or mine wastes		
4.2	Municipal waste (domestic and or commercial wastes)		
4.3	Hazardous wastes (as per Hazardous Waste Management Rules)		

4.4	Other industrial process wastes		
4.5	Surplus product		
4.6	Sewage sludge or other sludge from effluent treatment		
4.7	Construction or demolition wastes		
4.8	Redundant machinery or equipment		
4.9	Contaminated soils or other materials		
4.10	Agricultural wastes		
4.11	Other solid wastes		

5. **Release of pollutants or any hazardous, toxic or noxious substances to air (Kg/hr)**

S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities/rates, wherever possible) with source of information data**
5.1	Emissions from combustion of fossil fuels from stationary or mobile sources		
5.2	Emissions from production processes		
5.3	Emissions from materials handling including storage or transport		
5.4	Emissions from construction activities including plant and equipment		
5.5	Dust or odours from handling of materials including construction materials, sewage and waste		

5.6	Emissions from incineration of waste		
5.7	Emissions from burning of waste in open air (e.g. slash materials, construction debris)		
5.8	Emissions from any other sources		

6. Generation of Noise and Vibration, and Emissions of Light and Heat:

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data with source of information data
6.1	From operation of equipment e.g. engines, ventilation plant, crushers		
6.2	From industrial or similar processes		
6.3	From construction or demolition		
6.4	From blasting or piling		
6.5	From construction or operational traffic		
6.6	From lighting or cooling systems		
6.7	From any other sources		

7. **Risks of contamination of land or water from releases of pollutants into the ground or into sewers, surface waters, groundwater, coastal waters or the sea:**

S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities/rates, wherever possible) with source of information data**
7.1	From handling, storage, use or spillage of hazardous materials		
7.2	From discharge of sewage or other effluents to water or the land (expected mode and place of discharge)		
7.3	By deposition of pollutants emitted to air into the land or into water		
7.4	From any other sources		
7.5	Is there a risk of long term build up of pollutants in the environment from these sources?		

8. **Risk of accidents during construction or operation of the Project, which could affect human health or the environment**

S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities/rates, wherever possible) with source of information data**
8.1	From explosions, spillages, fires etc from storage, handling, use or production of hazardous substances		
8.2	From any other causes		
8.3	Could the project be affected by natural disasters causing environmental damage (e.g. floods, earthquakes, laudslides, cloudburst etc)?		

9. Factors which should be considered (such as consequential development) which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality

S. No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
9.1	Lead to development of supporting. lities, ancillary development or development stimulated by the project which could have impact on the environment e.g.: • Supporting infrastructure (roads, power supply, waste or waste water treatment, etc.). • housing development • extractive industries • supply industries • other		
9.2	Lead to after-use of the site, which could havean impact on the environment		
9.3	Set a precedent for later developments		
9.4	Have cumulative effects due to proximity to other existing or planned projects with similar effects		

(III) Environmental Sensitivity

S.No.	Areas	Name/ Identity	Aerial distance (within 15 km.) Proposed project location boundary
1	Areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value		

2	Areas which are important or sensitive for ecological reasons - Wetlands, watercourses or other water bodies, coastal zone, biospheres, mountains, forests		
3	Areas used by protected, important or sensitive species of flora or fauna for breeding, nesting, foraging, resting, over wintering, migration		
4	Inland, coastal, marine or underground waters		
5	State, National boundaries		
6	Routes or facilities used by the public for access to recreation or other tourist, pilgrim areas		
7	Defence installations		
8	Densely populated or built-up area		
9	Areas occupied by sensitive man-made land uses *(hospitals, schools, places of worship, community facilities)*		
10	Areas containing important, high quality or scarce resources *(ground water resources, surface resources, forestry, agriculture, fisheries, tourism, minerals)*		
11	Areas already subjected to pollution or environmental damage. *(those where existing legal environmental standards are exceeded)*		
12	Areas susceptible to natural hazard which could cause the project to present environmental problems (*earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions*)		

(IV). Proposed Terms of Reference for EIA studies

ANNEXURE III
Pre-Feasibility Report

PRE-FEASIBILITY REPORT

Environmental Aspects

- Details of ecologically-sensitive areas like tropical forests, biosphere reserves, national park, sanctuaries, important lakes, endangered species of flora & fauna and distance from site, etc.
- Places of archaeological importance, river, streams, estuary, sea, hills/ mountains etc.
- Places of historical, cultural, religious or tourist importance, defence installation.
- Location details
  - State/District/Village,
  - Longitude & Latitude
  - Nearest town & distance, nearby industries (Sugar, cement, power etc)
  - Approach to Site
  - Rail: Nearest Rail Head & Distance
  - Road: Existing Highway/roads distance from site
  - Distance from nearest airport (existing/proposed)
  - Distance from big cities.
  - Distance from nearest waterways
  - Constraints if any to approach site particularly for construction materials, plants and equipments etc. and indicate requirement of bridges etc.
- Land Availability
  - Extent of land available for Plant, Township, etc.
  - Land use pattern (agricultural, barren, forest etc.
  - Incase of agricultural land, whether irrigated/non irrigated, number of crops
  - Land ownership (Govt. Pvt., tribal, non-tribal etc.)
  - Prevailing land cost details
  - Estimation of population affected, Homestead Oustees, Land Ownership Details

Project Details

General

- Topography of the area
- Ground profile and levels Permanent features
- Soil Condition Soil investigation results
- Site Data: Whether the site is flood prone & HFL of the site
- Existence of sugar units and present & future development activity/proposal for distilleries
- Drainage patterns
- Water Information to be furnished by owner
- Source of Circulating/Consumptive water
- Location in relation to River/Canal/Dam, water availability and quality
- Lean season water availability and allocation source in case main source not perennial.

- Approved water allocation quota (Drinking, Irrigation and Industrial use) and surplus availability
- Water requirement for process, utilities ,domestic, gardening etc
- Quality of raw water, treated water
- Water budget calculations and effluent generation
- Inter-State Issue, if any
- Requirement of construction of Dam/barrage storage etc. if any and its location.
- Feasible ways of bringing water to site indicating constraints if any.
- Type of cooling system
- New facilities needed
- Source of construction water and potable water
- Source of construction power & operational power
- Source of availability of construction material like sand, brick, stone chips, borrow earth etc.
- Proximity to infrastructure facilities (Hospital, Schools, Residential accommodation)available nearby
- Location & vicinity plan identifying the areas proposed for distillery plant, colony and wastewater disposal.

Techno-economic Feasibility Aspects

- Land availability & its development
- General Layout
- Rehabilitation & Resettlement issue
- Access to site for Transportation of equipments/construction machinery, material etc
- Water availability for cooling & consumptive use
- Raw materials, fuels like Biomass (rice husk/wood chips), spent wash concentrate availability and its transportation
- Environmental and forest aspects
- Power evacuation from captive co-gen power plant (in case of manufacture of ethanol, power and allied products)
- Ultimate plant capacity, which could be set up

Technical Profile of the Project

- Technical parameters of the plant & equipment.
- Meteorological data like temperature, humidity, rainfall, wind pressure & wind direction.
- Seismological studies of project specific design seismic parameters.
- Project implementation:-Schedule showing various activities.

Justification of the Project

- Current Demand Scenario of the product
- Alternatives to meet the demand and
- Post Project scenario on Residual Demand

Distillery Project(s) Capacity

- Sustainability of raw material and Fuel Supply and quality

- Manufacturing process details (raw material consumption, output)
- Optimization of distillery Plant Capacity

Site Selection

- Options considered for sites
- Basis of site selection and analysis
- Infrastructure availability at selected site
- Distillery products demand around the selected site
- Scope of Geo-technical studies

Future Prospects

- Ascertain the costs and benefits of the proposed project for project life
- Technical and logistic constraints/ requirements of project sustainability

Project Design/Technology

- Analysis of all available technologies such as duel biofermenting process, etc.
- Analysis of various possible configurations for each technology or a combination of these technologies from available manufactures
- Document broad specifications for the proposed Distillery plant(s) including but not limited to:
  - Plant Outputs along with Heat Flow Diagrams for each alternative
  - Electrical equipment, I&C equipment, DCS equipment with redundancy
  - Balance of Plant equipment
  - General Plant Layout

Details of Socio-economic Consequences

- Corporate Responsibilities & Status of Compliance
- Employments and infrastructure added in the district of locations
- Status of land availability , current and post project land use variation

Project Schedule

- Outline project implementation and procurement arrangement including contract packaging and a project implementation schedule.

The above listing is not exhaustive. Thus the proponent may provide additional necessary information, felt appropriate, to include in the pre-feasibility study report in support of selecting the site for the proposed developmental activities. The Concerned EAC/SEAC during scrutiny, may specifically ask for any additional information/ data required to substantiate the requirement to prescribe the ToR for EIA studies. However, it is to make clear that all the required further information by EAC/SEAC shall be mentioned in one single letter, within the prescribed time.

ANNEXURE IV
Types of Monitoring and Network Design Considerations

TYPES OF MONITORING AND NETWORK DESIGN CONSIDERATIONS

A. Types of Monitoring

Monitoring refers to the collection of data using a series of repetitive measurements of environmental parameters (or, more generally, to a process of systematic observation). The environmental quality monitoring programme design will be dependent upon the monitoring objectives specified for the selected area of interest. The main types of EIA monitoring activities are:

- Baseline monitoring is the measurement of environmental parameters during the pre-project period for the purpose of determining the range of variation of the system and establishing reference points against which changes can be measured. This leads to the assessment of the possible (additional available) assimilative capacity of the environmental components in pre-project period w.r.t. the standard or target level.
- Effects monitoring is the measurement of environmental parameters during project construction and implementation to detect changes which are attributable to the project to provide the necessary information to:
  - verify the accuracy of EIA predictions; and
  - determine the effectiveness of measures to mitigate adverse effects of projects on the environment.
  - Feedback from environmental effect monitoring programs may be used to improve the predictive capability of EIAs and also determine whether more or less stringent mitigation measures are needed
- Compliance monitoring is the periodic sampling or continuous measurement of environmental parameters to ensure that regulatory requirements and standards are being met.

Compliance and effects monitoring occurs during the project construction, operation, and abandonment stages. The resources and institutional set-up should be available for the monitoring at these stages. All large-scale construction projects will require some construction stage monitoring. To control the environmental hazards of construction as specified in the EIA, a monitoring program should be established to ensure that each mitigation measure is effectively implemented. There are numerous potential areas for monitoring during operations.

The scope of monitoring topics discussed in this chapter is limited to Baseline and Effects monitoring. In addition, this chapter will also discuss the Compliance monitoring during the construction phase. Post-project monitoring requirements are discussed in the EMP.

Before any field monitoring tasks are undertaken there are many institutional, scientific, and fiscal issues that must be addressed in the implementation of an environmental monitoring program. Careful consideration of these issues in the design and planning stages will help avoid many of the pitfalls associated with environmental monitoring programs. Although these issues are important but the discussions here are confined to the monitoring network design component.

B. Network Design

Analysis of Significant Environmental Issues

At the outset of planning for an environmental monitoring network, the EIA manager may not know exactly what should be monitored, when monitoring should begin, where it should monitor, which techniques should be employed, and who should take responsibility for its conduct. Because there are usually a number of objective decisions associated with network design to be made, it is important to start with an analysis of environmental issues. The scoping phase of an EIA is designed to identify and focus on the major issues. Scoping should provide a valuable source of information on the concerns that need to be addressed by the monitoring network design. These are project specific as well as specific to the environmental setting of the location where the project is proposed to be located

Hence, the network designs are associated with questions like:

- What are the expected outputs of the monitoring activity?
- Which problems do we need to address to? *etc.*

Defining the output will influence the design of the network and optimize the resources used for monitoring. It will also ensure that the network is specially designed to optimize the information on the problems at hand

What to Monitor?

The question of what to monitor is associated with the identification of VECs.

VECs are generally defined as environmental attributes or components of the environment that are valued by society as identified during the scoping stage of the project. They are determined on the basis of perceived public concerns. For example, changes to water quality and quantity could have implications on fish by affecting habitat, food supply, oxygen, and contaminant uptake. Similarly, employment and business, and economies are both VECs that serve as pathways.

The choice of VECs is also related to the perceived significant impact of the project implementation on important environmental components. In general, the significance or importance of environmental components is judged based on:

- legal protection provided (for example, rare and endangered species)
- political or public concerns (for example, resource use conflicts and sustainable development)
- scientific judgment (for example, ecological importance); or
- commercial or economic importance

However, in addition to their economic, social, political or ecological significance, the chosen VEC should also have unambiguous operational ease, be accessible to prediction and measurement; and be susceptible to hazard. Once the VECs are defined, the VECs may be directly measured (for example, extent of habitat for an endangered species). In cases where it is impossible or impractical to directly measure the VECs, the chosen measurement endpoints or environmental indicators must correspond to, or be predictive of assessment endpoints.

The chosen environmental indicators must be: 1) measurable; 2) appropriate to the scale of disturbance/ contamination; 3) appropriate to the impact mechanism; 4) appropriate and proportional to temporal dynamics; 5) diagnostic; and 6) standardized; as well as have: 1) a low natural variability; 2) a broad applicability; and 3) an existing data series.

Where, How and How Many Times to Monitor?

These are the other components of Monitoring Network Design. These questions are best answered based on local field conditions, capacity and resources available, prevailing legal and regulatory priorities, *etc.* For this screening or reconnaissance Surveys of the study area also necessary. This may also include some simple inexpensive measurements and assimilative/dispersion modeling. The data will give some information on the prevailing special and temporal variations, and the general background air pollution in the area. The number of monitoring stations and the indicators to be measured at each station in the final permanent network may then be decided upon based on the results of the screening study as well as on the knowledge of the sources of the proposed development and prevailing local environmental/meteorological conditions. The best possible definition of the air pollution problem, together with the analysis of the resources: personnel, budget and equipment available, represent the basis for the decision on the following questions:

- What spatial density (number) of sampling stations is required? How many samples are needed and during what period (sampling (averaging) time and frequency)?
- Where should the stations be located?
- What kind of equipment should be used?
- What additional background information is needed?
  - meteorology
  - topography
  - population density
  - emission sources and emission rates
  - effects and impacts
- How will the data be made available/communicated?

C. Site Selection

This normally means that for designing a monitoring programme in an (study) area which might have an impact, several monitoring stations are needed for characterizing the baseline conditions of the impacted area. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without the undue influence from the immediate surroundings. In any measurement point in the study area the total ambient concentration is the representative of:

- natural background concentration
- regional background
- impact of existing large regional sources such as Industrial emissions

To obtain the information about the importance of these different contributions it is therefore necessary to locate monitoring stations so that they are representative for different impacts. In addition to the ambient pollution data, one would often need other data governing the variations such as meteorological data for air pollution, to identify and quantify the sources contributing to the measurements.. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without undue influence from the immediate surroundings.

ANNEXURE V
Guidance for Assessment of Baseline Components and Attributes

GUIDANCE FOR ASSESSMENT OF BASELINE COMPONENTS AND ATTRIBUTES*

Attributes	Sampling		Method of Measurement	Remarks
	Network	Frequency		
A. Land Environment				
▪ Soil ▪ Particle size distribution ▪ Texture ▪ pH ▪ Electrical conductivity ▪ Cation exchange capacity ▪ Alkali metals ▪ Sodium Absorption Ratio (SAR) ▪ Permeability ▪ Porosity	One surface sample from each landfill and/or hazardous waste site (if applicable) and prime villages, (soil samples be collected as per BIS specifications) in the study area	Season-wise	Collected and analyzed as per soil analysis reference book, M.I.Jackson and soil analysis reference book by C.A. Black	The purpose of impact assessment on soil (land environment) is to assess the significant impacts due to leaching of wastes or accidental releases and contaminating
B. Land Use/Landscape				
▪ Location code ▪ Total project area ▪ Topography ▪ Drainage (natural) ▪ Cultivated, forest plantations, water bodies, roads and settlements	At least 20 points along with plant boundary and general major land use categories in the study area.	Drainage once in the study period and land use categories from secondary data (local maps) and satellite imageries	▪ Global positioning system ▪ Topo-sheets ▪ Satellite Imageries ▪ (1:25,000) ▪ Satellite Imageries ▪ (1:25,000)	Drainage within the plant area and surrounding is very important for storm water impacts. From land use maps sensitive receptors (forests, parks, mangroves *etc.*) can be identified
C. Solid Waste				
Quantity: ▪ Based on waste generated	For green field unites it is based on	Process wise or activity wise for	Guidelines	

Attributes	Sampling		Method of Measurement	Remarks
	Network	Frequency		
from per unit production ▪ Per capita contribution ▪ Collection, transport and disposal system ▪ Process Waste ▪ Quality (oily, chemical, biological)	secondary data base of earlier plants.	respective raw material used. Domestic waste depends upon the season also	IS 9569 : 1980 IS 10447 : 1983 IS 12625 : 1989 IS 12647 : 1989 IS 12662 (PTI) 1989	
▪ General segregation into biological/organic/inert/hazardous ▪ Loss on heating ▪ pH ▪ Electrical Conductivity ▪ Calorific value, metals *etc.*	Grab and Composite samples	Process wise or activity wise for respective raw material used. Domestic waste depends upon the season also	Analysis IS 9334 : 1979 IS 9235 : 1979 IS 10158 : 1982	
Quality: ▪ Permeability And porosity ▪ Moisture pH ▪ Electrical conductivity ▪ Loss on ignition ▪ Phosphorous ▪ Total nitrogen ▪ Cation exchange capacity ▪ Particle size distribution ▪ Heavy metal ▪ Ansonia ▪ Flouride	Grab and Composite samples. Recyclable components have to analyzed for the recycling requirements	Process wise or activity wise for respective raw material used.	Analysis IS 9334 : 1979 IS 9235 : 1979 IS 10158 : 1982	Impacts of hazardous waste should be performed critically depending on the waste characteristics and place of discharge. For land disposal the guidelines should be followed and impacts of accidental releases should be assessed
D. Biological Environment (aquatic)				
▪ Primary productivity	Considering probable	Season changes are	Standards techniques	Seasonal sampling for

Attributes	Sampling		Method of Measurement	Remarks
	Network	Frequency		
▪ Aquatic weeds ▪ Enumeration of ▪ phytoplankton, zooplankton and benthos ▪ Fisheries ▪ Diversity indices ▪ Trophic levels ▪ Rare and endangered species ▪ Sanctuaries / closed areas / Coastal regulation zone (CRZ) ▪ Terrestrial ▪ Vegetation – species, list, economic importance, forest produce, medicinal value ▪ Importance value index (IVI) of trees ▪ Wild animals	impact, sampling points and number of samples to be decided on established guidelines on ecological studies based on site eco-environment setting within 10/25 km radius from the proposed site Samples to collect from upstream and downstream of discharge point, nearby tributaries at down stream, and also from dug wells close to activity site	very important	(APHA et. Al. 1995, Rau and Wooten 1980) to be followed for sampling and measurement	aquatic biota One season for terrestrial biota, in addition to vegetation studies during monsoon season Preliminary assessment Microscopic analysis of plankton and meiobenthos, studies of macrofauna, aquatic vegetation and application of indices, viz. Shannon, similarity, dominance IVI *etc* Point quarter plot-less method (random sampling) for terrestrial vegetation survey.
▪ Avifauna ▪ Rare and endangered species ▪ Sanctuaries / National park / Biosphere reserve	For forest studies, chronic as well as short-term impacts should be analyzed warranting data on micro climate conditions			Secondary data to collect from Government offices, NGOs, published literature Plankton net Sediment dredge Depth sampler Microscope

Attributes	Sampling		Method of Measurement	Remarks
	Network	Frequency		
				Field binocular
E. Socio-economic				
▪ Demographic structure ▪ Infrastructure resource base ▪ Economic resource base ▪ Health status: Morbidity pattern ▪ Cultural and aesthetic attributes	Socio-economic survey is based on proportionate, stratified and random sampling method	Different impacts occurs during construction and operational phases of the project	Primary data collection through R&R surveys (if require) or community survey are based on personal interviews and questionnaire	Secondary data from census records, statistical hard books, toposheets, health records and relevant official records available with Govt. agencies

* Project Specific

ANNEXURE VI
Sources of Secondary Data Collection

Annexure VIA: Potential Sources of Data For EIA

	Information	Source
	Air Environment	
1.	Meteorology- Temperature, Rainfall, Humidity, Inversion, Seasonal Wind rose pattern (16 point compass scale), cloud cover, wind speed, wind direction, stability, mixing depth	Indian Meteorology Department, Pune
2.	Ambient Air Quality- 24 hourly concentration of SPM, RPM, SO_2, NO_x, CO	Central Pollution Control Board (CPCB), State Pollution Control Board (SPCB), Municipal Corporations Ministry of Environment and Forests (MoEF) State Department of Environment (DoEN)
	Water Environment	
3.	Surface water- water sources, water flow (lean season), water quality, water usage, Downstream water users Command area development plan Catchment treatment plan	Central Water Commission (CWC), Central Pollution Control Board (CPCB), State Pollution Control Board (SPCB), Central Water and Power Research Institute (CWPRS), Pune State Irrigation Department Hydel Power generation organizations such as NHPC, State SEBs
4.	Ground Water- groundwater recharge rate/withdrawal rate, ground water potential groundwater levels (pre monsoon, post monsoon), ground water quality, changes observed in quality and quantity of ground water in last 15 years	Central Ground Water Board (CGWB) Central Ground Water Authority (CGWA) State Ground Water Board (SGWB) National Water Development Authority (NWDA)
5.	Coastal waters- water quality, tide and current data, bathymetry	Department of Ocean Development, New Delhi State Maritime Boards Naval Hydrographer's Office, Dehradun Port Authorities National Institute of Oceanography (NIO), Goa
	Biological Environment	
6.	Description of Biological Environment- inventory of flora and fauna in 7 km radius, endemic species, endangered species, Aquatic Fauna, Forest land, forest type and density of vegetation, biosphere, national parks, wild life sanctuaries, tiger reserve, elephant reserve, turtle nesting ground, core zone of biosphere reserve, habitat of migratory birds, routes of migratory birds	District Gazetteers National Remote Sensing Agency (NRSA), Hyderabad Forest Survey of India, Dehradun Wildlife Institute of India World Wildlife Fund Zoological Survey of India Botanical Survey of India Bombay Natural History Society, (BNHS), Mumbai State Forest Departments State Fisheries Department Ministry of Environment and Forests State Agriculture Departments State Agriculture Universities
	Land Environment	
7.	Geographical Information-Latitude, Longitude, Elevation (above MSL)	Toposheets of Survey of India, Pune National Remote Sensing Agency (NRSA), Hyderabad Space Application Centre (SAC), Ahmedabad

	Information	Source
8.	Nature of Terrain, topography map indicating contours (1:2500 scale)	⑨ Survey of India Toposheets ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ State Remote Sensing Centre, ⑨ Space Application Centre (SAC), Ahmedabad
9.	Hydrogeology- Hydrogeological report (in case of ground water is used/area is drought prone/wastewater is likely to discharged on land) Geomorphological analysis (topography and drainage pattern) Geological analysis (Geological Formations/Disturbances- geological and structural maps, geomorphological contour maps, structural features, including lineaments, fractures, faults and joints) Hydrogeological analysis (disposition of permeable formations, surface-ground water links, hydraulic parameter determination etc) Analysis of the natural soil and water to assess pollutant absorption capacity	⑨ NRSA, Hyderbad ⑨ Survey of India Toposheets ⑨ Geological Survey of India ⑨ State Geology Departments ⑨ State Irrigation Department ⑨ Department of Wasteland Development, Ministry of Rural Areas ⑨ National Water Development Authority (NWDA)
10.	Nature of Soil, permeability, erodibility classification of the land	⑨ Agriculture Universities ⑨ State Agriculture Department ⑨ Indian Council for Agriculture Research ⑨ State Soil Conservation Departments ⑨ National Bureau of Soil Survey and Landuse Planning ⑨ Central Arid Zone Research Institute (CAZRI), Jodhpur
11.	Landuse in the project area and 10 km radius of the periphery of the project	⑨ Survey of India- Toposheets ⑨ All India Soil and Landuse Survey; Delhi ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ Town and County Planning Organisation ⑨ State Urban Planning Department ⑨ Regional Planning Authorities (existing and proposed plans) ⑨ Village Revenue Map- District Collectorate ⑨ Directorate of Economics and Statistics-State Government ⑨ Space Application Centre, Ahmedabad
12.	Coastal Regulation Zones- CRZMP, CRZ classification, Demarcation of HTL and LTL*	⑨ Urban Development Department ⑨ State Department of Environment ⑨ State Pollution Control Board ⑨ Space Application Centre* ⑨ Centre for Earth Sciences Studies, Thiruvanthapuram* ⑨ Institute of Remote Sensing, Anna University Chennai* ⑨ Naval Hydrographer's Office, Dehradun* ⑨ National Institute of Oceanography, Goa* ⑨ National Institute of Ocean Technology, Chennai ⑨ Centre for Earth Science Studies

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* *Agencies authorized for approval of demarcation of HTL and LTL*

	Information	Source
	Social	
13.	Socioeconomic - population, number of houses and present occupation pattern within 7 km from the periphery of the project	⑨ Census Department ⑨ District Gazetteers- State Government ⑨ District Statistics- District Collectorate ⑨ International Institute of Population Sciences, Mumbai (limited data) ⑨ Central Statistical Organisation
14.	Monuments and heritage sites	District Gazetteer Archeological Survey of India, INTACH District Collectorate Central and State Tourism Department State Tribal and Social Welfare Department
	Natural Disasters	
15.	Seismic data (Mining Projects)- zone no, no of earthquakes and scale, impacts on life, property existing mines	⑨ Indian Meteorology Department, Pune ⑨ Geological Survey of India
16.	Landslide prone zone, geomorphological conditions, degree of susceptibility to mass movement, major landslide history (frequency of occurrence/decade), area affected, population affected	⑨ Space Application Centre
17.	Flood/cyclone/droughts- frequency of occurrence per decade, area affected, population affected	⑨ Natural Disaster Management Division in Department of Agriculture and Cooperation ⑨ Indian Meteorological Department
	Industrial	
18.	Industrial Estates/Clusters, Growth Centres	⑨ State Industrial Corporation ⑨ Industrial Associations ⑨ State Pollution Control Boards ⑨ Confederation Indian Industries (CII) ⑨ FICCI
19.	Physical and Chemical properties of raw material and chemicals (Industrial projects); fuel quality	⑨ Material and Safety Data Sheets ⑨ ENVIS database of Industrial Toxicological Research Centre, Lucknow ⑨ Indian Institute Petroleum
20.	Occupational Health and Industrial Hygiene- major occupational health and safety hazards, health and safety requirements, accident histories	⑨ Central Labour Institute, Mumbai ⑨ Directorate of Industrial Safety ⑨ ENVIS Database of Industrial Toxicological Research Centre, Lucknow ⑨ National Institute of Occupational Health, Ahmedabad
21.	Pollutant release inventories (Existing pollution sources in area within 10 km radius)	⑨ Project proponents which have received EC and have commenced operations
22.	Water requirement (process, cooling water, DM water, Dust suppression, drinking, green belt, fire service)	⑨ EIA Reports ⑨ National and International Benchmarks

Annexure VIB: Summary of Available Data with Potential Data Sources for EIA

	Agency	Information Available
1.	Archaeological Survey of India Department of Culture Government of India Janpath, New Delhi - 110011 Asi@del3.vsnl.net.in	⑨ Inventory of monuments and sites of national importance- Listing and documentation of monuments according to world heritage, pre historic, proto historic and secular, religious places and forts
2.	Botanical Survey Of India P-8, Brabourne Road Calcutta 700001 Tel#033 2424922 Fax#033 2429330 Email: envis@cal2.vsnl.net.in. . RO - Coimbatore, Pune, Jodhpur, Dehradun, Allahabad, Gantok, Itanagar, Port Blair	⑨ Photodiversity documentation of flora at National, State and District level and flora of protected areas, hotspots, fragile ecosystems, sacred groves etc ⑨ Identification of threatened species including endemics, their mapping, population studies ⑨ Database related to medicinal plants, rare and threatened plant species ⑨ Red data hook of Indian plants (Vol 1,2, and 3) ⑨ Manual for roadside and avenue plantation in India
3.	Bureau of Indian Standards Manak Bhawan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002 Tel#3230131, 3233375, 3239402 (10 lines) Fax : 91 11 3234062, 3239399, 3239382 Email- bis@vsnal.com	⑨ Bureau of Indian Standards Committees on Earthquake Engineering and Wind Engineering have a Seismic Zoning Map and the Wind Velocity Map including cyclonic winds for the country
4.	Central Water Commission (CWC) Sewa Bhawan, R.K.Puram New Delhi - 110066 cmanoff@niccwc.delhi.nic.in RO- Bangalore, Bhopal, Bhubaneshwar, Chandigarh, Coimbatore/Chennai, Delhi, Hyderabad, Lucknow, Nagpur, Patna, Shillong, Siliguri and Vadodara	⑨ Central Data Bank -Collection, collation and Publishing of Hydrological, Hydrometeorological, Sediment and Water Quality data-. ⑨ Basin wise Master Plans ⑨ Flood atlas for India ⑨ Flood Management and Development and Operation of Flood Forecasting System- CWC operate a network of forecasting stations Over 6000 forecasts are issued every year with about 95% of the forecasts within the permissible limit. ⑨ Water Year Books, Sediment Year Books and Water Quality Year Books. ⑨ Also actively involved in monitoring of 84 identified projects through National, State and Project level Environmental Committees for ensuring implementation of environmental safeguards
5.	Central Ground Water Board (HO) N.H.IV, New CGO Complex, Faridabad - 121001 RO - Guwahati, Chandigarh, Ahemadabad, Trivandrum, Calcutta, Bhopal, Lucknow, Banglore, Nagpur, Jammu, Bhubneshwar, Raipur, Jaipur, Chennai, Hyderabad, Patna	⑨ surveys, exploration, monitoring of ground water development

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[16] *Based on web search and literature review*

6.	Central Pollution Control Board Parivesh Bhawan, CBD-cum-Office Complex East Arjun Nagar, DELHI - 110 032 INDIA E-mail : cpcb@alpha.nic.in	⑨ National Air Quality Monitoring Programme ⑨ National River Water Quality Monitoring Programme- Global Environment Monitoring , MINARS ⑨ Zoning Atlas Programme ⑨ Information on 17 polluting category industries (inventory, category wise distribution, compliance, implementation of pollution control programmes
7.	Central Arid Zone Research Institute, Jodhpur Email : cazri@x400.nicgw.nic.in Regional Centre at Bhuj in Gujarat	⑨ AGRIS database on all aspects of agriculture from 1975 to date ⑨ Also have cell on Agriculture Research Information System; ⑨ Working on ENVIS project on desertification ⑨ Repository of information on the state of natural resources and desertification processes and their control ⑨ The spectrum of activities involves researches on basic resource inventories; monitoring of desertification, rehabilitation and management of degraded lands and other areas
8.	Central Inland Capture Fisheries Research Institute, Barrackpore-743101, Tel#033-5600177 Fax#033-5600388 Email : cicfri@x400.nicgw.nic.in	⑨ Data Base on Ecology and fisheries of major river systems of India. Biological features of commercially important riverine and estuarine fish species. Production functions and their interactions in floodplain wetlands. ⑨ Activities - Environmental Impact Assessment for Resource Management ; Fisheries Resource surveys
9.	Central Institute of Brackish Water Aquaculture 141, Marshalls Road, Egmore , Chennai - 600 008, Tel# 044-8554866, 8554891, Director (Per) 8554851 Fax#8554851,	⑨ Repository of information on brackish water fishery resources with systematic database of coastal fishery resources for ARIS ⑨ Agricultural Research Information System (ARIS) database covers State wise data on soil and water quality parameters, land use pattern, production and productivity trends, ⑨ Social, economic and environmental impacts of aquaculture farming, ⑨ Guidelines and effluent standards for aquaculture farming
10.	Central Marine Fisheries Research Institute (CMFRI), Cochin	⑨ Assessing and monitoring of exploited and un-exploited fish stocks in Indian EEZ ⑨ Monitoring the health of the coastal ecosystems, particularly the endangered ecosystems in relation to artisanal fishing, mechanised fishing and marine pollution ⑨ The institute has been collecting data on the catch and effort and biological characteristics for nearly half a century based on scientifically developed sampling scheme, covering all the maritime States of the country ⑨ The voluminous data available with the institute is managed by the National Marine Living Resources Data Centre (NMLRDC)
11.	Central Water and Power Research Station, Pune Tel#020-4391801-14; 4392511; 4392825 Fax #020-4392004,4390189	⑨ Numerical and Physical models for hydro-dynamic simulations
12.	Central Institute of Road Transport, Bhosari, Pune 411 026, India. Tel : +91 (20) 7125177, 7125292, 7125493, 7125494	⑨ Repository of data on all aspects of performance of STUs and a host of other related road transport parameters

13.	Department of Ocean Development	⑨ Assessment of environment parameters and marine living resources (primary and secondary) in Indian EEZ (Nodal Agency NIO Kochi) ⑨ Stock assessment, biology and resource mapping of deep sea shrimps, lobsters and fishes in Indian EEZ (Nodal agency-Fisheries Survey of India) ⑨ Investigations of toxical algal blooms and benthic productivity in Indian EEZ (Nodal agency- Cochin University of Science and technology) ⑨ Coastal Ocean Monitoring and Prediction System (COMAP) - monitoring and modelling of marine pollution along entire Indian coast and islands. Parameters monitored are temp, salinity, DO, pH, SS, BOD, inorganic phosphate, nitrate, nitrite, ammonia, total phosphorus, total nitrite, total organic carbon, petroleum hydrocarbons, pathogenic vibros, pathogenic E.coli, shigella, salmonella, heavy metals (Cd, Hg, Pb) and pesticide residues (DDT, BHC, Endosulfan). Monitoring is carried out along the ecologically sensitive zones and urban areas (NIO Mumbai- Apex coordinating agency). ⑨ Sea Level Measurement Programe (SELMAM)- sea level measurement at selected stations (Porbandar, Bombay, Goa, Cochin, Tuticorin, Madras, Machilipatnam, Visakhapatnam, Paradeep, Calcutta and Kavaratti (Lakshadweep Island)) along Indian coast and islands using modern tide gauges ⑨ Detailed coastal maps through Survey of India showing contour at 1/2 a metre interval in the scale of 1:25000. (Nellore- Machhalipatnam work already over) ⑨ Marine Data Centre (MDC) IMD for Ocean surface meteorology, GSI for marine geology, SOI for tide levels, Naval Hydrographic Office for bathymetry, NIO Goa for physical chemical and biological oceanography, NIO Mumbai for marine pollution, CMFRI for coastal fisheries, Institute of Ocean Management Madras for coastal geomorphology ⑨ DOD has setup Indian National Centre for Ocean Information Services (INCOIS) at Hyderabad for generation and dissemination of ocean data products (near real time data products such as sea surface temperature, potential fishing zones, upwelling zones, maps, eddies, chlorophyll, suspended sediment load etc). MDC will be integrated with INCOIS ⑨ Integrated Coastal and Marine Area Management (ICMAM) programme - GIS based information system for management of 11 critical habitats namely Pichavaram, Karwar, Gulf of Mannar, Gulf of Khambat, Gulf of Kutch, Malvan, Cochin, Coringa mangroves, Gahirmata, Sunderbans and Kadamat (Lakshadeep) ⑨ Wetland maps for Tamil Nadu and Kerala showing the locations of lagoons, backwaters, estuaries, mudflats etc (1:50000 scale) ⑨ Coral Reef Maps for Gulf of Kachch, Gulf of Mannar, Andaman and Nicobar and Lakshadeep Islands (1:50,000 scale) indicating the condition of corals, density etc
14.	Environment Protection Training and Research Institute Gachibowli, Hyderabad - 500 019, India Phone: +91-40-3001241, 3001242, 3000489 Fax: +91-40- 3000361 E-mail: info@eptri.com	⑨ Environment Information Centre- has appointed EPTRI as the Distributed Information Centre for the Eastern Ghats region of India. EIC Collaborates with the Stockholm Environment Institute Sweden Database on Economics of Industrial Pollution Prevention in India Database of Large and Medium Scale Industries of Andhra Pradesh Environmental Status of the Hyderabad Urban Agglomeration Study on 'water pollution-health linkages' for a few Districts of A.P

		⑨ Environment Quality Mapping Macro level studies for six districts in the State of Andhra Pradesh Micro level studies for two study zones presenting the permissible pollutant load and scoping for new industrial categories Zonation of the IDA, Parwada which helped APIIC to promote the land for industrial development Disaster management plan for Visakhapatnam Industrial Bowl Area
15.	Forest Survey of India (FSI) Kaulagarh Road, P.O., IPE Dehradun - 248 195 Tel# 0135-756139, 755037, 754507 Fax # 91-135-759104 E-Mail : fsidir@nde.vsnl.net.in fsihq@nde.vsnl.net.in RO- Banglore, Calcutta, Nagpur and Shimla	⑨ State of Forest Report (Biannual) ⑨ National Forest Vegetation Map (Biannual exercise) (on 1: 1 million scale) ⑨ Thematic mapping on 1:50,000 scale depicting the forest type, species composition, crown density of forest cover and other landuse National ⑨ Basic Forest Inventory System ⑨ Inventory survey of non forest area ⑨ Forest inventory report providing details of area estimates, topographic description, health of forest, ownership pattern, estimation of volume and other growth parameters such as height and diameter in different types of forest, estimation of growth, regeneration and mortality of important species, volume equation and wood consumption of the area studied
16.	Geological Survey of India 27 Jawaharlal Nehru Road, Calcutta 700 016, India Telephone +91-33-2496941 FAX 91-33-2496956 gsi_chq@vsnl.com	⑨ Environmental hazards zonation mapping in mineral sector ⑨ Codification of base line information of geo-environmental appreciation of any terrain and related EIA and EMP studies ⑨ Lineament and geomorphological map of India on 1:20,000 scale. ⑨ Photo-interpreted geological and structural maps of terrains with limited field checks.
17.	Indian Council of Agriculture Research, Krishi Bhawan, New Delhi, Tel#011-338206 – ICAR complex, Goa- Agro metrology – Central Arid Zone Research Institute- Agro forestry – Central Soil salinity Research Institute, – Indian Institute of Soil Science – Central Soil and Water Conservation Research and Training Institute – National Bureau of Soil Survey and Landuse Planning	⑨ A total of 80,000 profiles at 10 kms grid across the country were analyzed to characterize the soils of India. ⑨ Detailed soil maps of the Country (1:7 million), State (1:250,000) and districts map (1:50,000) depicting extent of degradation (1:4.4 millions) have been prepared. ⑨ Thematic maps depicting soil depth, texture drainage, calcareousness, salinity, pH, slope and erosion have been published ⑨ Agro-climate characterization of the country based on moisture, thermal and sunshine regimes ⑨ Agro-ecological zones (20) and sub-zones (60) for the country were delineated based on physiography, soils, climate, Length of Growing Period and Available Water Content, and mapped on 1:4.4 million scale. ⑨ Digitization of physiography and soil resource base on 1:50,000 scale for 14 States have been completed. ⑨ .Soil fertility maps of N,P,K,S and Zn have also been developed ⑨ Water quality guidelines for irrigation and naturally occurring saline/sodic water ⑨ Calibration and verification of ground water models for predicting water logging and salinity hazards in irrigation commands
18.	Indian Bureau of Mines Indira Bhawan, Civil Lines Nagpur Ph no - 0712-533 631, Fax- 0712-533 041	⑨ National mineral inventory for 61 minerals and mineral maps ⑨ Studies on environmental protection and pollution control in regard to the mining and mineral beneficiation operations ⑨ Collection, processing and storage of data on mines, minerals and mineral-based industries, collection and maintenance of world mineral intelligence, foreign mineral legislation and other related matters

19.	Indian Meteorology Department Shivaji nagar, Pune 41100 RO- Mumbai, Chennai, Calcutta, New Delhi, Nagpur, Guwahati	⑨ Meteorological data ⑨ Background air quality monitoring network under Global Atmospheric Watch Programme (operates 10 stations) ⑨ Seismicity map, seismic zoning map; seismic occurrences and cyclone bazard monitoring; list of major earthquakes ⑨ Climatological Atlas of India , Rainfall Atlas of India and Agroclimatic Atlas of India ⑨ Monthly bulletin of Climate Diagnostic Bulletin of India ⑨ Environmental Meteorological Unit of IMD at Delhi to provide specific services to MoEF
20.	INTACH Natural Heritage, 71 Lodi Estate, New Delhi-110 003 Tel. 91-11-4645482, 4632267/9, 4631818, 4692774, 4641304 Fax : 91-11-4611290 E-mail : nh@intach.net	⑨ Listing and documentation of heritage sites identified by municipalities and local bodies (Listing excludes sites and buildings under the purview of the Archaeological Survey of India and the State Departments of Archaeology)
21.	Industrial Toxicology Research Centre Post Box No. 80, Mahatma Gandhi Marg, Lucknow-226001, Phone: +91-522-221856,213618,228227; Fax : +91-522 228227 Email: itrc@itrcindia.org	⑨ Activities include health survey on occupational diseases in industrial workers, air and water quality monitoring studies, ecotoxicological impact assessment, toxicity of chemicals, human health risk assessment ⑨ Five databases on CD-ROM in the area of environmental toxicology viz: TOXLINE, CHEMBANK, POISINDEX, POLTOX and PESTBANK. The Toxicology Information Centre provides information on toxic chemicals including household chemicals ⑨ ENVIS centre and created a full-fledged computerized database (DABTOC) on toxicity profiles of about 450 chemicals
22.	Indian Institute of Forest Management Post Box No. 357, Nehru Nagar Bhopal - 462 003 Phone # 0755-575716, 573799, 765125, 767851 Fax # 0755-572878	⑨ Consultancy and research on joint forest management (Ford Foundation, SIDA, GTZ, FAO etc)
23.	Indian Institute of Petroleum Mohkampur , Dehradun, India, 248005 0135- 660113 to 116 0135- 671986	⑨ Fuel quality characterisation ⑨ Emission factors
24.	Ministry of Environment and Forest	⑨ Survey of natural resources ⑨ National river conservation directorate ⑨ Environmental research programme for eastern and western ghats ⑨ National natural resource management system ⑨ Wetlands conservation programme- survey, demarcation, mapping landscape planning, hydrology for 20 identified wetlands National ⑨ wasteland identification programme
25.	Mumbai Metropolitan Regional Development Authority	⑨ Mumbai Urban Transport Project ⑨ Mumbai Urban Development Project ⑨ Mumbai Urban Rehabilitation Project ⑨ Information on MMR; statistics on councils and corporations Regional ⑨ Information Centre- Basic data on population, employment, industries and other sectors are regularly collected and processed

26.	Municipal Corporation of Greater Mumbai	◉ Air Quality Data for Mumbai Municipal Area ◉ Water quality of lakes used for water supply to Mumbai
27.	Ministry of Urban Development Disaster Mitigation and Vulnerability Atlas of India Building Materials & Technology Promotion Council G-Wing,Nirman Bhavan, New Delhi-110011 Tel: 91-11-3019367 Fax: 91-11-3010145 E-Mail: bmtpc@del2.vsnl.net.in	◉ Identification of hazard prone area ◉ Vulnerability Atlas showing areas vulnerable to natural disasters ◉ Land-use zoning and design guidelines for improving hazard resistant construction of buildings and housing ◉ State wise hazard maps (on cyclone, floods and earthquakes)
28.	Natural Disaster Management Division in Department of Agriculture and Cooperation	◉ Weekly situation reports on recent disasters, reports on droughts, floods, cyclones and earthquakes
29.	National Bureau Of Soil Survey & Land Use Planning P.O. Box No. 426, Shankar Nagar P.O., Nagpur-440010 Tel#91-712-534664,532438,534545 Fax#:91-712-522534 RO- Nagpur, New Delhi, Banglore, Calcutta, Jorhat, Udaipur	◉ NBSS&LUP Library has been identified as sub centre of ARIC (ICAR) for input to AGRIS covering soil science literature generated in India ◉ Research in weathering and soil formation, soil morphology, soil mineralogy, physicochemical characterisation, pedogenesis, and landscape-climate-soil relationship. ◉ Soil Series of India- The soils are classified as per Soil Taxonomy. The described soil series now belong to 17 States of the country. ◉ Landuse planning- watershed management, land evaluation criteria, crop efficiency zoning ◉ Soil Information system is developed state-wise at 1:250,000 scale. Presently the soil maps of all the States are digitized, processed and designed for final output both digital and hardcopy. The thematic layers and interpreted layers of land evaluation (land capability, land irrigability and crop suitability), Agro-Ecological Zones and soil degradation themes are prepared. ◉ Districts level information system is developed for about 15 districts at 1: 50, 000 scale. The soil information will be at soil series level in this system. Soil resource inventory of States, districts water-sheds (1:250,000; 1:50,000; 1:10,000/8000)
30.	National Institute of Ocean Technology, Velacherry-Tambaram main road Narayanapuram Chennai, Tamil Nadu Tel#91-44-2460063 / 2460064/ 2460066/ 2460067 Fax#91-44-2460645	◉ Waste load allocation in selected estuaries (Tapi estuary and Ennore creek) is one the components under the Integrated Coastal and Marine Area Management (ICMAM) programme of the Department of Ocean Development ICMAM is conducted with an IDA based credit to the Government of India under the Environmental Capacity Building project of MoEF (waste assimilation capacity of Ennore creek is over) ◉ Physical oceanographic component of Coastal & Ocean monitoring Predictive System (COMAPS) a long term monitoring program under the Department of Ocean Development ◉ Identification of suitable locations for disposal of dredge spoil using mathematical models & environmental criteria ◉ EIA Manual and EIA guidelines for port and harbour projects
31.	National Institute of Oceanography, Goa RO- Mumbai, Kochi	◉ Coastal Ocean Monitoring and Predictions(COMAP)-Monitoring of coastal waters for physicochemical and biological parameters including petroleum hydrocarbons, trace metals, heavy metals, and biomass of primary (phytoplankton) and secondary (zooplankton, microbial and benthic organisms) ◉ Marine Biodiversity of selected ecosystem along the West Coast of India

32.	National Botanical Research Institute, Post Box No 436 Rana Pratap Marg Lucknow- 226001, Tel: (+91) 522 271031-35 Fax: (+91) 522 282849, 282881 Lucknow	⑨ Dust filtering potential of common avenue trees and roadside shrubs has been determined, besides studies have also been conducted on heavy-metals accumulation potential of aquatic plants supposedly useful as indicators of heavy metal pollution in water bodies and capable of reducing the toxic metals from water bodies. ⑨ Assessment of bio-diversity of various regions of India
33.	National Geophysical Research Institute, Uppal Road, Hyderabad Telephone:0091-40-7171124, FAX:0091-40-7171564	⑨ Exploration, assessment and management of ground water resources including ground water modelling and pollution studies
34.	National Environmental Engineering Research Institute, Nagpur RO- Mumbai, Delhi, Chennai, Calcutta, Ahmedabad, Cochin, Hyderabad, Kanpur	⑨ National Air Quality Monitoring (NAQM) for CPCB ⑨ Database on cleaner technologies of industrial productions
35.	National Hydrology Institute, Roorkee RO- Belgaum (Hard Rock Regional Centre), Jammu (Western Himalayan Regional Centre), Guwahati (North Eastern Regional Centre), Kakinada (Deltaic Regional Centre), Patua (Ganga Plains North Regional Centre), and Sagar (Ganga Plains South)	⑨ Basin studies, hydrometeorological network improvement, hydrological year book, hydrological modelling, regional flood formulae, reservoir sedimentation studies, environmental hydrology, watershed development studies, tank studies, and drought studies.
36.	National Institute Of Urban Affairs, India Habitat Centre, New Delhi	⑨ Urban Statistics Handbook
37.	National Institute of Occupational Health Meghaninagar, Ahmedabad RO- Banglore, Calcutta	⑨ epidemiological studies and surveillance of hazardous occupations including air pollution, noise pollution, agricultural hazards, industrial hazards in organised sectors as well as small scale industries, carcinogenesis, pesticide toxicology, etc ⑨ WHO collaborative centre for occupational health for South East Asia region and the lead institute for the international programme on chemical safety under IPCS (WHO)
38.	NRSA Data Centre Department of Space, Balanagar, Hyderabad 500 037 Ph- 040-3078560 3078664 sales@nrsa.gov.in	⑨ Satellite data products (raw data, partially processed (radiometrically corrected but geometrically uncorrected), standard data (radiometrically and geometrically corrected), geocoded data(1:50,000 and 1:25000 scale), special data products like mosaiced, merged and extracted) available on photographic (B?W and FCC in form of film of 240 mm X 240mm or enlargements/paper prints in scale varying between 1:1M and 1:12500 and size varying between 240mm and 1000mm) and digital media (CD-ROMs, 8 mm tapes)
39.	Rajiv Gandhi National Drinking Water Mission	⑨ Database for groundwater using remote sensing technology (Regional Remote Sensing Service Centre involved in generation of ground water prospect maps at 1:50,000 scale for the State of Kerala, Karnataka, AP, MP and Rajasthan for RGNDWM)
40.	Space Application Centre Value Added Services Cell (VASC) Remote Sensing Application Area Ahmedabad 380 053 079-676 1188	⑨ National Natural Resource Information System ⑨ Landuse mapping for coastal regulation zone (construction setback line) upto 1:12500 scale ⑨ Inventory of coastal wetlands, coral reefs, mangroves, seaweeds ⑨ Monitoring and condition assessment of protected coastal areas

	Fax- 079-6762735	• Wetland mapping and inventory • Mapping of potential hotspots and zoning of environmental hazards • General geological and geomorphological mapping in diverse terrain • Landslide risk zonation for Tehre area
41.	State Pollution Control Board	• State Air Quality Monitoring Programme • Inventory of polluting industries • Identification and authorization of hazardous waste generating industries • Inventory of biomedical waste generating industries • Water quality monitoring of water bodies receiving wastewater discharges • Inventory of air polluting industries • Industrial air pollution monitoring • Air consent, water consent, authorization, environment monitoring reports
42.	State Ground Water Board	
43.	Survey of India	• Topographical surveys on 1:250,000 scales, 1:50,000 and 1:25,000 scales • Digital Cartographical Data Base of topographical maps on scales 1:250,000 and 1:50,000 • Data generation and its processing for redefinition of Indian Geodetic Datum • Maintenance of National Tidal Data Centre and receiving/ processing of tidal data of various ports. • Coastal mapping along the Eastern coast line has been in progress to study the effect of submergence due to rise in sea-level and other natural phenomenon. Ground surveys have been completed for the proposed coastal region and maps are under printing. • District planning maps containing thematic information (135 maps) have been printed out of 249 maps covering half the districts of India. Districts planning maps for remaining half of the area are being processed by National Atlas and Thematic Mapping Organisation (NATMO)
44.	Town and Country Planning Organisation	• Urban mapping - Thematic maps and graphic database on towns (under progress in association with NRSA and State town planning department)
45.	Wildlife Institute of India Post Bag No. 18, Chandrabani Dehradun - 248 001, Uttaranchal Tel#0135 640111 -15, Fax#0135 640117 email : wii@wii .	• Provide information and advice on specific wildlife management problems. • National Wildlife Database
46.	Zoological Survey of India Prani Vigyan Bhawan 'M' Block, New Alipore Calcutta - 700 053 Phone # 91-33-4786893, 4783383 Fax # 91-33-786893 RO - Sbillong, Pune, Dehradun, Jabalpur, Jodhpur, Chennai, Patna, Hyderabad, Canning, Behrampur, Kozikode, Itanagar, Digha, Port Bliar, Solan	• Red Book for listing of endemic species • Survey of faunal resources

ANNEXURE VII
Impact Prediction Tools

Table 1: Choice of Models for Impact Prediction: Air Environment

MODEL	APPLICATION	REMARKS
ISCST 3	Appropriate for point, area and line sources Application for flat or rolling terrain Transport distance up to 50 km valid Computes for 1 hr to annual averaging periods	Can take up to 99 sources Computes concentration on 600 receptors in Cartesian on polar coordinate system Can take receptor elevation Requires source data, meteorological and receptor data as input.
AERMOD with AERMET	Settling and dry deposition of particles; Building wake effects (excluding cavity region impacts); Point, area, line, and volume sources; Plume rise as a function of downwind distance; Multiple point, area, line, or volume sources; Limited terrain adjustment; Long-term and short-term averaging modes; Rural or urban modes; Variable receptor grid density; and Actual hourly meteorology data	Can take up to 99 sources Computes concentration on 600 receptors in Cartesian on polar coordinate system Can take receptor elevation Requires source data, meteorological and receptor data as input.
PTMAX	Screening model applicable for a single point source Computes maximum concentration and distance of maximum concentration occurrence as a function of wind speed and stability class	Require source characteristics No met data required Used mainly for ambient air monitoring network design
PTDIS	Screening model applicable for a single point source Computes maximum pollutant concentration and its occurrences for the prevailing meteorological conditions	Require source characteristics Average met data (wind speed, temperature, stability class etc.) required Used mainly to see likely impact of a single source
MPTER	Appropriate for point, area and line sources applicable for flat or rolling terrain Transport distance up to 50 km valid Computes for 1 hr to annual averaging periods Terrain adjustment is possible	Can take 250 sources Computes concentration at 180 receptors up to 10 km Requires source data, meteorological data and receptor coordinates
CTDM PLUS (Complex Terrain Dispersion Model)	Point source steady state model, can estimate hrly average concentration in isolated hills/ array of hills	Can take maximum 40 Stacks and computes concentration at maximum 400 receptors Does not simulate calm met conditions Hill slopes are assumed not to exceed 15 degrees Requires sources, met and terrain

MODEL	APPLICATION	REMARKS
		characteristics and receptor details
UAM (Urban Airshed Model)	3-D grid type numerical simulation model Computes O_3 concentration short term episodic conditions lasting for 1 or 2 days resulting from NOx and VOCs Appropriate for single urban area having significant O_3 problems	
RAM (Rural Airshed Model)	Steady state Gaussian plume model for computing concentration of relatively stable pollutants for 1 hr to 1 day averaging time Application for point and area sources in rural and urban setting	Suitable for flat terrains Transport distance less than 50 km.
CRESTER	Applicable for single point source either in rural or urban setting Computes highest and second highest concentration for 1hr, 3hr, 24hr and annual averaging times Tabulates 50 highest concentration for entire year for each averaging times	Can take up to 19 Stacks simultaneously at a common site. Unsuitable for cool and high velocity emissions Do not account for tall buildings or topographic features Computes concentration at 180 receptor, circular wing at five downwind ring distance 36 radials Require sources, and met data
OCD (Offshore and coastal Dispersion Model)	It determines the impact of offshore emissions from point sources on the air quality of coastal regions It incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shore line Most suitable for overwater sources shore onshore receptors are below the lowest shore height	Requires source emission data Require hrly met data at offshore and onshore locations like water surface temperature; overwater air temperature; relative humidity etc.
FDM (Fugitive Dust Model)	Suitable for emissions from fugitive dust sources Source may be point, area or line (up to 121 source) Require particle size classification max. up to 20 sizes Computes concentrations for 1 hr, 3hr, 8hr, 24hr or annual average periods	Require dust source particle sizes Source coordinates for area sources, source height and geographic details Can compute concentration at max. 1200 receptors Require met data (wind direction, speed, Temperature, mixing height and stability class) Model do not include buoyant point sources, hence no plume rise algorithm
RTDM (Rough Terrain Diffusion Model)	Estimates GLC is complex/rough (or flat) terrain in the vicinity of one or more co-located point sources Transport distance max. up to 15 km to up to 50 km Computes for 1 to 24 hr. or annual	Can take up to 35 co-located point sources Require source data and hourly met data Computes concentration at maximum 400 receptors Suitable only for non reactive gases Do not include gravitational effects or

MODEL	APPLICATION	REMARKS
	ave5rage concentrations	depletion mechanism such as rain/ wash out, dry deposition
CDM (Climatologically Dispersion Model)	It is a climatologically steady state GPM for determining long term (seasonal or annual) Arithmetic average pollutant concentration at any ground level receptor in an urban area	Suitable for point and area sources in urban region, flat terrain Valid for transport distance less than 50 km Long term averages: One month to one year or longer
PLUVUE-II (Plume Visibility Model)	Applicable to assess visibility impairment due to pollutants emitted from well defined point sources It is used to calculate visual range reduction and atmospheric discoloration caused by plumes It predicts transport, atmospheric diffusion, chemical, conversion, optical effects, and surface deposition of point source emissions.	Require source characteristics, met data and receptor coordinates & elevation Require atmospheric aerosols (back ground & emitted) characteristics, like density, particle size Require background pollutant concentration of SO_4, NO_3, NOx, NO_2, O_3, SO_2 and deposition velocities of SO_2, NO_2 and aerosols
MESO-PUFF II (Meso scale Puff Model)	It is a Gaussian, Variable trajectory, puff superposition model designed to account fro spatial and temporal variations in transport, diffusion, chemical transformation and removal mechanism encountered on regional scale. Plume is modeled as a series of discrete puffs and each puff is transported independently Appropriate for point and area sources in urban areas Regional scale model.	Can model five pollutants simultaneously (SO2, SO4, NOx, HNO3 and NO3) Require source characteristics Can take 20 point sources or 5 area source For area source – location, effective height, initial puff size, emission is required Computes pollutant concentration at max. 180 discrete receptors and 1600 (40 x 40) grided receptors Require hourly surface data including cloud cover and twice a day upper air data (pressure, temp, height, wind speed, direction) Do not include gravitational effects or depletion mechanism such as rain/ wash out, dry deposition

Table 2: Choice of Models for Impact Modeling: Noise Environment

Model	Application
FHWA (Federal Highway Administration)	Noise Impact due to vehicular movement on highways
Dhwani	For predictions of impact due to group of noise sources in the industrial complex (multiple sound sources)
Hemispherical sound wave propagation Air Port	Fore predictive impact due to single noise source For predictive impact of traffic on airport and rail road

Table 3: Choice of Methods for Impact Modeling: Land Environment

Model	Application	Remarks
Digital Analysis Techniques	Provides land use / land cover distribution	
Ranking analysis for soil suitability criteria	Provides suitability criteria for developmental conversation activities	Various parameters viz. depth, texture, slope, erosion status, geomorphology, flooding hazards, GW potential, land use etc. are used.

Table 4: Choice of Models for Impact Modeling: Water Environment

Model	Application	Remarks
QUAL-II E	Wind effect is insignificant, vertical dispersive effects insignificant applicable to streams Data required Deoxygenation coefficients, re-aeration coefficients for carbonaceous, nitrogenous and benthic substances, dissolved oxygen deficit	Steady state or dynamic model
	The model is found excellent to generate water quality parameters Photosynthetic and respiration rate of suspended and attached algae	
	Parameters measured up to 15 component can be simulated in any combination, e.g. ammonia, nitrite, nitrate, phosphorous, carbonaceous BOD, benthic oxygen demand, DO, coliforms, conservative substances and temperature	
DOSAG-3, USEPA: (1-D) RECEIV – II, USEPA	Water quality simulation model for streams & canal A general Water quality model	Steady-state
Explore –I, USEPA	A river basin water quality model	Dynamic, Simple hydrodynamics
HSPE, USEPA	Hydrologic simulation model	Dynamic, Simple hydrodynamics
RECEIVE-II, USEPA	A general dynamic planning model for water quality management	
Stanford watershed model	This model simulates stream flows once historic precipitation data are supplied The major components of the hydrologic cycle are modeled including interception, surface detention, overland inflow, groundwater, evapo-transpiration and routing of channel flows, temperature, TDS, DO, carbonaceous BOD coliforms, algae, zooplanktons, nitrite, nitrate, ammonia, phosphate and conservative substances can be simulated	
Hydrocomp model	Long-term meteorological and wastewater characterization data is used to simulate stream flows and stream water quality	Time dependant (Dynamic)
Stormwater Management	Runoff is modeled from overland flow, through surface channels, and through sewer network Both combined and	Time Dependent

Model	Application	Remarks
model (SWMM)	separate sewers can be modeled. This model also enables to simulate water quality effects to stormwater or combined sewer discharges. This model simulates runoff resulting from individual rainfall events.	
Battelle Reservoir model	Water body is divided into segments along the direction of the flow and each segment is divided into number of horizontal layers. The model is found to generate excellent simulation of temperature and good prediction of water quality parameters. The model simulates temperature, DO, total and benthic BOD, phytoplankton, zooplankton, organic and inorganic nitrogen, phosphorous, coliform bacteria, toxic substances and hydrodynamic conditions.	Two Dimensional multi-segment model
TIDEP (Turbulent diffusion temperature model reservoirs)	Horizontal temperature homogeneity Coefficient of vertical turbulent diffusion constant for charge of area with depth negligible coefficient of thermal exchange constant Data required wind speed, air temperature, air humidity, net incoming radiation, surface water temperature, heat exchange coefficients and vertical turbulent diffusion coefficients.	Steady state model
BIOLAKE	Model estimates potential fish harvest from a take	Steady state model
Estuary models/ estuarial Dynamic model	It is simulates tides, currents, and discharge in shallow, vertically mixed estuaries excited by ocean tides, hydrologic influx, and wind action Tides, currents in estuary are simulated	Dynamic model
Dynamic Water Quality Model	It simulates the mass transport of either conservative or non-conservative quality constituents utilizing information derived from the hydrodynamic model Bay-Delta model is the programme generally used. Up to 10 independent quality parameters of either conservative or non-conservative type plus the BOD-DO coupled relationship can be handled	Dynamic model
HEC -2	To compute water surface profiles for stead7y, gradually: varying flow in both prismatic & non- prismatic channels	
SMS	Lake circulation, salt water intrusion, surface water profile simulation model	Surface water Modeling system Hydrodynamic model
RMA2	To compute flow velocities and water surface elevations	Hydrodynamic analysis model
RMA4	Solves advective-diffusion equations to model up to six non-interacting constituents	Constituent transport model
SED2D-WES	Model simulates transport of sediment	Sediment transport model
HIVEL2D	Model supports subcritical and supercritical flow analysis	A 2-dimensional hydrodynamic model
MIKE-II, DHI	Model supports, simulations of flows, water quality, and sediment transport in estuaries, rives, irrigation systems, channels & other water hodies	Professional Engineering software package

Table 5: Choice of Methods for Impact Modeling: Biological Environment

Name	Relevance	Applications	Remarks
Flora			
Sample plot methods	Density and relative density Density and relative dominance	Average number of individuals species per unit area Relative degree to which a species predominates a community by its sheer numbers, size bulk or biomass	The quadrant sampling technique is applicable in all types of plant communities and for the study of submerged, sessile (attached at the base) or sedentary plants
	Frequency and relative frequency importance value	Plant dispersion over an area or within a community	Commonly accepted plot size: 0.1 m^2- mosses, lichens & other mat-like plants
		Average of relative density, relative dominance and relative frequency	0.1 m^2- herbaceous vegetation including grasses
			10.20 m^2 – for shrubs and saplings up to 3m tall, and
			100 m^2 – for tree communities
Transects & line intercepts methods	Cover	Ratio of total amount of line intercepted by each species and total length of the line intercept given its cover	This methods allows for rapid assessment of vegetation transition zones, and requires minimum time or equipment of establish
	Relative dominance	It is the ratio of total individuals of a species and total individuals of all species	Two or more vegetation strata can be sampled simultaneously
Plot-less sampling methods	Mean point plant Mean area per plant	Mean point – plant distance Mean area per plant	Vegetation measurements are determined from points rather than being determined in an area with boundaries
	Density and relative density		Method is used in grass-land and open shrub and tree communities
	Dominance and relative dominance		It allows more rapid and extensive sampling than the plot method
	Importance value		Point- quarter method is commonly used in woods and forests.
Fauna			
Species list methods	Animal species list	List of animal communities observed directly	Animal species lists present common and scientific names of the species involved so that the faunal resources of the area are catalogued
Direct Contact Methods	Animal species list	List of animals communities observed directly	This method involves collection, study and release of animals
Count indices	Drive counts	Observation of animals	Count indices provide estimates of

Name	Relevance	Applications	Remarks
methods (Roadside and aerial count methods)	Temporal counts	by driving them past trained observers	animal populations and are obtained from signs, calls or trailside counts or roadside counts
	Call counts	Count of all animals passing a fixed point during some stated interval of time	These estimates, through they do not provide absolute population numbers, Provide an index of the various species in an area
			Such indices allow comparisons through the seasons or between sites or habitats
Removal methods	Population size	Number of species captured	Removal methods are used to obtain population estimates of small mammals, such as, rodents through baited snap traps
Market capture methods	Population size estimate (M)	Number of species originally marked (T) Number of marked animals recaptured (t) and total number of animals captured during census (n) N = nT/t	It involves capturing a portion of the population and at some later date sampling the ratio of marked to total animals caught in the population

Table 6: Choice of Methods for Impact Predictions: Biological Environment

Relevance		
Name	**Application**	**Remarks**
Extrapolative Methods	A prediction is made that is consistent with past and present socio-economic data, e.g. a prediction based on the linear extrapolation of current trends	
Intuitive Forecasting (Delphi techniques)	Delphi technique is used to determine environmental priorities and also to make intuitive predictions through the process of achieving group consensus	Conjecture Brainstorming Heuristic programming Delphi consensus
Trend extrapolation and correlation	Predictions may be obtained by extrapolating present trends Not an accurate method of making socio-economic forecasts, because a time series cannot be interpreted or extrapolated very far into the future with out some knowledge of the underlying physical, biological, and social factors	Trend breakthrough precursor events correlation and regression
Metaphors and analogies	The experience gained else where is used to predict the socio-economic impacts	Growth historical simulation commonsense forecasts
Scenarios	Scenarios are common-sense forecasts of data. Each scenario is logically constructed on model of a potential future for which the degrees of "confidence" as to progression and outcome remain undefined	Common-sense
Dynamic modeling (Input-	Model predicts net economic gain to the society after considering all inputs required for conversion of raw	

Relevance		
Name	**Application**	**Remarks**
Out model)	materials along with cost of finished product	
Normative Methods	Desired socio-economic goals are specified and an attempt is made to project the social environment backward in time to the present to examine whether existing or planned resources and environmental programmes are adequate to meet the goals	Morphological analysis technology scanning contextual mapping - functional array - graphic method Mission networks and functional arrays decision trees & relevance trees matrix methods scenarios

ANNEXURE VIII

Form through which the State Governments/Administration of the Union Territories Submit Nominations for SEIAA and SEAC for the Consideration and Notification by the Central Government

Form for Nomination of a professional/expert as Chairperson / Member / Secretary of the SEIAA / EAC / SEAC

1	Name (in block letters)	
2	Address for communication	
3	Age & Date of Birth (Shall be less than 67 years for the members and 72 years for the Chairman)	
4	Area of Expertise (As per Appendix VI)	

5	Professional Qualifications (As per Appendix VI)	Qualification(s)	University	Year of passing	Percentage of marks

6	Work experience (High light relevant experience as per Appendix VI)	Position	Years of association			Nature of work. If required, attach separate sheets
			From	to	Period in years	

7	Present position and nature of job	Serving Central / State Government Office?	Yes/No
		Engaged in industry or their associations?	Yes/No
		Associated with environmental activism?	Yes/No
		If no is the answer for above three, please specify the present position and name of the organization	

8	Whether experienced in the process of prior environmental clearance?	Yes/No. If yes, please specify the experience in a separate sheet (Please restrict to 500 words)
9	Whether any out-standing expertise has been acquired?	Yes/ No If yes, please provide details in a separate sheet (Please restrict to 500 words).
10	Any other relevant information?	May like to attach separate sheets (Research projects, consultancy projects, publications, memberships in associations, trainings undergone, international exposure cum experience etc.)

The Government of……………………is pleased to forward the Nomination of Dr./Sh. …………………..…. for the position of Chairperson / Member / Secretary of the SEIAA / SEAC / EAC to the Ministry of Environment & Forests, the Government of India for the Notification.

(Authorized Signature with Seal)

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Government of Canada
Gouvernement du Canada

Canadian General Standards Board
Office des normes générales du Canada

CAN/CGSB-32.311-2006

Supersedes part of CAN/CGSB-32.310-99

Amended
October 2008 and December 2009

Organic Production Systems Permitted Substances Lists

ICS 67.040

Standards Council of Canada
Conseil canadien des normes

National Standard of Canada

Canada

Experience and excellence
Expérience et excellence
CGSB
ONGC

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Process Biochemistry 38 (2003) 1275–1284

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Aerobic–anaerobic biodegradation of beet molasses alcoholic fermentation wastewater

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Received 4 November 2002; accepted 14 November 2002

Abstract

A study of the aerobic degradation of beet molasses alcoholic fermentation wastewater diluted to 50% (chemical oxygen demand, COD: 82 g/l) was carried out using the following fungi: *Penicillium* sp., *Penicillium decumbens*, *Penicillium lignorum* and *Aspergillus niger*. These four microorganisms produce a decolorization of the wastewater from the first day of incubation, achieving the maximum decolorization level at the fourth day of treatment in all cases. *P. decumbes* showed the maximum decolorization with a percentage of 40%. Simultaneously, a significant reduction in the phenolic content of the wastewater was also observed in all cases, reaching average removals of 70% for the four microorganisms studied. Average COD removals were similar in the four cases, achieving maximum values of 52.1 and 50.7%, respectively, on the fifth day of fermentation with *Penicillium* sp. and *P. decumbens*. Finally, a comparative study of the mesophilic anaerobic digestion of untreated and previously fermented (with *P. decumbens*) beet molasses was carried out in laboratory-scale suspended cell bioreactors. Average COD removals of 93% and methane yield coefficient of 305 ml methane at STP conditions per g of COD removed were found in the anaerobic digestion of pre-treated molasses. The combined aerobic–anaerobic process showed the following advantages in relation to the single anaerobic digestion process: higher average percentages of COD removal (96.5 compared with 90.0%) and a decrease of the hydraulic retention time (HRT) necessary to achieve these COD reductions, increasing the decolorization of the wastewater.

Keywords: Beet molasses; Aerobic pre-treatments; *Penicillium decumbens*; Anaerobic digestion; Combined aerobic–anaerobic treatment

1. Introduction

There are a number of small and medium-sized industries in Spain that produce ethanol by fermentation–distillation. The industrial production of ethanol by fermentation results in the discharge of large quantities of high-strength liquid wastes generally called stillages, distillery slops or vinasses. The production of vinasses in a traditional alcohol factory is in the range of 9–14 l of wastewater per l of ethanol obtained. These wastes are strongly acidic (pH: 4–5), and have a high organic content (chemical oxygen demand (COD) in the range of 50–100 g/l). Their free disposal presents a serious challenge to the natural ecosystem and can cause considerable environmental problems [1].

Some researchers [2] have reviewed several methods for the treatment, utilization and disposal of wastewaters from ethanol fermentation industries. Among these are both chemical and biological treatments (aerobic or anaerobic classical methods, trickling filters, lagoons, etc. evaporation–condensation with or without combustion, direct dispersion on soil as a fertilizer, etc.) [2]. A common feature of all these methods is their relatively high cost and, for some, the simultaneous creation of other hazardous by-products/pollutants [3].

The aerobic biological treatment of high-organic load wastes, such as molasses, is associated with operational difficulties of sludge bulking, inability of the system to treat high BOD or COD loads economically, relatively

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doi:10.1016/S0032-9592(02)00325-4

high biomass production and high cost in terms of energy. On the other hand, with the diminishing supply of natural gas and other fossil fuels, bacterial conversion of liquid (or solid) wastes to methane and stabilized by-products through anaerobic digestion would be beneficial [3–5]. These by-products could subsequently serve as food or fertilizer and generally be disposed of with fewer problems (easier dewatering, smaller amounts). Also, the high temperatures and high organic load concentrations of the effluents to be treated, as well as the high-energy requirements of the distillery process, are very suitable conditions for the application of anaerobic digestion.

Anaerobic digestion has a number of advantages. For example, it demands less energy input, anaerobic bacteria are capable of transforming most of the organic substances present into biogas, sludge formation is minimal and nutrient demands are very low. The production of biogas enables the process to generate some energy in addition to the reduced consumption; this can reduce operational costs by a large margin compared with high-energy consumptive aerobic processes [6].

For these reasons, anaerobic digestion of molasses alcoholic fermentation wastewaters have been the subject of a number of studies using laboratory or pilot-scale digesters [7–12], but studies on full-scale mesophilic plants have been reported less often. Several related reviews have been presented and many pilot-scale investigations have been reported, using different anaerobic reactor configurations [13–15].

Although anaerobic digestion of most types of distillery wastewaters is feasible and quite appealing from an energy point of view, the presence of inhibitory substances such as phenolic compounds severely hinders the anaerobic process. This slows down the kinetics, and reduces mean rates of methane production, methanogenic activities and yield coefficients. These problems were previously observed in anaerobic batch cultures of wine distillery wastewaters and cane molasses stillages [16–18].

Many phenolic compounds are known to be toxic and interfere with the activity of methanogenic bacteria. There are numerous reports in the literature showing the toxicity and the inhibitory effects of these compounds on anaerobic digestion processes [19–23]. In addition, the high salinity of this waste (average conductivity of 40 mS/cm) can also cause osmotic pressure problems to the microorganisms responsible for the anaerobic process [24].

Therefore, although the anaerobic digestion of this wastewater is attractive and energetically promising, the presence of a high phenolic content slows down the process, and hinders the removal of part of its organic content, making the utilization of high hydraulic retention times (HRT) necessary. Moreover, the anaerobic digestion process does not remove the intense color from this wastewater or an important fraction of the initial COD, even working at organic loading rates (OLR) as low as 2–4 kg COD/m^3 day.

Table 1
Features and composition of the beet molasses used in the experiments[a]

pH	5.2
Chemical oxygen demand (COD)	80.5 g/l
Soluble COD	74.5 g/l
Total solids (TS)	109 g/l
Mineral solids (MS)	30 g/l
Volatile solids (VS)	79 g/l
Total suspended solids (TSS)	3.6 g/l
Mineral suspended solids (MSS)	1.1 g/l
Volatile suspended solids (VSS)	2.5 g/l
Volatile acidity (acetic acid)	8.5 g/l
Alkalinity ($CaCO_3$)	6.0 g/l
Kjeldahl nitrogen	1.8 g/l
Soluble Phosphorous	0.12 g/l
Sulfates	5 g/l
Conductivity	40 mS/cm
Total phenols (gallic acid)	0.450 g/l
Color (pH 7.5, $\lambda = 580$ nm, dilution 10%)	302

[a] Values are averages of 50 determinations; there was virtually no variation (less than 5%) between analyses.

Thus, the aim of this work was to study a combined aerobic–anaerobic treatment of beet molasses alcoholic fermentation wastewater. In the first step of the treatment most of the phenolic content, color and part of the initial COD will be removed; in the anaerobic step the remaining organic content (not previously removed) will be eliminated. The anaerobic digestion process was carried out in two suspended cell bioreactors operating in continuous mode.

2. Materials and methods

2.1. Wastewater

The beet molasses used were collected from the alcohol factory of el Puerto de Santa María (Cádiz, Spain). The samples of wastewater were collected from the exit of the rectification column, packed in 1 l bottles and, finally, frozen at −20 °C with the aim of carrying out all the experiments with the same type of wastewater.

2.2. Analyses

The following parameters were determined in the wastewater used: pH, solids, COD, volatile acidity, alkalinity, Kjeldhal nitrogen, phosphorous, sulfates, conductivity, and color. All analyses were carried out in accordance with the Standard Methods for the

Examination of Water and Wastewater [25]. The total phenol content was determined according to the Folin–Ciocalteau method [26]. Heavy metals were determined by atomic absorption.

The features and composition of the beet molasses used are summarized in Table 1.

2.3. Microorganisms used

The fungal species used for the study were: *Penicillium lignorum* IFJM-B 22 isolation 0.46 Rio Tinto (Huelva, Spain); *Penicillium decumbens* and *Penicillium* sp. isolated from molasses and *Aspergillus niger* IJFM-A570 from the collection of LNETI (Portugal). All the cultures were supplied by the 'Centro de Investigaciones Biológicas' (C.S.I.C.) of Madrid (Spain) except *P. decumbens* NRRL3388 (synonymous of *Penicillium glauco lanosum*), which was supplied by the culture collection of the Department of Agriculture, Peoria University, Illinois, USA.

The culture medium (PPG) used for growth and formation of the fungi spores was composed of: mashed potatoes, 20; glucose, 20; and agar, 20 g/l. The cultures were maintained in a thermostatic chamber at 20 °C until the phase of spores formation was achieved. Part of these cultures were used to maintain the active population through fresh reseeding that was carried out every 15–30 days. After the phase of spores formation was achieved, conidia were collected using a Triton × 100 solution diluted to 0.1%, this detergent was used given the hydrophobic character of the spores. Finally, these were filtered through a sterile filter and counted in a Bürker Superior W-Germany chamber.

The growth medium used for the count of viable spores (Sutter IV) contained:

- Solution A (per 500 ml of distilled water): Sutter concentrated, 20 ml; L-Asparragine, 2; and H_2KPO_4, 5 g.
- Solution B (per l of distilled water): glucose, 20; and agar, 15 g.

These two solutions were mixed, after each one was previously sterilized separately and, finally, 0.7 ml of a 35% HCl solution was added to acidify the medium and to avoid the extended growth of the population, making it easy to count the colonies.

2.4. Aerobic treatment

Aerobic treatments were carried out in 250 ml glass flasks placed in an orbital shaking incubator operating at 100 rpm and 22 °C. After sterilization of the flasks, 100 ml of beet molasses, diluted to 50% and sterilized, were added to each flask. Each one was inoculated with spores suspended in saline (10^7 viable spores per ml). The air input flow rate was 3 l/h per l of molasses during 5 days. Adjustment of the pH was not necessary as molasses have a pH of 5.2, which is favorable for the growth of the fungus.

2.5. Anaerobic treatment

Two anaerobic reactors, with a working volume of 1 l, equipped with magnetic stirring and placed in a thermostatic chamber at 35 °C were used. The reactors were fed daily by means of external feeders and liquid effluents removed daily through a hydraulic seals, comprising 25 cm liquid columns, designed to prevent air from entering the reactors and biogas from leaving. This reactor has been described in detail elsewhere [27].

The methane volume produced in the process was measured using 5 l Mariotte reservoirs fitted to the reactors. Tightly closed bubblers containing a NaOH solution (3 M) to collect the CO_2 produced in the process were intercalated between the two elements. The methane produced displaced a given volume of water from the reservoirs, allowing ready determination of the gas [27].

The reactors were inoculated with biomass from an industrial anaerobic contact digester operating with vinasses. It was methanogenically active and its content in volatile solids was 59.1 g/l.

The anaerobic reactors were initially charged with 750 ml of a synthetic solution containing peptone (1%), yeast extract (0.5%), sodium chloride (0.5%) and 135 ml of the inoculum. The biomass of each reactor was initially acclimatized by batch feedings of 10–100 ml of diluted wastewater (10 g COD per l) over a period of 2 weeks.

This preliminary step was followed by a series of two continuous experiments in which natural molasses and molasses previously fermented with *P. decumbens*, were added to the digesters with biomass suspended. The influent daily feed volumes were varied to give 18.7, 31.2, 44.0, 56.0, 68.7, 81.0 and 94.0 ml/day of untreated molasses (equivalent to 53.3, 32.0, 22.7, 17.8, 14.7, 12.3 and 10.6 days HRT), respectively, and 65, 108, 152, 195, 239, 283 and 326 ml/day of pre-treated molasses (equivalent to 15.4, 9.3, 6.6, 5.1, 4.2, 3.5 and 3.1 days HRT), respectively. These values of feed flow-rates and HRTs corresponded to organic loading rate (OLR) values of 1.5, 2.5, 3.5, 4.5, 5.5, 6.5 and 7.5 g COD per l day, respectively, for the two substrates studied. The biomass concentration ranged between 10.0 and 10.4 g VSS per l (mean value = 10.2 g VSS per l) and was, therefore, approximately constant for all experiments.

Once steady-state conditions were achieved at each feeding flow-rate, the daily volume of methane produced, pH, volatile acidity, alkalinity and COD of the different effluents studied were determined. The samples were collected and analyzed for at least 5 consecutive

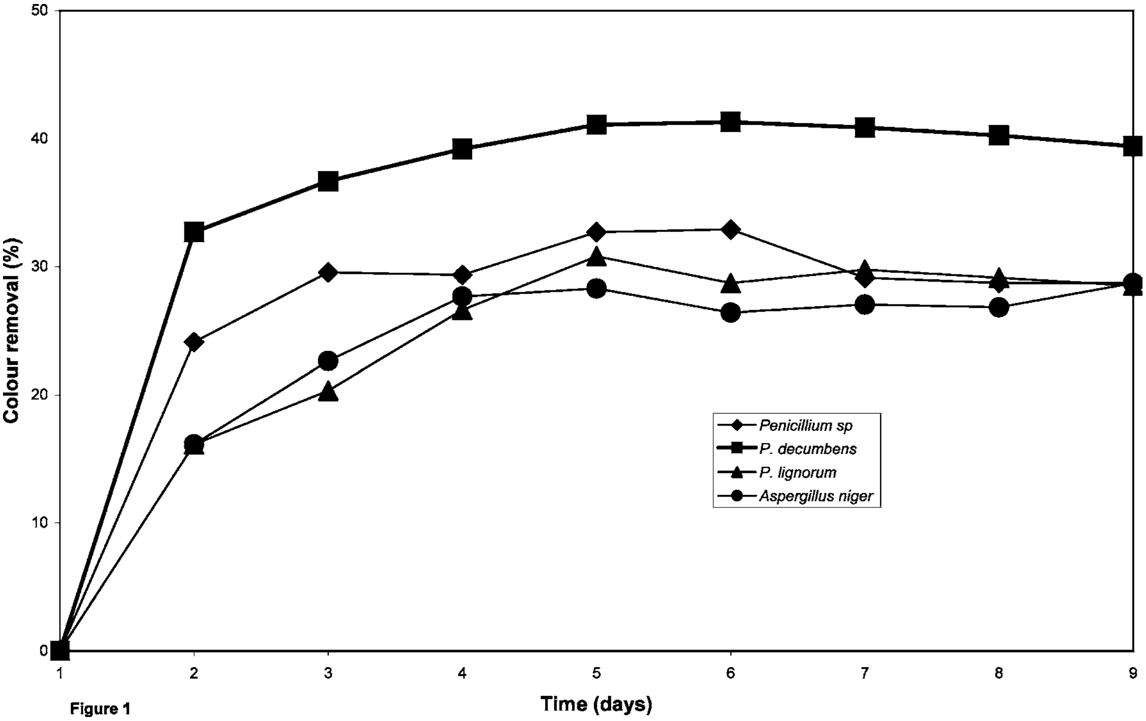

Fig. 1. Variation of the percentage of color removal with time (days) for the four microorganisms assayed.

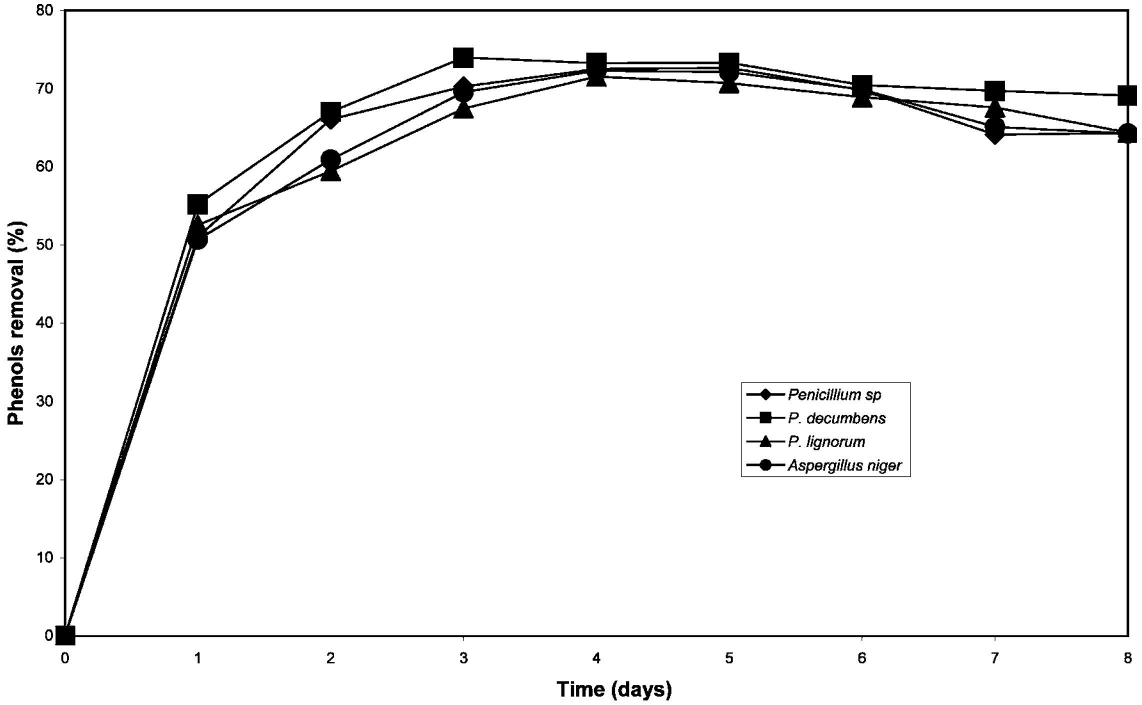

Fig. 2. Variation of the percentage of phenols removal with time (days) for the four microorganisms assayed.

days. The steady-state value of a given parameter was taken as the average of these consecutive measurements for that parameter when the deviations between the observed values were less than 5% in all cases. The organic loadings applied in this investigation were increased in a stepwise fashion in order to minimize the transient impact on the reactors that might be induced by a sudden increase in loadings.

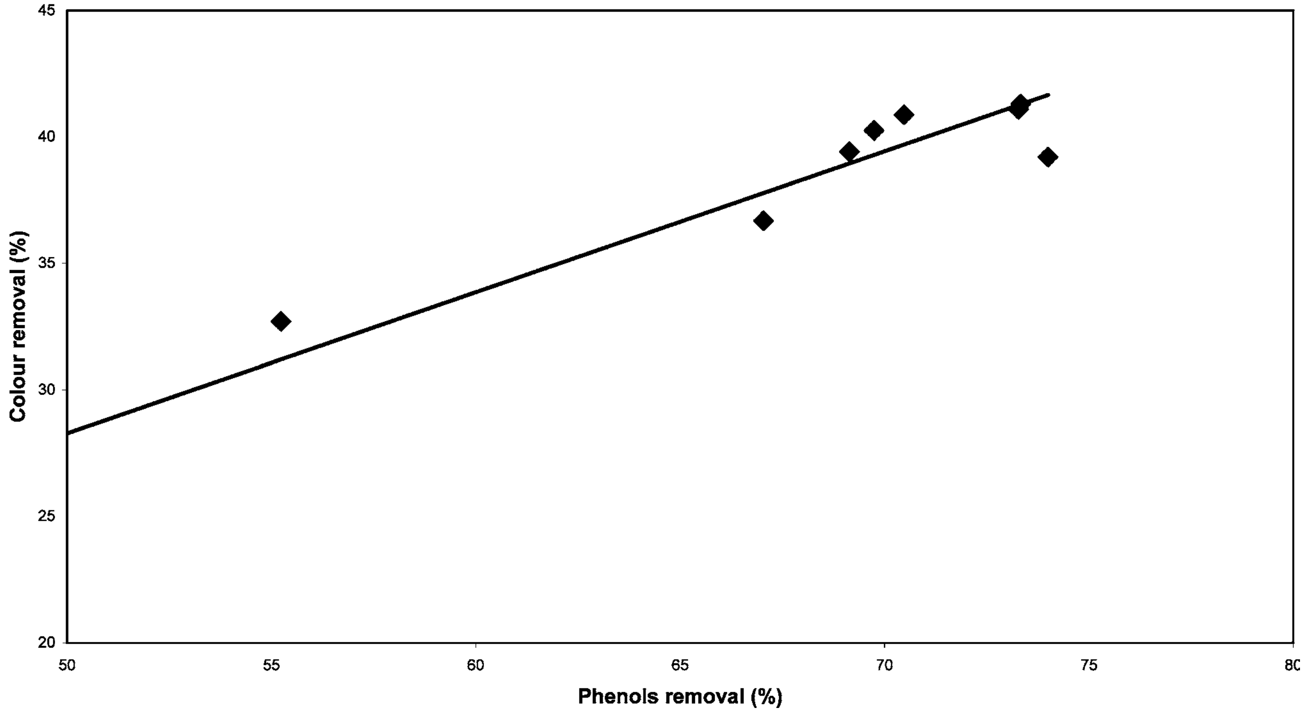

Fig. 3. Variation of the percentage of color removal as a function of the percentage of phenols removal.

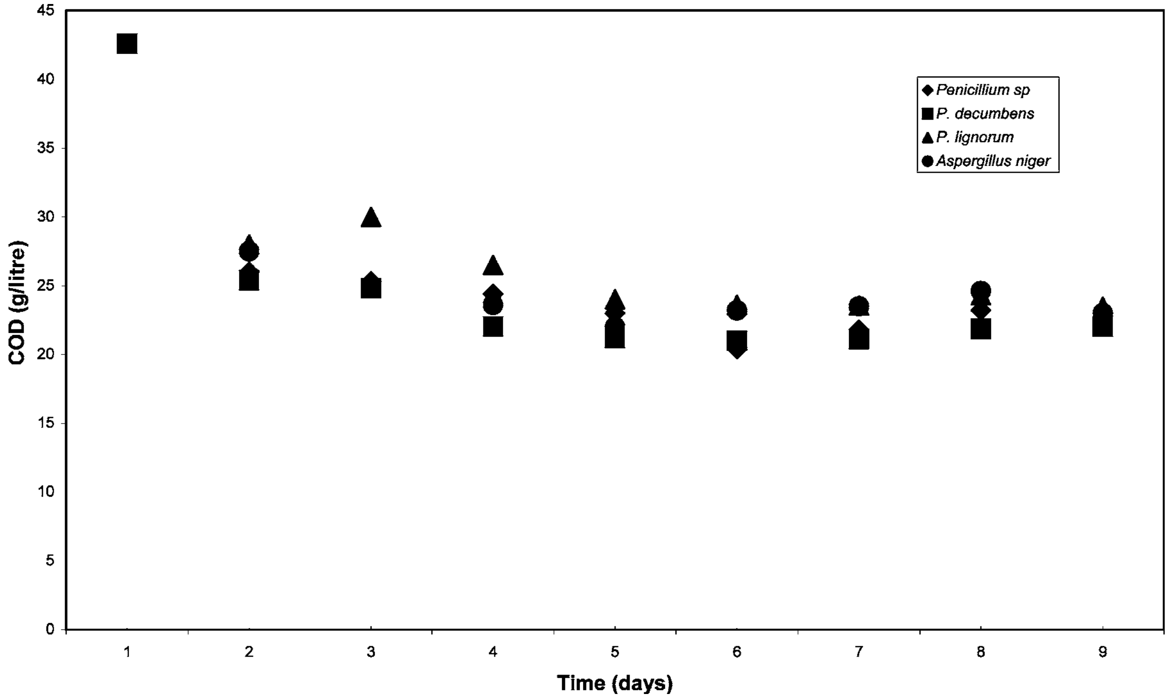

Fig. 4. Variation of the COD of molasses with incubation time for the four microorganisms assayed.

3. Results and discussion

3.1. Aerobic treatment

Fig. 1 shows the variation of the percentage of color removal as a function of time for the four microorganisms assayed. As can be seen, all the fungi studied produced a decolorization of the beet molasses from the first day of incubation, although the first removed percentages were low. The higher reductions in color were achieved between the fourth and fifth day of treatment, with *P. decumbens* achieving the best results with 41% of the initial color removed after 4 days of treatment. This decrease in the coloration of beet molasses may be attributed to the degradation and/or adsorption of tannins and some phenolic compounds on the mycelium, as was previously observed by Hamdi et al. in the treatment of olive mill wastewater (OMW) with *A. niger* [28].

Similar results were obtained by Sayadi and Ellouz treating OMW with the fungi: *Pycnoporus cinnabarinus*, *Phlebia radiata* and *Polyporus frondosus*, with percentages of color removal ranging between the 32 and 46% after 5 days of treatment [29]. Similar percentages in color removal were also obtained by Hamdi et al. [28] fermenting OMW with *A. niger*.

The variation of the percentage of phenolic compound removal with the operation time is shown in Fig. 2. Although this variation was similar for the four microorganisms used, *P. decumbens* showed a maximum value of phenols removal of 74% after 3 days of treatment. Garcia et al. obtained a 66 and 70% reduction in phenols, treating cane sugar vinasses with *Aspergillus terreus* and *Geotrichum candidum*, respectively, after 5 days of incubation [30]. Values of 90.0 and 94.3%, respectively, in the phenol content removals, were obtained in the treatment of OMW with *Azotobacter chroococcum* and *A. terreus* after 5 and 3 days of treatment [31].

Fig. 3 shows the variation of the percentage of color removal with the percentage of phenol removal for the treatment with *P. decumbens*. As can be observed, there is a strong linear correlation among both variables. By using a linear regression with the least squares method, the following equation was obtained:

$$\begin{aligned}&\%\ \text{of Colour removed}\\&\quad = 0.42 + 0.55(\%\ \text{of Phenols removed})\end{aligned} \qquad (1)$$

This equation demonstrates that although the fungi removed 100% of the phenols, only 55.4% of the initial color would be eliminated, which suggests the occurrence of another type of compound, different from the phenols that are not eliminated by the fungi assayed.

The variation of the COD content of molasses with the operation time for the four microorganisms studied is given in Fig. 4. As can be seen, the reduction of the COD with time was similar in all cases, with *Penicillium* sp. and *P. decumbens* achieving the maximum removal values of 52.1 and 50.7%, respectively, at the end of the treatment. The monitoring of this variable is of great interest to measure the growth of the microorganisms, in addition to allowing the study the evolution of the biodegradation process. Sayadi and Ellouz obtained 48 and 51% reductions in COD content of the OMW treated with *P. radiata* 28773 and *P. radiata* FR DAOM 53209 after 5 days of incubation [29]. Garcia et al. found a COD reduction of 29 and 28% in vinasses treated with *A. terreus* and *G. candidum*, respectively [30]. Other researchers [28,32] found COD removals of 62.8 and 55.0%, respectively, in OMWs fermented with *Candida tropicalis* and *Geotrichum* sp., after 7 days of treatment. Finally, values of 63.3, 74.5 and 74.0%, respectively, in COD removal were obtained in the treatment of OMW with *G. candidum*, *A. chroococcum* and *A. terreus* after 5, 5 and 3 days of treatment, respectively [31].

Table 2
Average concentrations (mg/l) of heavy metals before and after treatment of molasses with *P. decumbens*

Cation	Molasses	Pretreated molasses
Na	2500	1875
K	3550	2540
Ca	985	833
Mg	510	500
Fe	83	6.8
Mn	85	0.7
Zn	20	1.0
Cu	7	0.3
Co	2	0.1
Ni	4	0.3
Cr	2	0.2

In parallel to COD removal, an elimination of heavy metals takes place, as can be observed in Table 2; this topic has been widely investigated. In this way, Ross and Townsley [33] observed that the cell walls of the fungi adsorb a great variety of heavy metals. Kiff and Little [34] observed that some exopolymers are optimally located to interact with the metallic ions. Gadd [35] also carried out a study using a number of metals, recommending the use of fungi for the removal of heavy metals. Townsley et al. [36] studied the removal of copper using *Trichoderma viride*. Moreover, other researchers [37,38] were able to remove uranium using the species *A. niger*.

3.2. Anaerobic treatment

Tables 3 and 4 summarize the steady-state operating results including OLR, HRT, pH, methane flow-rates, percentages of COD removal, volatile acidity, alkalinity and volatile acidity/alkalinity ratios, for the anaerobic digestion experiments carried out with untreated molasses and molasses previously treated with *P. decumbens*. The pH in both reactors remained approximately constant for all the HRTs studied, with 7.8 and 8.4 as extreme values. This stability can be attributed to carbonate/bicarbonate buffering. This is produced by the generation of CO_2 in the digestion process, which is not completely removed from the reactor as gas. Buffering in anaerobic digestion is normally due to bicarbonate as carbonate is, generally, negligible if compared with the bicarbonate (carbonate/bicarbonate

Table 3
Results obtained under different experimental conditions in the anaerobic digestion process of untreated molasses

OLR	HRT	pH	q_g	COD removal (%)	Volatile acidity	Alkalinity	Volatile acidity/alkal
1.5	53.5	8.0	0.296	93.7	0.30	7.5	0.04
2.5	32.0	8.4	0.495	91.6	0.65	15.4	0.04
3.5	22.7	7.8	0.700	88.7	0.99	10.2	0.10
4.5	17.8	8.3	0.835	87.7	0.60	14.8	0.04
5.5	14.7	8.2	0.925	85.0	4.70	17.9	0.26
6.5	12.3	8.1	0.761	73.9	5.01	18.7	0.27
7.5	10.6	8.3	0.755	68.6	9.30	18.9	0.49

OLR, organic loading rate (g COD per l day); HRT, hydraulic retention time (day); q_g (l CH_4 per l day), methane production rate; volatile acidity (g acetic acid per l); alkalinity (g $CaCO_3$ per l).

ratio is equal to 0.01 for pH 8.2). The buffering guards against possible acidification of the reactor giving a pH of the same order as optimal for methanogenic bacteria [39]. The high pH values and the buffering capacity is a guarantee as opposed to an acidification of the reactor that could be caused by a sudden overloading of the reactor, an abrupt change of the operation temperature or by the presence of toxic compounds or inhibitors in the substrate.

The VFA/alkalinity ratio can be used as a measure of process stability [39]: when this ratio is less than 0.3–0.4 the process is considered to be operating favorably without acidification risk. As was observed (Tables 3 and 4), the ratio values were lower than the suggested limit value in all cases except in the experiment corresponding to the lowest HRT studied (10.6 days) for untreated molasses. Between HRTs of 53.5 and 12.3 days for untreated molasses and between 15.4 and 3.1 days for pre-treated molasses, the VFA/alkalinity ratio was always lower than the above-mentioned failure limit value, and the VFA values were always lower than 5.01 and 1.02 g/l (as acetic acid), respectively. However, in the case of the anaerobic digestion of untreated molasses, at a HRT of 10.6 days, a considerable increase of the VFA/alkalinity ratio was observed in the reactor (0.49), which was due to an important rise in the VFA concentration (9.30 g/l, as acetic acid) with an alkalinity value of 18.9 g/l as $CaCO_3$. In addition, the VFA/alkalinity ratio of the effluents of both reactors was always lower than those corresponding to the two molasses studied (1.7 and 0.6 for untreated and previously fermented molasses, respectively). This fact confirms the uptake of volatile organic acids present in both feeds and the tendency of the systems to reach a dynamic equilibrium.

The COD removal efficiencies observed at different HRTs and OLRs for both substrates are also summarized in Tables 3 and 4. For untreated molasses, COD removal decreased slightly from 93.7 to 85.0% when OLR increased from 1.5 to 5.5 g COD per l day and HRT decreased from 53.5 to 14.7 days. At an OLR of 7.5 g COD per l day a marked decrease in efficiency was observed (68.6%). In consequence, it appears that the performance of the anaerobic system treating untreated molasses becomes independent of HRT and OLR, provided that the HRT and OLR of the reactor are maintained above 14.7 days and below 5.5 g COD per l day, respectively. In contrast, for molasses previously fermented with *P. decumbens*, the decrease in the percentage of COD removal with increased OLRs was softer than that observed for untreated molasses in the same range of organic loadings (1.5–7.5 g COD per l day).

Table 4
Results obtained under different experimental conditions in the anaerobic digestion process of molasses pre-treated with *P. decumbens*

OLR	HRT	pH	q_g	COD removal (%)	Volatile acidity	Alkalinity	Volatile acidity/alkal
1.5	15.4	7.8	0.337	82.6	0.288	1.50	0.19
2.5	9.3	8.3	0.546	78.3	0.936	7.07	0.13
3.5	6.6	8.2	0.710	76.1	0.740	7.95	0.09
4.5	5.1	8.0	0.867	73.0	0.710	8.05	0.09
5.5	4.2	7.8	1.008	69.6	1.020	10.3	0.10
6.5	3.5	7.8	1.108	65.2	0.552	10.6	0.05
7.5	3.1	8.0	1.331	63.5	0.432	10.2	0.04

OLR, organic loading rate (g COD per l day); HRT, hydraulic retention time (day); q_g (l CH_4 per l day), methane production rate; volatile acidity (g acetic acid per l); alkalinity (g $CaCO_3$ per l).

Table 5
Volume of methane per gram of COD added for the different OLRs used in the anaerobic digestion processes of untreated and previously treated molasses

OLR (g COD per l day)	Untreated molasses l CH_4 STP per g COD	Pre-treated molasses l CH_4 STP per g COD
1.5	0.197	0.224
2.5	0.198	0.218
3.5	0.200	0.203
4.5	0.186	0.193
5.5	0.168	0.183
6.5	0.167	0.170
7.5	0.101	0.177

The values of volumetric methane production rates for each OLR studied in natural and previously fermented molasses are also given in Tables 3 and 4, respectively. In the case of untreated molasses, it can be seen that the volume of methane produced per day increased progressively with increased OLR up to OLR values of 5.5 g COD per l day, after which a marked decrease was observed over the range tested. Apparently, the activity of methanogenic bacteria was not impaired up to OLR values of 5.5 g COD per l day because of the adequate buffering capacities provided in the experimental system. Nevertheless, the methane production rate decreased from 0.925 to 0.755 l/l day when the OLR was increased from 5.5 to 7.5 g COD per l day. This decrease in the methane production at the highest OLR values might be attributed to an inhibition of the methanogenic bacteria at high OLR values, which caused an increase in effluent VFA contents and VFA/alkalinity ratios, as can be seen in Table 4. Specifically, VFA content increased from 4.7 to 9.3 g/l (as acetic acid) when the OLR was increased from 5.5 to 7.5 g COD per l day. In the case of molasses previously treated with *P. decumbens*, the methane production rate increased linearly from 0.337 to 1.331 l/l day with increased OLR in all the range of OLR tested (1.5–7.5 g COD per l day). In addition, the values found for this parameter were always higher than those observed for anaerobic digestion of untreated molasses for the same values of OLR, which clearly shows the advantage of previously fermenting the molasses to be treated by anaerobic digestion.

On the other hand, the methane yield coefficient (volume of methane per COD added to the reactor) can be calculated from Tables 3 and 4. As can be observed in Table 5, a gradual decrease in the fraction of organic matter transformed into methane was found after an OLR value of 5.5 g COD per l day, decreasing the values of methane yield coefficient 49% (untreated molasses) and 20% (pre-treated molasses) for the experiments corresponding to an OLR of 7.5 g COD per l day in relation to the values found at an OLR of 1.5 g COD per l day.

Finally, the values of the substrate removal rate can be calculated from data summarized in Tables 3 and 4. Fig. 5 shows the variation of the HRT with the organic loading removal rate in the cases of the anaerobic digestion of untreated and pre-treated molasses. This

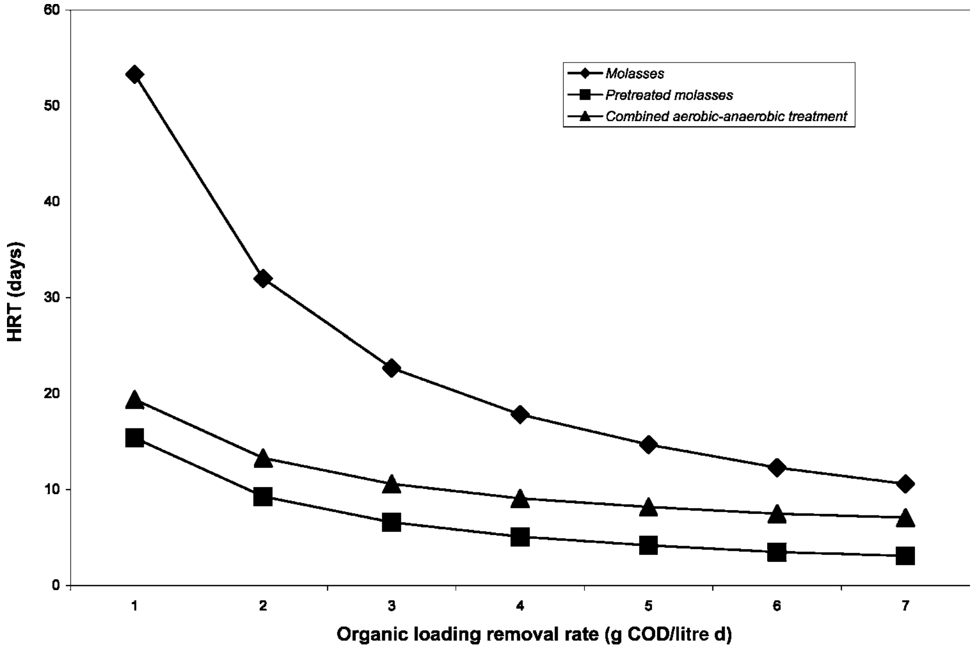

Fig. 5. Variation of the HRT with the organic loading removal rate (g $COD_{removed}$ per l day) in the cases of the anaerobic digestion of untreated molasses, previously fermented molasses and in the combined aerobic–anaerobic digestion process.

plot also clearly shows the advantage of the pre-treatment of molasses with *P. decumbens* previous to its anaerobic digestion. For a given value of the organic loading removal rate, the HRT decreased considerably when the molasses are previously fermented. In order to establish a more rigorous comparison, the time used in the pre-treatment (4 days) has been added to the HRT of the pre-treated molasses, obtaining a curve located in an intermediate position (Fig. 5). It is apparent that, even under these circumstances, the previous statement continues being valid. Therefore, the time necessary for digesting a given organic load, in the case of using a combined aerobic–anaerobic treatment, is always lower than that necessary to anaerobically treat the waste. On the other hand, the performance of the reactor processing untreated molasses starts to become destabilized for OLR values of 5.5 g COD per l day, which does not happen when the wastewater has been pre-treated, since the reactor admits loading rates of up to 7.5 g COD per l day without destabilization symptoms appreciated.

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Electronic Journal of Biotechnology ISSN: 0717-3458
Vol.12 No.1, Issue of January 15, 2009
Received April 17, 2008 / Accepted August 20, 2008
DOI: 10.2225/vol12-issue1-fulltext-5

REVIEW ARTICLE

Utilization and biodegradation of starch stillage (distillery wastewater)

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Keywords: biodegradation, distillery, ethanol, starch stillage, utilization.

Stillage (distillery wastewater) is the main by-product originating in distilleries, and its volume is approximately 10 times that of ethanol produced. It is not surprising that the utilization of the stillage raises serious problems, and that many attempts have been made all over the world to solve them. In Poland most of the ethanol (about 90%) is produced from starch-based feedstocks, *i.e.* grains and potatoes. Starch feedstocks are widely used for spirit production also in other European countries, as well as outside Europe. The manuscript provides an overview of global fuel ethanol production and information on methods used for starch-based stillage biodegradation and utilization. The methods presented in this paper have been classified into two major groups. One of these includes the mode of utilizing starch stillage, the other one comprises methods, both aerobic and anaerobic, by which the stillage can be biodegraded.

Scarcely 5 per cent of world's ethanol production comes from chemical synthesis. More than 95 per cent of the ethanol produced is obtained from agricultural or agriculture-related feedstocks. Of these, sugar-based feedstocks account for approximately 42%, and non-sugar feedstocks (mainly starch-based ones) for about 58% of the ethanol volume produced (Tolmasquim, 2007). It seems interesting to note that about 67% of the global ethanol volume (in 2006 this was a total of 39 billion litres (REN21, 2008)) is used for fuel production.

In Poland ethanol obtained from starch-based feedstock now accounts for about 90% of the overall production. Ethanol is produced from grain crops (primarily rye, triticale and wheat), root crops (mainly potatoes) and molasses (as well as other agricultural feedstocks) (Dzwonkowski et al. 2007; Lopaciuk et al. 2007). Although the use of maize grain as feedstock is now becoming increasingly frequent in Polish distilleries, it is still far from being a widely accepted practice (Lopaciuk et al. 2007). It should be noted that the structure of the agricultural feedstock made use of for ethanol production varies according to the market situation. Thus, about two decades

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Table 1. Group B vitamins [mg/kg d.m.] in potato stillage and rye stillage, and mineral compounds [g/kg d.m.] in barley and wheat stillage.

Vitamins of group B	Potato stillage (Becker and Nehging, 1967)	Rye stillage (Becker and Nehging, 1967)
Vitamin B_1	7.8	15
Vitamin B_2	18.6	14.4
Vitamin B_6	18.8	4.0
Vitamin B_{12}	0.0088	0.118
Biotin	0.014	0.56
Nicotinic acid	212	54.9
Pantothenic acid	71.2	60.0
Folic acid	0.78	2.4
Mineral compounds	Barley stillage (Mustafa et al. 1999)	Wheat stillage (Mustafa et al. 1999)
Ca	5.3	4.2
P	11.3	12.1
Mg	5.4	5.9
K	0.0016	0.0016
Mn	0.0522	0.1101
Na	0.0006	0.0002
Fe	0.4932	0.4191
Cu	0.0054	0.0057

ago, it was potato-based ethanol that accounted for approximately 70% of the overall production. In the year 2000 its contribution dropped to less than 8%. Potato ethanol production totalled 3.2% in 2003 and rose to 4.2% in 2004. But in 2005 it dropped again, amounting to 3.1%. In 2006 potato ethanol production decreased to 5.5 million litres (from 9.1 million litres in 2005) (Dzwonkowski et al. 2007). In general, the use of starch-based feedstocks is dominant in Poland, rye being the most popular raw material for ethanol production (approx. 90%) (Lopaciuk et al. 2007). The quite frequent use of starch-containing wastes (*e.g.* putrid or frozen potatoes, peelings, pulp, potato slops, waste flour or wet sprouted and mouldy grain) is to be attributed to the unfavourable proportion of the feedstock cost in the overall costs of spirit production (50 to 60%) (Dzwonkowski et al. 2007).

In Poland, 95% of the overall ethanol production comes from rural distilleries (Jarosz, 2002). In 1995 about 940 were run in this country, but their number has been falling ever since and in 2006 only 217 distilleries were operated (Kupczyk, 2007). As the number of distilleries decreased, so did the volume of the ethyl alcohol produced, which dropped from 278 million litres in 1996 to approximately 170 million litres in 1999 and 2000. But subsequently, in 2001, ethanol production increased slightly (to 181 million litres) and continued to rise in the years that followed, to reach an annual volume of 220 and 230 million litres in 2003 and 2004, respectively. In 2005 ethanol production increased by 27.56% compared to 2004, and in 2006 the volume of ethanol produced totalled 344 million litres (Dzwonkowski et al. 2007).

In 2006 approximately 62.9% of the ethanol produced by rural distilleries in Poland was used as a fuel additive (Kupczyk, 2007), and the volume of ethanol produced as a biofuel equalled 161 million litres. Compared with the volume attained in 2006, fuel ethanol production in Q1-Q3 of 2007 decreased, amounting to 68 million litres only (Licht, 2008). Polish refineries Orlen and Lotos sourced 60% of the fuel ethanol contracted from abroad, since in those days domestic producers were not competitive. But the long-term outlook for domestic biofuel production and consumption is positive (Licht, 2008). The increase in fuel ethanol demand that is expected in the context of both the national bio-fuel programme and the Biofuel Directive

2003/30/EC shows great promise to distilling industries which hope to raise their production.

The United States is a global leader in the use of starch-based feedstocks for ethanol production. In 2006 the USA production accounted for 38% of world’s overall ethanol production (REN21, 2008). In the United States, maize is the principal starch feedstock. This is not surprising, as this country is the leading producer of maize crops. Besides maize, some other grains are in use as feedstocks, *e.g.* wheat, sorghum or rye (Tolmasquim, 2007). In the USA the distilling industry is based on large distilleries-factories. In 2005 approximately 95 of them were operated, with a total capacity of 16.4 billion litres per year. In mid-2006 there were 35 additional plants under construction, providing further capacity of 8 billion litres per year (OECD/IEA, 2007). At the beginning of 2008 there were 9 distilleries under construction and 7 undergoing expansion (Licht, 2008). In 2004 the United States ranked second in ethanol production. The leader was then Brazil with an annual ethyl alcohol volume of 14.66 billion litres produced (RFA, 2008). It is essential to note, however, that this country almost invariably uses sugar cane as feedstock. In 2005 the USA became world's largest fuel ethanol producer, and thus outdistanced Brazil. In 2006 fuel ethanol production in the USA and Brazil amounted to 18.3 billion litres and 17.5 billion litres, respectively (REN21, 2008). In the USA over 99% of the ethanol produced is utilized for fuel production (Ribando Seelke and Yacobucci, 2007); in Brazil the proportion amounts to 90%. Canada (with an annual ethanol volume of 550 million litres produced in 2006 (OECD/FAO, 2007) and fuel ethanol production of 200 million litres (REN21, 2008)) uses starch feedstocks (mainly maize grains) for ethanol production (Berg, 2004). Other widely accepted feedstocks include wheat, barley, triticale and rye (Klein et al. 2008).

In 2006 the EU produced close to 1.6 billion litres of ethanol for fuel (EUBIA, 2008). The major part of this was distilled out of cereals, which accounts for 976 million litres or roughly 61% of total ethanol feedstock. Among the different grains used for the ethanol production, wheat is the most important cereal with a market share of 36%, followed by rye (15%), barley (7%), maize (only 2%) and triticale (marginal) (Biofuels International, 2007). In 2006 the largest starch-based bioethanol fuel producer in the EU was Germany with an overall output of 430 million litres (Biofuels International, 2008). The main feedstock used for the German ethanol production was rye (49.5%) followed by wheat (41.3%), barley (8%) and triticale (no precise numbers). Spain, as the second largest producer of ethanol in the EU (396 million litres in 2006), mainly processed wheat (57%) followed by barley (21%). The rest of the Spanish production came from wine alcohol. In 2007 the greatest production was achieved in France (578 million litres), where the production almost doubled (Biofuels International, 2008), but France was the only large scale producer of bioethanol coming from sugar beet (around 81%) (Biofuels International, 2007). In 2007 the next largest producers were Germany (394 million litres) and Spain (348 million litres). In that year fuel ethanol production decreased compared to 2006 with the most significant decline in Sweden, which halved its production to 70 million litres due in part to high cereal prices. As a result the costs of bioethanol production rose to a level that made its manufacture no longer profitable (Biofuels International, 2008).

As is the case with the United States, Europe invests a great deal in large distillery plants, whose overall ethanol production capacity is likely to approach 3 billion litres per annum by the end of 2008 (Kupczyk, 2007). As for Asia, the leadership in utilizing starch-based feedstocks for ethanol production belongs to China, which ranks third as a global ethanol producer with a yearly volume of approximately 4.1 billion litres in 2006 (Tolmasquim, 2007). Fuel ethanol production in that country in 2006 amounted to 1.5 billion litres (OECD/FAO, 2007).

The choice of the feedstock for the production of fuel ethanol is determined by economic calculation, and this includes all the protective measures taken by the governments of some countries that want to pursue their social policy also in this way. But if spirits are produced for human consumption, this is the recipe for the alcoholic drink that determines the choice of the feedstock. For example, the production of whisky, of some flavoured vodkas, or of the majority of the Japanese shochu types requires starch-based feedstock. And that is why in many countries local distillers specialise in the production of regional alcoholic drinks. The diversity of the feedstocks used for ethanol production and the fact that distillery plants widely differ in size (production capacity) are the contributory factors in the use of different methods for distillery wastewater utilization and biodegradation.

The purpose of the paper was to provide an overview of the growing scale of ethanol production worldwide, as well as to give an account of methods that are used for starch stillage biodegradation and utilization. The methods presented in the paper have been classified into two major groups. One of these includes the mode of utilizing starch stillage, the other one comprises methods, both aerobic and anaerobic, by which the stillage can be biodegraded.

Methods of stillage utilization

Distillery stillage from the fermentation of starch-based feedstock by the yeasts contains not only some feedstock components (Sweeten et al. 1981-1982; Davis et al. 2005), but also degraded yeast cells (Sanchez et al. 1985). Many of those substances are characterised by a high nutritive value. They contain vitamins (with large amounts of those classified as group B) (Table 1), proteins rich in exogenous aminoacids (Mustafa et al. 1999), and mineral components (Table 1). Upon comparing the proportions of particular mineral compounds in barley and wheat stillage it can bee seen that barley stillage contains more calcium, iron and

Table 2. Chemical composition of dry matter content for starch stillage of choice [%].

Stillage	Dry matter	Crude protein	Fat	Crude fibre	Sugars	Starch	Ash	References
Grain sorghum	5.8	1.7	nd	1.51	2.6	1.01	3.77	(Sweeten et al. 1981-1982)
Barley	5.97	2.21	0.76	2.35	2.14	0.04	0.58	(Mustafa et al. 1999)
Maize	6.2	1.3	1.3	0.1*	2.8	0.5	0.8	(Kim et al. 1999)
Maize	3.7	1.44	nd	1.81	0.97	0.56	0.27	(Sweeten et al. 1981-1982)
Maize	7.5	2.3	nd	nd	0.5	nd	2.1	(Maiorella et al. 1983)
Potato	6.0	1.45	0.05	0.7	3.1	nd	0.7	(Czupryński et al. 2000)
Wheat	8.4	3.8	1.14	2.86	2.67	0.185	0.7	(Mustafa et al. 1999]
Wheat	12	3.8	2.3	0.12	6	nd	0.156	(Davis et al. 2005)

Note: nd = no data available. *Acid detergent fibre.

sodium than wheat-based stillage (Mustafa et al. 1999). Owing to the chemical composition of the dry matter basis (Table 2) (but primarily because of the beneficial proportion of the total protein content to the contents of the other nutrients) potato stillage has been regarded as valuable fodder (despite high water content, 90 to 95.3%) (Maiorella et al. 1983; Larson et al. 1993; Ham et al. 1994; Fisher et al. 1999; Mustafa et al. 2000). It should, however, be noted that the feeding value of the potato stillage (determined as protein and vitamin content) is lower than that of the grain stillage (Maiorella et al. 1983). As far as the stillage derived from wheat, rye, triticale and barley is concerned, the lowest nutritive value (measured as crude protein and neutral detergent fibre fraction) is that of the barley-derived stillage, both in its liquid and solid fraction (Mustafa et al. 2000).

Unprocessed warm stillage has the highest feeding value, but also a serious drawback: it cannot be stored over a longer period because of its proneness to souring and mould growth. This means that the animals should be fed shortly after the stillage has been produced, which makes this method of stillage utilization really troublesome. Feeding farm animals with “raw” stillage is cost-effective only if the users live in the close proximity of the distillery. Because of the high water content, the transport of the stillage over long distances is unprofitable (The Mother Earth News, 1980; Ganesh and Mowat, 1985; Aines et al. 1986). The best solution to this problem seems to be the integration of a small rural distillery with a large animal farm that would be able to consume the whole volume of the stillage produced (Carioca et al. 1981; Ganesh and Mowat, 1985). But in Poland an opposite trend is being observed. Rural distilleries are becoming independent economic units interested in their own development. On the other hand, large animal farms are lacking. Under such conditions the problem of utilizing the stillage volume produced entirely as animal fodder remains unsolved.

Since “raw” stillage cannot be stored over a long period, it must be processed as otherwise its nutritive value is lost. One of the methods for extending the storage life of starch-based stillage is souring by the addition of corn or hay for example. The fodder obtained in this way can be stored for several months but the nutritive value may decrease (McCullough et al. 1963; Hunt et al. 1983; Muntifering et al. 1983). Another drawback inherent in stillage is the remarkably high content of crude fibres, which limits its application as fodder, especially for nonruminant farm animals (Kienholz et al. 1979). Recent research has shown that lactic bacterial inoculants improve feed preservation (Garcia and Kalscheur, 2004).

Another method of utilizing starch stillage is yeast cultivation, where the yeast biomass is used as fodder (Murray and Marchant, 1986; Jamuna and Ramakrishna, 1989). However, the investigations reported on in the literature involved predominantly vinasse (Tauk, 1982; Malnou et al. 1987; Moriya et al. 1990; Cibis et al. 1992), while yeast was cultivated on an industrial scale. Unfortunately, the COD level in the effluent from cultivation was so high that the reduction in this pollutant approached 70% at the most. That is why this method of utilizing vinasse has been abandoned and investigations into yeast cultivation on distillery stillage have been practically discontinued.

Table 3. Chemical composition of liquid phase in starch stillage [g/L] (except pH [-], density [^{o}Blg], COD and BOD$_5$ [g O$_2$/l]).

Parameter	Type of stillage																		
	Maize (Dahab and Young, 1981)	Maize (Cibis, 2004)	Wheat (Weiland and Thomsen, 1990)	Wheat (Nagano et al. 1992)	Wheat (Hutnan et al. 2003)	Wheat (Hutnan et al. 2003)	Barley (Kitamura et al. 1996)	Barley (10%) and sweet potato (90%) (Shin et al. 1992)	Rye (Cibis, 2004)	Grain (Laubscher et al. 2001)	Awamori (rice) (Tang et al. 2007)	Jowar (shorgum) (Khardenavis et al. 2007)	Rice (Khardenavis et al. 2007)	Starch waste feedstocks (Cibis, 2004)	Potato (Cibis et al. 2002)	Potato (Cibis et al. 2002)	Potato (Cibis et al. 2006)	Potato (Weiland and Thomsen, 1990)	Sweet potato (Nagano et al. 1992)
pH	-	3.70	3.8-4.0	4.6	3.35	3.7	3.7-4.1	5.1	3.94	4.0-4.5	3.65	3.6	2.9	3.88	3.69	3.62	3.88	3.9-4.9	4.5
Density	-	2.9		-	-	-	-	-	3.1	-	-	-	-	12.2	4.6	4.7	7.9	-	-
Suspended solids	-	-	40-65	18.4-23.0	38.6	70.34	-	15.3	-	1.0**	-	-	-	-	-	-	-	20-50	16.6
COD (BOD$_5$)	59.4 (43.1)	21.85	40-55	17.5-20.8 (12.5-13.6)	90.75	107.0	97 (83)	17.6	28.98	20-30	56 (50)	10.8	35	122.33	48.95	51.75	103.76	20-55	12.1 (8.5)
TOC	-	9.15	-	-	-	-	-	-	10.70	-	28.33	-	-	45.60	-	-	35.15	-	-
Reducing substances	-	4.05	-	-	-	-	-	-	11.81	-	-	0.1	2	37.06	10.47	10.6	37.44	-	-
Glycerol	-	3.95	-	-	-	-	-	-	3.22	-	-	-	-	3.81	3.04	3.25	5.96	-	-
Lactic acid	-	6.63	-	-	-	-	-	-	3.51	-	1.4	-	-	61.14	-	-	17.53	-	-
Propionic acid	-	0.21	-	0.8-1.24	-	-	-	-	0.12	-	0.623	-	-	2.77	-	-	2.64	-	0.80
Succinic acid	-	0.21	-	-	-	-	-	-	0.31	-	1.059	-	-	0.23	-	-	0.430	-	-
Acetic acid	-	0.44	-	2.1-6.6	-	-	-	-	0.27	-	0.132	-	-	4.14	-	-	2.10	-	1.90
Sum of organic acids	-	9.67	-	-	-	-	-	-	5.29	-	10.795***	0.65***	1.46***	75.11	-	-	24.46	-	-
Total nitrogen	0.546	0.67	-	1.5-1.6	4.09*	8.8*	6.0	-	0.83	0.17-0.18*	2.18*	0.126	0.140	2.57	0.52	0.81	1.05	-	1.20
Ammonia nitrogen	-	0.096	-	0.5-0.6	-	-	-	0.01	0.19	-	0.052	-	-	0.361	0.235	0.07	0.308	-	0.18
Total phosphorus	0.228	0.441	-	0.17-0.18	0.40	0.218	-	-	0.47	0.27-0.30	-	-	-	0.816	0.259	0.327	0.277	-	0.140
Phosphate phosphorus	-	0.363	-	-	-	-	-	0.039	0.28	-	0.004	0.0642	0.0416	0.588	0.167	0.260	0.165	-	-

Note: * TKN = Total Kjeldahl Nitrogen. ** TSS = Total Suspended Solids. ***VFA = Volatile Fatty Acids.

Attempts have been reported of recirculation of liquid part the stillage after solids separation (thin stillage) to the steamer or mash tub. It has been found that when approximately 75% of the water entering the steamer was replaced with grain sorghum-based thin stillage, a large increase was observed in the solids content and COD in the stillage (Egg et al. 1985). It should, however, be noted that the recirculation of the thin stillage to the mash tub is effective only if no more than 40-50% of thin stillage is recycled (Sheehan and Greenfield, 1980; Wilkie et al. 2000; Yeoh et al. 2001). Once these values have been exceeded, alcohol yield decreases, which might be attributed to the accumulation of such substances that inhibit the activity of the yeast cells (Egg et al. 1985; Kim et al. 1999; Wilkie et al. 2000). Although the recirculation of thin stillage brings about a 25% reduction in the final volume of the distillery wastewater, this is concomitant with a rise in the COD level (Wilkie et al. 2000).

Other methods of utilizing starch-based stillage include concentration and drying. Both are characterised by a high energy demand, which makes them apply to very large distilleries only (Murphy and Power, 2008). Such are in Poland the distilleries under construction with an expected production volume much greater than that of the existing ones (Reuters, 2008). The concentration and drying of starch stillage that is to be used as fodder have found wide acceptance in the United States and in Canada, where the processes are carried out in several variants (The Mother Earth News, 1980; Aines et al. 1986; Wu, 1988; Akayezu et al. 1998). One of these involves the separation of the solid fraction from the liquid fraction, using sieves, centrifuges or pressing devices (the product obtained in this way is referred to as Wet Distiller's Grain). The solid phase is then dried (Distiller's Dried Grain), while the liquid phase is concentrated until a 30-40% suspended solids content has been obtained (Condensed Distiller's Solubles). In some distilleries the concentrated liquid fraction is dried (Distiller's Dried Solubles) or mixed with the previously separated solid fraction, and the mixture obtained is dried (Distiller's Dried Grains with Solubles).

Investigations into less energy-consuming methods that would increase the suspended solids content of the stillage have also been reported. Promising results have been obtained with ultrafiltration and high-pressure reverse osmosis. The solids and ash concentrations in the permeate after reverse osmosis (measured indirectly as conductivity) are lower than those of tap water (Wu, 1988), and that is why the permeate can be used as substitute for technological water in the process of ethanol production. It is worth noting that the fermentation yield does not change even after 8fold recirculation of the permeate (Kim et al. 1999). The concentrated fraction can be used as fodder in unprocessed or dried form (Nguyen, 2003). A major drawback of this method is the occurrence of fouling and scaling phenomena, which account for membrane clogging (Gryta, 2005).

Another method for increasing the suspended solids content includes drying stillage together with a carrier, *e.g.* soy hulls or dry beet pulp. In this way pellets are obtained (Garcia and Kalscheur, 2004).

Consideration has also been given to the problem of utilizing starch-based feedstock as fertilisers (Jenkins et al. 1987), the more so as vinasse has been used for this purpose (Monteiro, 1975; Maiorella et al. 1983). It has been suggested that starch based stillage should be used for direct soil fertilization or for the production of organic fertilisers, after being mixed and composted, for example, with cow feces (Tanaka et al. 1995). However, direct fertilization must be carried out when the time is right for doing this, so as not to damage the crops (Sheehan and Greenfield, 1980; Milewski et al. 2001; Czupryński et al. 2002), but this requires storage of the stillage. It is not recommended to pour the stillage direct onto the soil, which is hollow in places, because the stillage may accumulate there and produce contamination. One of the weaknesses inherent in such application is the unpleasant odour. It is also possible to fertilise soil with the product of starch stillage incineration (Yamauchi et al. 1999), as in the case of vinasse (Maiorella et al. 1983).

The literature also includes references to other methods of utilizing starch stillage. One of these publications pertains to the use of this waste effluent for the production of rigid polyurethane-polyisocyanurate foams (Czupryński et al. 2000). The product obtained displayed properties identical to those of standard foam, besides brittleness. There are also reports on the utilization of concentrated liquid maize stillage fractions as the feedstock for the production of some cosmetics, *e.g.* alternan (Leathers, 1998) and pullulan (West and Strohfus, 1996). Furthermore, maize stillage was made use of as the feedstock for the synthesis of astaxanthin carotenoid by *Phaffia rhodozyma* (Leathers, 2003). Other starch stillage has been used for the synthesis of protease (Morimura et al. 1994; Yang and Lin, 1998), chitosan (Yokoi et al. 1998) and biodegradable plastics, e.g. poly β-hydroxybutyrate (Khardenavis et al. 2007).

Biodegradation of starch stillage

The methods considered in the foregoing section do not enable utilization of the whole starch stillage volume produced. As a result distilleries are facing a serious problem. The stillage is a high-strength effluent which - because of a considerable organic matter content (Table 3) - can neither be sent to the sewer system nor be discharged into a watercourse or soil; at least a certain portion of the COD load must be removed at the source origin.

The COD load of the liquid phase varies from 12.1 g O_2/l for the sweet potato stillage (Nagano et al. 1992) to 122.33 g O_2/l for the stillage from waste feedstocks containing wheat starch (80%) and potato starch (20%) (Cibis, 2004). The comparison of the chemical composition (Table 3) shows that even if the stillage comes from the same feedstocks, it differs considerably in its chemical properties. This finding should be attributed to the fact that the COD content is influenced not only by the feedstock but by the technology of spirit production and the method of feedstock and stillage storage as well.

Distiller's stillage shows a proneness to sour fermentation. This is due to the formation (within a comparatively short period) of organic acids, mainly lactic acid, which usually dominates in that type of stillage (Table 3). As for the other carbon sources, reducing substances and glycerol are found to occur in large amounts (Table 3). The presence of total and phosphate phosphorus, as well the large amounts of total nitrogen (Table 3), can be explained as being associated with the high protein proportion in the feedstock from which the stillage comes (Wilkie et al. 2000).

Such chemical composition suggests that starch stillage is biodegradable to a great extent. Aerobic and anaerobic fermentation of thin stillage was first reported four decades ago (Fargey and Smith, 1965; Smith and Fargey, 1965). The problem, however, has not attracted much attention until recently. In the past 15 years, a number of publications have dealt with the biodegradation of starch stillage, but they have described anaerobic processes only (Weiland and Thomsen, 1990; Nagano et al. 1992; Goodwin and Stuart, 1994; Laubscher et al. 2001; Gao et al. 2007; Tang et al. 2007). Laboratory investigations into the anaerobic treatment of wheat stillage of an initial COD ranging from 91 to 107 g O_2/l (Hutnan et al. 2003) and of malt whisky distillery wastewater with an initial COD between 30.5 and 47.9 g O_2/l (Goodwin and Stuart, 1994) have revealed an approximately 90% reduction of this pollutant. The treatment of grain distillation wastewater whose initial COD level ranged from 20 to 30 g O_2/l with the aid of an upflow anaerobic sludge bed (UASB) system has yielded an approximately 80% COD removal efficiency (Laubscher et al. 2001). When barley stillage and sweet potato stillage of an initial organic matter content of 29.5 g O_2/l were treated in a continuous process, COD reduction amounted to 80% (Shin et al. 1992). A 98% reduction in COD was attained with wheat stillage and sweet potato stillage of an initial pollution load of 40 g O_2/L (Nagano et al. 1992). When potato stillage with an initial content of organics ranging between 20 and 55 g O_2/l was treated, the extent of COD reduction varied from 80 to 95% (Weiland and Thomsen, 1990). With a potato and sugar beet stillage of an initial organic pollution load of 40 g O_2/l, the reduction in COD amounted to 90% (Wilkie et al. 2000).

Anaerobic biodegradation of stillage is being carried out on an industrial scale. At least 135 anaerobic bioreactors are operated all over the world; nine of these (with four operating in Germany) are used for the treatment of starch stillage, the other bioreactors being made use of for treating primarily vinasse (Wilkie et al. 2000).

Starch stillage can be treated with an equal efficiency by aerobic methods. One of the first publications dealing with this problem comes from 1965 (Smith and Fargey, 1965). The investigations reported there have shown that if maize stillage is treated in a stirred tank reactor (STR) at room temperature, COD can be reduced by 60.7%. The same investigators have obtained a much higher (98%) reduction in COD, using a bioreactor with a fixed bed and recirculation of the stillage being treated.

Over the 35-year period that followed no research on aerobic biodegradation of starch stillage was reported. It was only a few years ago that such problems became, again, the focus of attention (Cibis et al. 2002; Krzywonos et al. 2002; Cibis, 2004; Cibis et al. 2004; Ferzik et al. 2004; Cibis et al. 2006; Krzywonos et al. 2008). Some of the investigations dealt with the treatment of potato stillage, and were conducted batchwise in an STR with a mixed culture of thermo- and mesophilic bacteria of the genus *Bacillus*. The extent of COD reduction obtained in this way totalled up to 89.8%. The efficiency of biodegradation depended on the following factors: temperature, pH, initial COD, and addition of nutrients (ammonia nitrogen and phosphate phosphorus) (Cibis et al. 2002, Krzywonos et al. 2002; Cibis, 2004; Cibis et al. 2004; Cibis et al. 2006; Krzywonos et al. 2008). The same bacterial culture was used for the biodegradation of the stillage coming from maize and rye. With the maize stillage, the reduction in COD amounted to 82.6%; with rye stillage, COD reduction totalled 84.6% (Cibis, 2004). When the stillage under treatment came from the waste feedstock for the production of glucose syrup and chips (about 80% of wheat starch and about 20% of potato starch), the extent of COD reduction approached 94% (Cibis, 2004). Similar treatment effects for this stillage were obtained with the continuous biodegradation process (Cibis, 2004). Reports are also available on the aerobic degradation of distiller's stillage (wheat grain) with bacterial cultures (Ferzik et al. 2004). A batch biodegradation system yielded a 64% COD reduction at 45ºC, whereas a continuous process brought about an approximately 90% reduction in COD at 55ºC.

In contrast to anaerobic methods, aerobic biodegradation of starch stillage with thermo- and mesophilic bacteria has not yet been conducted on an industrial scale. The results obtained during laboratory-scale aerobic thermo- and mesophilic biodegradation of distillery wastewater indicate that the effectiveness of this method the same as for another microorganisms (Anastassiadis and Rehm, 2006; Battestin and Macedo, 2007; Choorit and Wisarnwan, 2007) is influenced by the aerobic conditions, pH and temperature (Cibis et al. 2002; Krzywonos et al. 2002; Krzywonos at al. 2008). The results of laboratory investigations seem to encourage the upgrading of the research scale.

CONCLUDING REMARKS

In principle, only distilleries integrated with stock farms and large distilleries-factories rarely have trouble with the utilization of starch-based stillage. Any other distillery has to tackle the problem more or less successfully (Wilkie et al. 2000; Nguyen, 2003). It is essential to note, however, that in Germany the integration of distilleries with stock farms permits them to avoid troubles. This is not so in the USA, where ethanol plants have difficulties with the profitability of stillage marketing or disposal. Most of the stillage produced is sold in the form of Distiller's Dried Grains with Solubles. As for Poland's distilleries, the majority of them are not able either to utilize their stillage in ruminant diets or treat it efficiently. Only four have constructed mechanical-biological wastewater treatment plants, and some distilleries treat their effluents with mechanical methods (Cavey et al. 1998). Regretfully, 20% of distilleries discharge their wastewater direct into a watercourse or into soil without recultivation (Milewski et al. 2001). This indicates that the poor utilization of the stillage produced must raise serious concern. Considering the environmental rules and regulations recently enforced in Poland immediate measures have to be taken to solve the problem, which has taken on a sense of urgency.

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Chapter 16

Feedstocks, fermentation and distillation for production of heavy and light rums

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Introduction

The US Bureau of Alcohol, Tobacco and Firearms regulations (1982) define rum as: 'an alcoholic distillate from the fermented juice of sugar cane, sugarcane syrup, sugarcane molasses or other sugarcane by-products, produced at less than 190° proof (95° GL), in such a manner that the distillate possesses the taste, aroma and characteristics generally attributed to rum, and bottled at not less than 80° proof (40° GL), and also includes mixtures solely of such distillates'.

It should be noted that unlike the US regulations for whisky, the regulations for rum do not include any requirement that it be aged in oak barrels for a minimum period of time. The US regulations also do not specify any geographic region in which rum may be produced, however the British regulations define rum as: 'a spirit distilled directly from sugarcane products in sugarcane-growing countries'.

The regulations are rather vague of necessity owing to the very wide variety of rums ranging from the light, nearly neutral, continuous still products to the heavily flavored, dark, navy-type pot still products. The diversity of rum types and their production methods makes comprehensive coverage of the industry almost impossible for a publication such as this. Thus, readers should consult the references for additional information. What are now considered the classic studies on rum production were published by Rafael Arroyo of Puerto Rico in the 1940s (see reference list). That was at a time when the island's rum industry increased production very significantly in order to meet the demand arising from a wartime shortage of whisky and grain spirits. Other more recent studies and helpful reviews of the rum industry have been published by Clutton (1974), Ianson (1971), Kampen (1975), Lehtonen and Suomalainen, (1977) and Paturau (1969).

Feedstocks: fresh sugarcane juice or diluted molasses

Cane juice

Using cane juice for rum production has both advantages and disadvantages. The main advantage is that no additional processing is required. The cane is simply crushed and the juice fed directly into the fermenters. Another advantage is that cane juice does not have a high content of dissolved salts and therefore does not cause as much scaling and blocking of distillation columns as may occur using molasses.

One of the main disadvantages of using cane juice is that it normally contains only about 12-16% w/w sugar, so that the alcohol content of the fermented material is limited to about 6 -8% v/v as compared to 10-13% v/v obtainable from molasses. Another significant disadvantage is that cane juice cannot be stored in bulk for any considerable length of time. Heavy contamination with bacteria and yeasts causes it to start to ferment spontaneously and very rapidly. This means that the distillery must be located in close proximity to the cane mill. It also means that the cane juice is only available during the cane harvesting season, which generally does not exceed six months per year. Thus, some rum distilleries may use cane juice during the harvest season and molasses for the remainder of the year. Cane juice may also have cost disadvantages in that it is a primary, or at least an intermediate product in the production of sugar. In contrast, molasses is generally a by-product, considered to be of lower value.

Cane juice normally becomes heavily infected with bacteria and yeasts in the crushing process. Pasteurization prior to fermentation is usually infeasible due to the large amount of suspended fiber in the juice, which would tend to block most heat exchangers. Thus the contaminating organisms may significantly reduce alcohol yields from cane juice.

Molasses

The use of molasses as a feedstock for alcohol production has been covered in an earlier chapter in this volume; therefore only a few comments are necessary with specific reference to rum.

The source of the molasses can have a strong influence on the aromatic quality of rum. This has been demonstrated in trials on making rum from beet molasses where it was found that it was not possible to obtain the same characteristic aromas as obtained from cane molasses (Arroyo, 1948b). Arroyo (1941, 1942) reported that fresh blackstrap molasses with its low viscosity, high total sugars, nitrogen, phosphorus and a low ash and gum content was preferable in the production of rums with desirable odors and tastes.

Fermentation methods

Heavy rum

Just as there are many different types of rum, there are many different methods of fermentation. In the production of heavily flavored rums, cane juice or diluted molasses mash may be allowed to ferment spontaneously using yeasts present naturally in the feedstock. This is relatively inefficient in terms of alcohol production; and the results may vary. However, it is the high level of bacterial contamination in these fermentations that produces many of the desirable congeners such as acids and esters. In some processes, e.g. in Jamaica, the spontaneous fermentation may be assisted by the addition of 'dunder' at the start of fermentation. Dunder is old stillage that has been stored in open tanks to allow development of a strong bacterial flora.

To attempt a more controlled fermentation in production of heavy rums, a pure culture of yeast may be used together with a pure bacterial culture. A specially selected strain of yeast, usually *Saccharomyces cerevisiae*, which is a budding yeast, or possibly other species such as the fission yeast *Schizosaccharomyces pombe*, is propagated from an agar slant. This culture is transferred every 12-24 hrs through a series of Erlenmeyer flasks each holding increasing amounts of sterilized, diluted molasses mash supplemented with malt syrup or other sources of nutrients. When about 20 liters of yeast culture have been produced, it may be used to inoculate about 200 liters of diluted molasses mash in a small plant propagator or 'prefermenter'. The contents of the vessel are aerated, and after about 8-12 hrs of propagation are used to inoculate a larger prefermenter containing about 2,000 liters of mash. This vessel may also be aerated and fed incrementally with more diluted molasses medium until it contains the equivalent of about 10% of the capacity of the plant fermenters.

It is generally considered desirable to have a minimum of about 50 million yeast cells/ml of medium when the fermentation has been completed. Thus, after allowing for yeast propagation during the filling process, the 10% yeast inoculum should have a cell count of about 200 million cells/ml to achieve this objective.

A pure culture of bacteria such as *Clostridium saccharobutyricum* may be added after 6-12 hrs of the yeast fermentation. Usually the bacterial inoculum amounts to about 2% of the fermenter capacity; and the pH of the fermenting mash is adjusted upwards to about pH 5.5 before addition to give more suitable conditions for the bacterial propagation. The bacteria produce a mixture of acids, predominantly butyric, together with others such as acetic, propionic, and caproic acids. These acids in turn react with the alcohol to produce desirable esters.

Fermentation for light rums

In light rum production, the emphasis is generally on maintaining clean, rapid fermentations to minimize development of undesirable congeners and to maximize fermentation efficiency. Pure cultures of yeast may be propagated as previously described. These may be accompanied by the use of antibiotics such as penicillin or bactericides such as chlorine dioxide, ammonium bifluoride or quaternary ammonium compounds to control bacterial contamination.

Some plants use 'mother yeasting'. In this system a pure yeast culture is propagated in the prefermenter. The pH is lowered to about 3.7 to reduce bacterial growth; and up to 90% of the yeast volume is used to inoculate a fermenter. The prefermenter is refilled with mash to repeat the process several times.

In other plants, the yeast may be recycled from one fermenter to another. This is done by centrifuging the yeast out of the fermented beer prior to distillation and then subjecting it to an acid washing at pH 2.2-2.5 to kill most of the contaminating bacteria. As an alternative to acid washing, the yeast may be treated with about 15 ppm chlorine dioxide at a pH of about 3.5. The objective of yeast recycling is to save on sugar that would otherwise be needed for yeast growth and to ensure a very high cell count in the fermenter inoculum. This provides a rapid fermentation in which bacteria lack sufficient opportunity to get well established.

Commercial dry yeasts may also be used in light rum fermentations. A large quantity of dry yeast may be added to the molasses mash at the start of fermenter filling. More commonly, in order to save cost a smaller quantity of the dry yeast may be rehydrated and propagated for several hours in a prefermenter before transfer to the fermenter.

Distillation

The method of distillation used has a considerable effect on the nature of the rum product. Heavy rums are usually produced by batch distillation, while light rums are normally produced by continuous distillation.

Batch distillation: heavy rum

Batch distillation may be performed with various types of equipment. The simplest form is a single, simple pot still. Here, the fermented beer is transferred into a copper tank or 'pot', as shown in Figure 1. The pot is heated either by an internal steam coil (calandria) or by a fire of wood or bagasse underneath, usually in a brick enclosure. The pot is fitted with a vapor pipe which leads to a condenser coil immersed in a water tank. As the beer is heated, the alcohol and other volatile congeners are distilled off, condensed and run into a storage tank. Usually the first fraction distilled contains much of the more volatile, pungent 'heads' congeners and is discarded as the 'heads cut'. The process is continued until most of the alcohol has been distilled out of the beer.

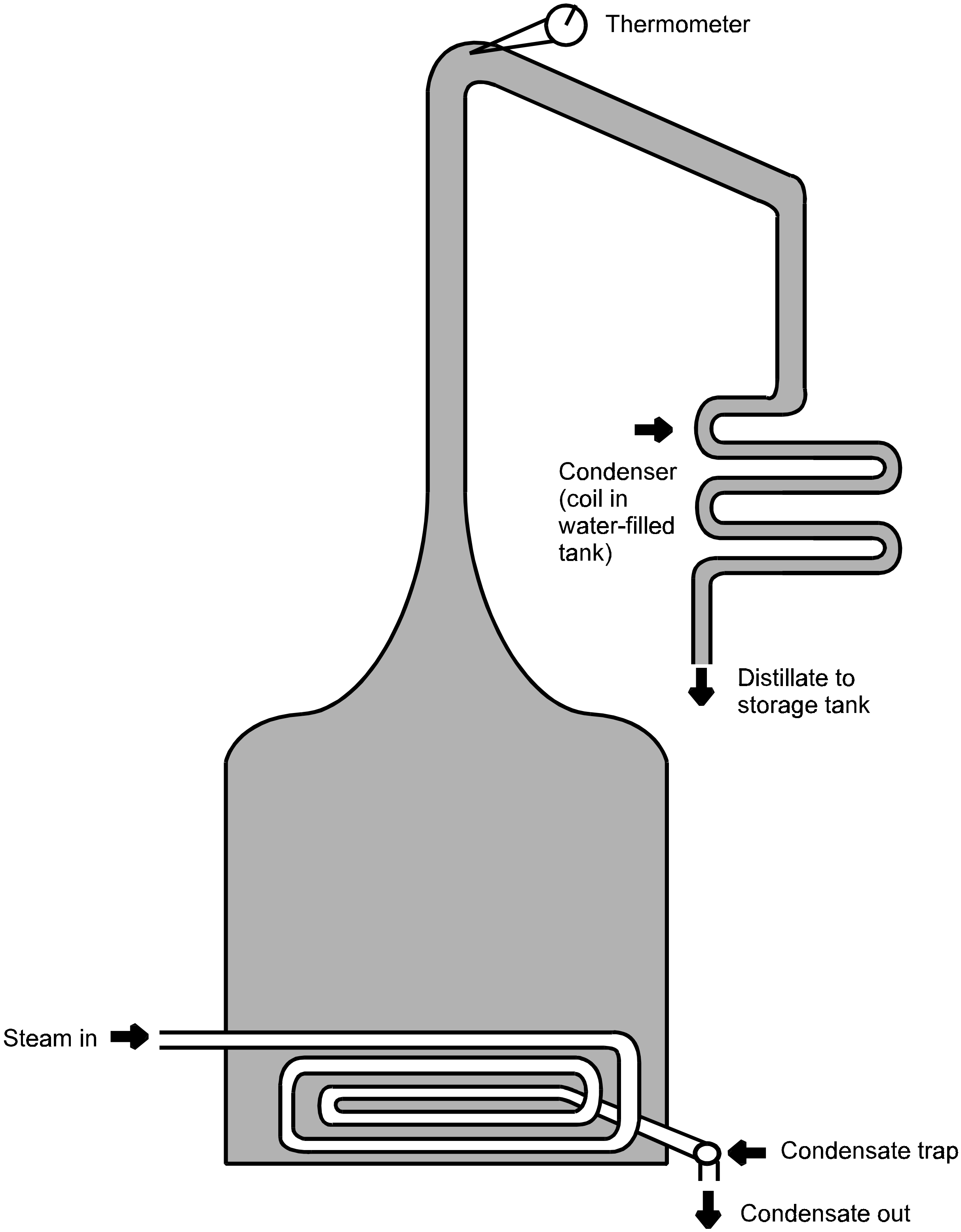

Figure 1. Simple pot still for heavy rum production.

The beer residue, or 'stillage', is emptied out of the pot and the distillate is returned from the storage tank to the pot to be redistilled to increase the proof. A heads cut may again be discarded together with a 'tails cut' taken toward the end of the distillation. The 'center cut', which is the bulk of the distillate, has the more pleasant aromas of fruity esters characteristic of rum. Normally, there are only two pot distillations, but there may be a third if desired.

Two or three pot stills may be interconnected, as shown in Figure 2, to eliminate the need to transfer the distillate back into the first pot for redistillation and to conserve energy. The efficiency of the pot still in separating congeners may be improved considerably by including perhaps five or six bubble cap trays between the pot and the vapor pipe, and a simple condenser above the trays to provide some reflux as shown in Figure 3. This is the design of pot still most frequently used by small, on-farm producers of common tafia and aguardiente rums. It is a simple progression from this pot still to the batch kettle and column still used by larger scale rum producers, as shown in Figure 4.

In some countries crude rum or aguardiente is produced on a small scale by numerous farmers using pot stills. Their product may then be sold to companies that redistill it in a batch system to standardize quality for sale as heavy rum or for blending with neutral or nearly neutral spirits to make light rums.

Continuous distillation: light rum

Continuous distillation is usually confined to the production of light rums. A two column beer still with a Barbet type prestripper, as shown in Figure 5, is normally preferred as it permits removal of heads, volatile sulfur compounds and some other undesirable fractions before the bulk of the alcohol enters the concentrating column. (Operation of this type of beer still is discussed in the chapter on neutral spirit production).

When a lighter or less flavorful rum than can be produced on a simple two column beer still is required, an extractive distillation column and a rectifier as employed in neutral spirit production can be used (Figure 6).

Combinations of batch and continuous distillation

There are many possible variations and combinations of distillation processes. For example, crude pot still distillates may be put through a simple continuous distillation unit to produce a more acceptable, standardized product. Arroyo has described two techniques for combinations of continuous and batch distillations to produce both heavy and light rums at the same time. In one system Arroyo (1948c) suggested that the beer first be distilled in a single continuous column with only about five concentrating plates. Provision for fusel oil removal allows some control over the fusel content in the distillate, which has a proof of about 70° GL. He then recommended that the distillate be diluted to about 40° GL and be submitted to a batch distillation.

The distillate from the batch column should be collected as five separate fractions based on monitored odor variations and rising distillation temperature. Arroyo found that the first fraction, which distilled between 69 and 72°C at a proof of about 91° GL, represented about 5% of the total distillate volume and consisted of unpleasant aldehydes, organic acids and esters. He recommended this fraction either be discarded or held for subsequent reprocessing to recover some of the ethanol. The second fraction, distilling over a temperature range of 72-77°C at a proof of 93-94° GL, represented about 10% of the total distillate volume and contained ethanol with appreciable amounts of aldehydes and esters. The third fraction, which distilled at a fixed temperature of 78°C and a proof of about 95.5° GL, was the largest in volume at 55-60% of the total and contained mostly ethanol with very small amounts of congeners such as aldehydes, esters and higher alcohols. It also contained the lowest

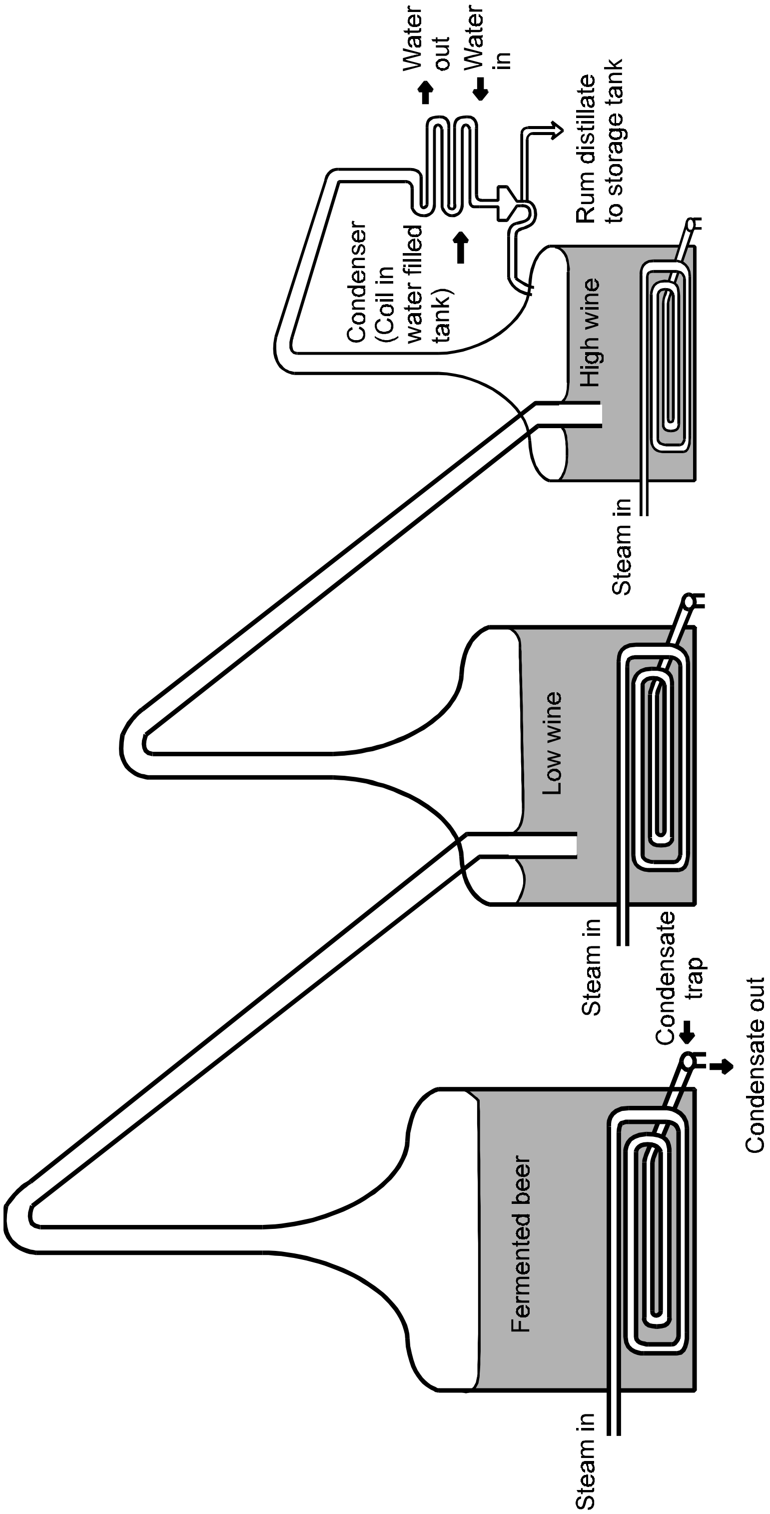

Figure 2. Triple pot still system for heavy rum production.

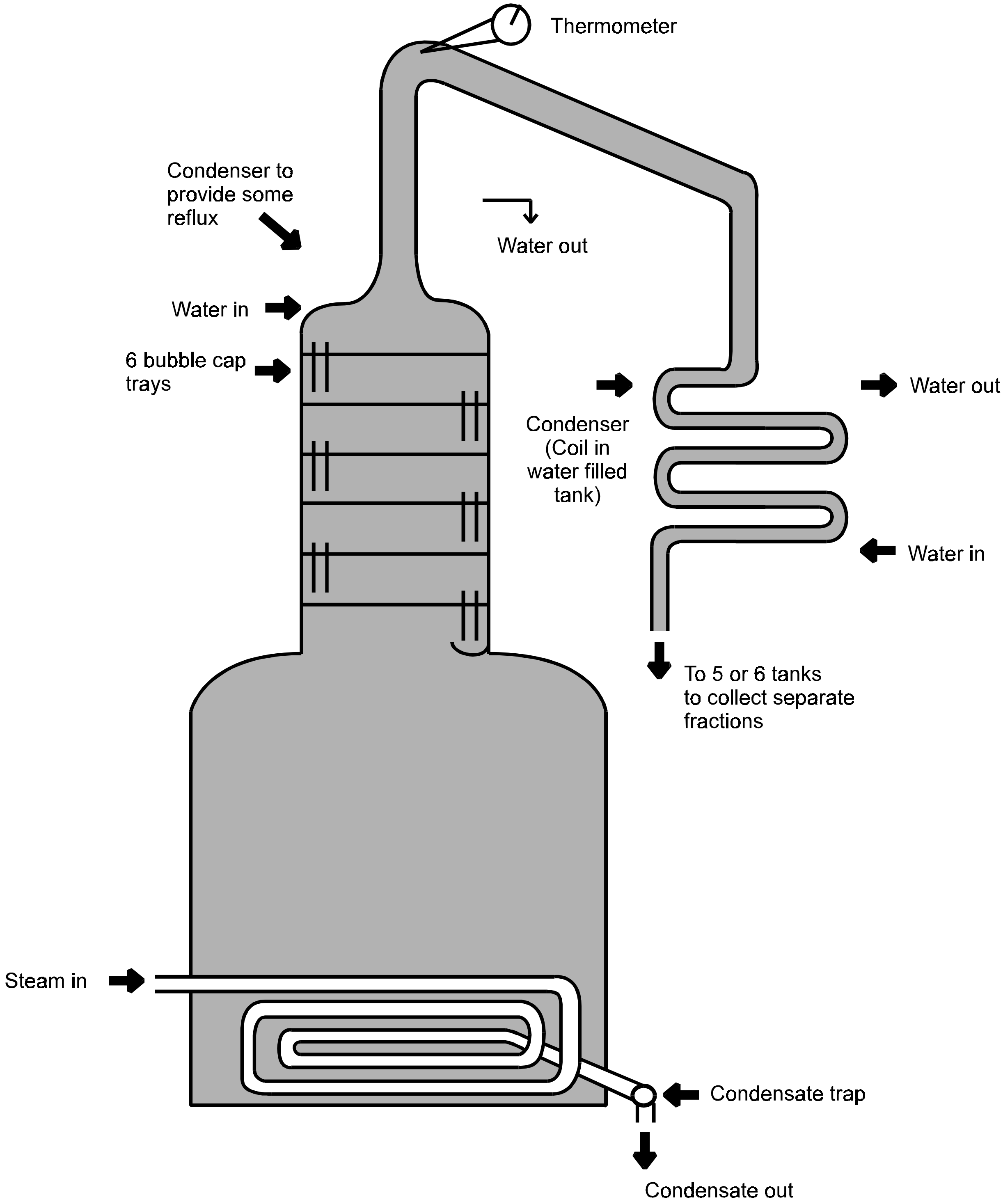

Figure 3. Pot still with bubble cap tray section.

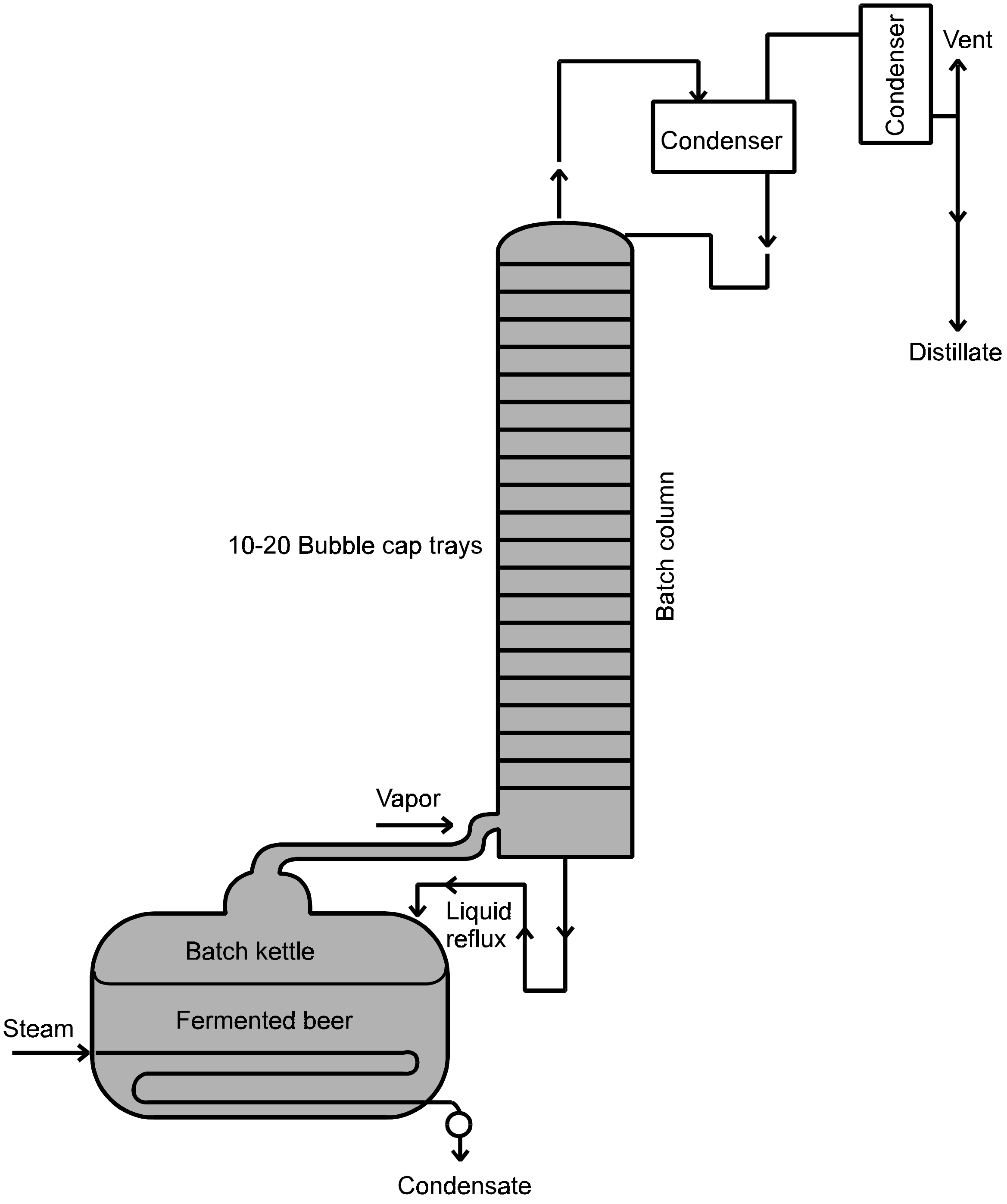

Figure 4. Batch still for rum production.

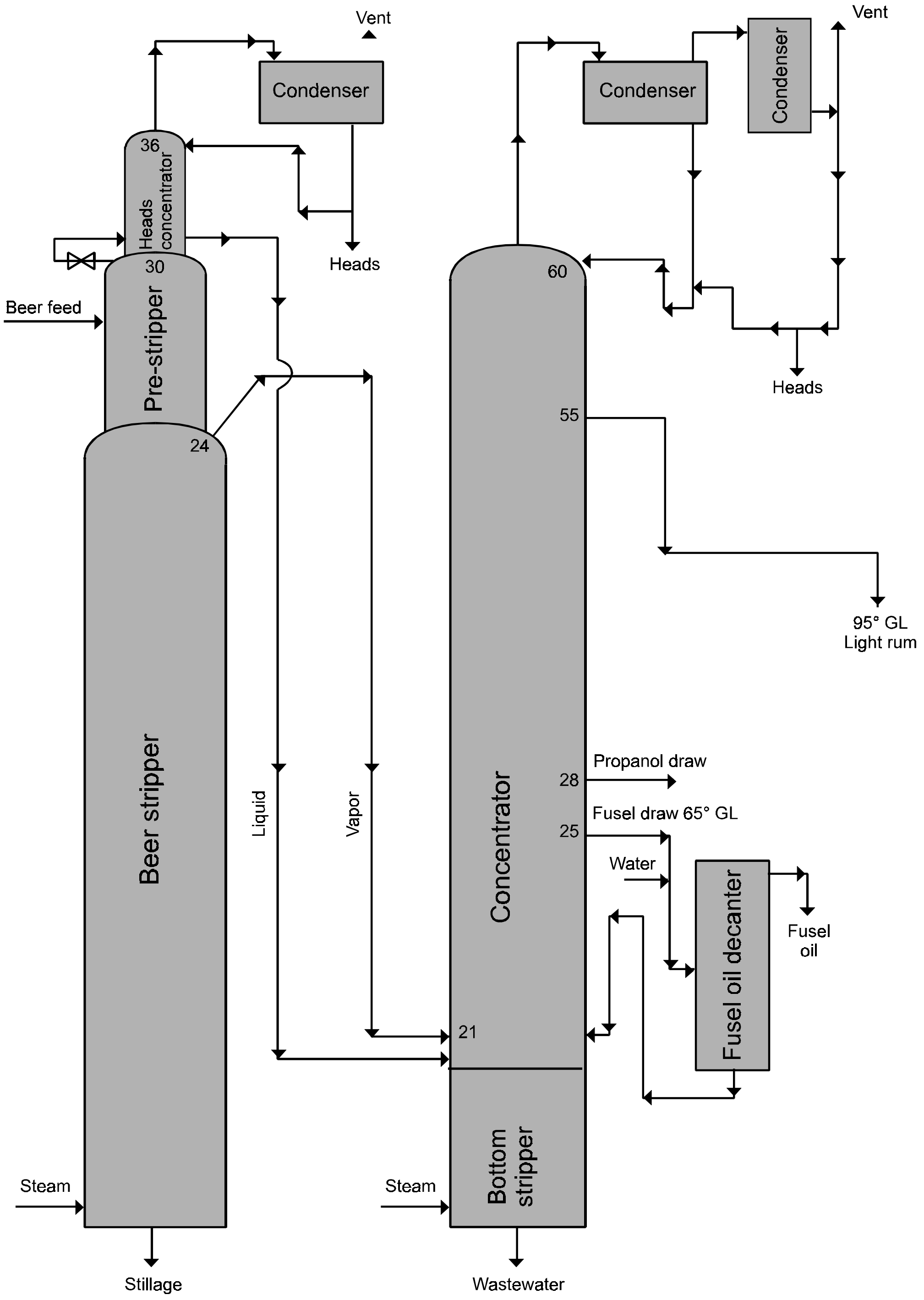

Figure 5. Modified Barbet beerstill for light rum production.

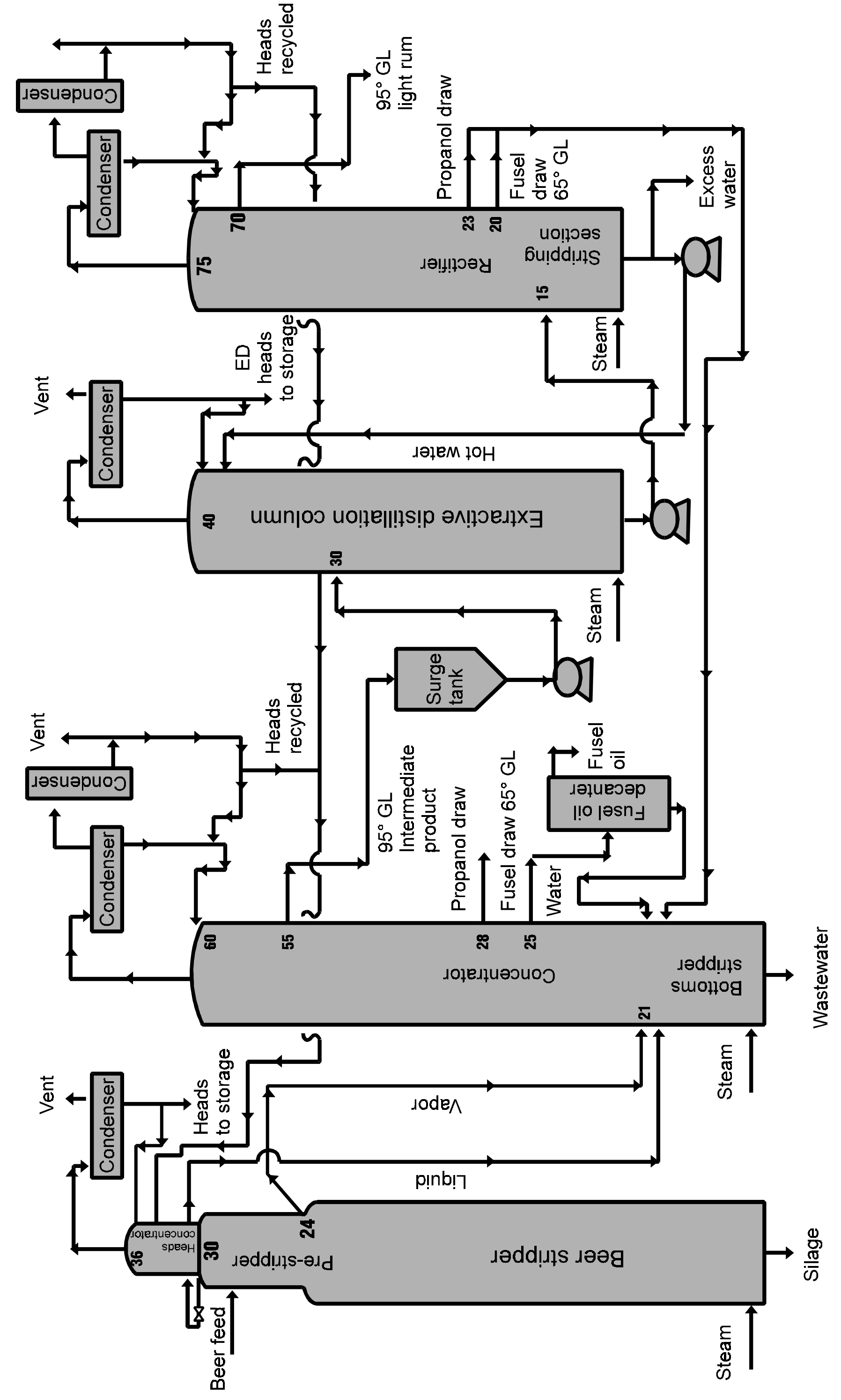

Figure 6. Four column distillation and rectification system for the production of light rum.

concentration of volatile organic acids. The fourth fraction was collected at a distilling temperature range of 78.5-85°C at a proof of about 90° GL. This fraction was characterized by the presence of most of the higher alcohols from the original continuous still distillate together with more esters, aldehydes and acids than in the previous fraction. The fifth and final fraction was collected over a distilling temperature range of 85-90°C and had a much lower proof than the other fractions (25-30° GL). This fraction was opalescent or turbid due to the presence of some of the highest boiling point esters and aldehydes which are more soluble in ethanol than in water.

Arroyo then recommended mixing the last four fractions in various proportions to make both light and heavy rums. He quoted an example of using 25% of the second fraction, 50% of the third fraction, 40% of the fourth fraction and 15% of the fifth fraction to make a light rum while using all the balances to make a heavy rum and avoid wastage.

In another combined process, Arroyo (1949b) suggested that the various congener sidestreams removed in the production of very light rums or neutral spirit by continuous distillation should be mixed, diluted with water and subjected to a fractional distillation almost identical to that used in the previous process. The distillate should be split into a similar set of five fractions with the first discarded, the third mixed with the light rum and the other three fractions used in various proportions for blending heavy rums. Arroyo claimed that these rums matured more rapidly than normally produced heavy rums when aged in oak barrels. As such there was a saving on warehouse space and other costs.

Rum maturation and blending

The normal and most reliable method of maturing rum to make it more suitable for consumption is by aging in oak barrels. Light rums with very low levels of congeners may require very little aging and may be acceptable after just a few weeks in barrels. In fact, many of the currently popular lighter rums are not aged at all. The heavy rums, however, tend to require much more aging to become palatable and may be held in barrels for five years or longer.

The barrels normally used for rum aging are obtained from the US, where government regulations specify that bourbon whiskey must be aged in new oak barrels thereby creating a large supply of once-used barrels. The bourbon barrels are charred on the inside and are used for aging rum either with the char intact or after its removal, depending on the preference of individual distillery.

Oak wood has a strong influence on the maturation and ultimate flavor of the rum, largely due to the extraction of compounds such as tannins and calcium salts and colorings such as quercitine. The type and quantity of the extracted compounds depend largely on the length of time and temperature of aging, the proof of the rum, the type and former usage of the barrel and the amount of contact surface it offers. New oak barrels, or fresh, once-used bourbon barrels naturally have more extractable compounds than old barrels that have been used many times over several years. Thus, a light rum stored in new or once-used barrels for a year or two may emerge with much of the odor and taste of a bourbon whiskey, as the main characteristics of bourbon are derived from the oak wood. This odor and taste may or may not be desirable. A program should therefore be established to identify individual barrels and code them as to history of usage in order to select particular types or ages of barrels for particular rum products. For example, in countries requiring that rum be aged in wooden barrels for a minimum period of time (which may be 1-3 years), light rums should be aged in the oldest available barrels as these will contribute the least amount of flavor. Even then, it may be necessary to treat the aged product with activated charcoal to reduce the color and flavor before bottling.

The main reactions that take place during aging to make rums more palatable are esterification, condensation and oxidation. The formation of esters involves a reaction between acids and the ethanol or other alcohols in the rum, and can take a considerable amount of time. The presence of esters gives the rum a generally desirable fruity aroma. In the condensations, molecules such as aldehydes and alcohols may combine to form acetals. In oxidations that occur with air passing through the pores in the wood, ethanol may be oxidized to acetaldehyde, which in turn may be oxidized to acetic acid, to then undergo esterification to ethyl acetate.

The temperature at which rums are aged will greatly affect the rate of maturation. It is reported that the rate of maturation at 25°C may double at 35°C (Kampen, 1975). This means that rums aged in the tropics will tend to mature more rapidly than those aged in temperate climates unless the warehouses are heated. The higher temperatures do, however, increase the annual rate of evaporation loss of rum through the wood.

The wood contact surface area may be increased by adding some charred or toasted oak chips to the barrels. The chips are relatively inexpensive as they can be made from scrap wood and can provide a means of standardizing the rate of maturation if fresh supplies are used each time.

Some rum producers add fruit extracts, sugar and even artificial rum essences to their products. The use of artificial essences should, however, be avoided or kept to a minimum as the product will usually have a noticeably artificial character. This is because an essence containing possibly four or five chemical compounds cannot give the overall 'roundness' of odor and taste that comes from the dozens or even hundreds of different congeners present naturally in a good heavy rum.

Characteristics of the aged rums should be carefully checked prior to bottling. Some blending may be required to ensure consistency with rum bottled previously under the same brand labels. Caramel coloring may be added to adjust the color of the rum to a standard in order to compensate for color variations acquired from the barrels used in aging.

Disposal of rum distillery wastes

The disposal of molasses stillage is a major problem in most rum producing areas as the liquid waste has a high biological oxygen demand (BOD) and will cause serious pollution if discharged into rivers or other watercourses.

There are some limited uses of the stillage. It may, for example, be sprayed on unpaved roads in dry seasons to reduce dust. Similarly, if evaporated to a syrup referred to as 'condensed molasses solubles', it may be used as a dust suppressant and source of minerals in cattle feeds. In some countries, a dried molasses stillage powder is sold for cattle feeding.

Evaporated stillage syrup may be burned in boilers as a partial replacement for bunker-C fuel oil; but the energy yield barely covers the energy required for the evaporation. There have also been reports of the use of molasses stillage as a binder in the production of concrete blocks. Generally, however, molasses stillage must be subjected to waste treatment processes. It was reported by Szendrey (1983) that the Bacardi Corporation in Puerto Rico uses an anaerobic digestion system to treat stillage and to produce methane for use as a boiler fuel. Other stillage waste treatment systems include anerobic and aerobic lagoons.

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DISTILLERY WASTEWATER TREATMENT AND DISPOSAL

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ABSTRACT

1. One of the most important environmental problems faced by the world is management of wastes. Industrial processes create a variety of wastewater pollutants; which are difficult and costly to treat. Wastewater characteristics and levels of pollutants vary significantly from industry to industry. Now-a-days emphasis is laid on waste minimization and revenue generation through byproduct recovery. Pollution prevention focuses on preventing the generation of wastes, while waste minimization refers to reducing the volume or toxicity of hazardous wastes by water recycling and reuse, and process modifications and the byproduct recovery as a fall out of manufacturing process creates ample scope for revenue generation thereby offsetting the costs substantially.

2. Production of ethyl alcohol in distilleries based on cane sugar molasses constitutes a major industry in Asia and South America. The world's total production of alcohol from cane molasses is more than13 million m^3/annum. The aqueous distillery effluent stream known as spent wash is a dark brown highly organic effluent and is approximately 12-15 times by volume of the product alcohol. It is one of the most complex, troublesome and strongest organic industrial effluents, having extremely high COD and BOD values. Because of the high concentration of organic load, distillery spent wash is a potential source of renewable energy. The paper reviews the status and appropriate treatment alternatives for disposal of the distillery wastewater.

KEYWORDS

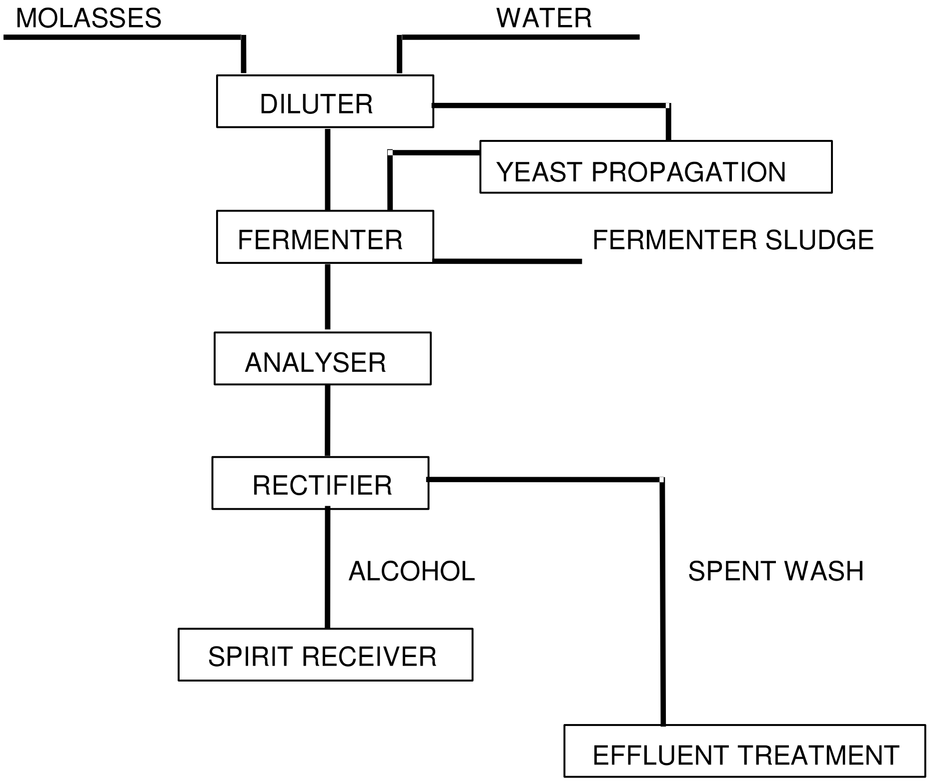
Distillery Spentwash, Revenue Generation, Byproduct Recovery.

INTRODUCTION

1. Production of ethyl alcohol in distilleries based on cane sugar molasses constitutes a major industry in Asia and South America. The world's total production of alcohol from cane molasses is more than13 million m^3/annum. The aqueous distillery effluent stream known as spent wash is a dark brown highly organic effluent and is approximately 12-15 times by volume of the product alcohol. It is one of the most complex, troublesome and strongest organic industrial effluents, having extremely high COD and BOD values. Because of the high concentration of organic load, distillery spent wash is a potential source of renewable energy.

2. The 295 distilleries in India produce 2.7 billion litres of alcohol and generating 40 billion litres of wastewater annually. The enormous distillery wastewater has potential to produce 1100 million cubic meters of biogas. The population equivalent of distillery wastewater based on BOD has been reported to be as high as 6.2 billion which means that contribution of distillery waste in India to organic pollution is approximately seven times more than the entire Indian population. The wastewater from distilleries, major

portion of which is spentwash, is nearly 15 times the total alcohol production. This massive quantity, approximately 40 billion litres of effluent, if disposed untreated can cause considerable stress on the water courses leading to widespread damage to aquatic life.



ALCOHOL MANUFACTURING PROCESS AND NATURE OF DISTILLERY WASTEWATER

3. In India bulk of the alcohol is being produced from sugar cane molasses. Molasses is a thick viscous byproduct of the sugar industry which is acidic in nature, rich in salts, dark brown in colour and it also contains sugar which could not be crystallized. For manufacturing alcohol, the Molasses is diluted with water into a solution containing 15-16 % of sugars. This solution is then inoculated with yeast strain and is allowed to ferment at room temperature. The fermented wash is distilled in a series of distillation columns to obtain alcohol of adequate/ requisite strength and quality/specification. This alcohol is used for various purposes including potable and industrial. For manufacture of alcoholic beverages, the alcohol is, if required, matured and blended with malt alcohol (for manufacture of whisky) and diluted to requisite strength to obtain the desired type of liquor/ Indian Made Foreign Liquor (IMFL). This is bottled in bottles of various sizes for the convenience of consumers.

S.No.	Parameter	Range
1.	pH	4.3-5.3
2.	Total Suspended Solids	12,000-14,000
3.	Total Dissolved Solids	45,000-75,000
4.	B.O.D., 20 ^{0}C, 5 days	40,000-50,000
5.	C.O.D.	80,000-1,00,000

BIO-ENERGY POTENTIAL FROM DISTILLERY EFFLUENTS

4. In India there are 295 distilleries producing 3.20 billion litres of alcohol generating 45 billion litres of wastewater annually. The enormous distillery wastewater has potential to produce 1200 million cubic meters of biogas. The post methanation wastewater if used carefully for irrigation of agricultural crops can produce more than 85000 tonne of biomass annually. This biogas normally contains 60% methane gas, which is a well-recognized fuel gas with minimum air pollution potential. If this source of energy is tapped, it will fetch additional energy units worth 5 trillion-kilo calories annually. Besides, the Post Methanation Effluent (PME) can provide 245000 tones of potassium, 12500 tones of nitrogen and 2100 tones of phosphorus annually. Thus the manorial potential of effluent can be measured by the fact that one year's effluent can meet the potassium requirement of 1.55 million hectare land, nitrogen requirement of 0.13 million hectare land and phosphorus requirement of 0.025 million hectare land if two crops are taken in a year.

Annual Bio energy Potential of Distillery Effluent in Various States of India

State	Units	Capacity (M Ltr/Yr)	Effluent (M Ltr/Yr)	Biogas (M m^3)	Total N (tones)	Total Ka (tones)	Biomass (tones)
A P	24	123	1852	50	566	11115	3704
Assam	1	2	24	0.7	7	144	48
Bihar	13	88	1323	35.7	397	7940	2646
Goa	6	15	218	6	65	1304	436
Gujarat	10	128	1919	51.8	576	11511	3838
Karnataka	28	187	2799	75.6	840	16794	5598
M P	21	469	7036	190	2111	42219	14072
Maharashtra	65	625	9367	253	2810	56217	18734
Punjab	8	88	1317	35.6	395	7902	2634
Tamilnadu	19	212	3178	86	953	1971	6356
U P	43	617	9252	250	2776	55512	18504
W B	6	24	371	10.1	111	22223	742
Rajasthan	7	14	202	3	61	1215	404
Kerala	8	23	343	9.3	103	2064	686
Pondicherry	3	11	165	4.5	50	990	330
Sikkim	1	7	98	5.5	29	585	196
Nagaland	1	2	24	0.7	7	144	48
J & K	7	24	366	11	110	2196	732
H P	2	3	39	1	12	234	78
Haryana	5	41	615	16.6	185	3690	1230
Total	285	2703	40,508	1096.1	12,154	263,070	81016

PRESENT STATUS OF TREATMENT AND DISPOSAL

5. Spent wash treatment is proposed by three different routes currently viz; (a) Concentration followed by incineration, (b) Anaerobic digestion with biogas recovery followed by aerobic polishing and (c) Direct wet oxidation of stillage by air at high temperature with generation of steam followed by aerobic polishing. All of these processes are capital intensive. The incineration process involves an investment of the order of 400% of the distillery cost, whereas the other two processes along with the secondary treatment require an investment of 200-300% of the distillery cost. The unfavourable economics make it difficult to implement these treatment processes on the plant scale. Because anaerobic digestion and wet oxidation are less expensive, these alternatives are more attractive. However, there is a need for development of a suitable process with lower investments and higher energy recovery. Many distilleries in India are allowing their effluent for application on land as direct irrigation water, spent wash cake and spent wash-press mud compost. The advances manifesting the possibilities of energy conservation are also discernible in the case of distilleries. The methane gas generated in the digesters is used as a fuel to compensate the

energy needs of the industry. A general estimate suggests that the cost of an anaerobic biological digester is recovered within 2-3 years of installation because of substantial saving of coal and other fuels.

COST RECOVERY METHODS FROM THE DISTILLERY EFFLUENTS

6. The wastewaters generated during the distillery and brewery operations contain high organic loads. It has a BOD from 30,000 to 60,000 mg/1. So due to this high organic contents, the wastewaters can be subjected to treatment for the production of biogas, composting, aquaculture and potash recovery.

(a) **BIOGAS**. For the production of biogas from distillery effluent, anaerobic biomethanation of the effluent is adopted, generally. High rate anaerobic technologies are utilized for biogas generation. Fluidised Bed Reactors and Up flow Anaerobic Sludge Blanket (UASB) Reactors are mostly utilized for the production of biogas from the effluents. Some of the biogas production processes being commercial1y established in India at present are:-

- **BIOTHANE PROCESS**: This process uses the UASB reactor for the production of biogas. This is a stable and automatic process with low operational costs.

- **BIOBED PROCESS**: It is similar to Bio thane process. It uses UFB reactors. It needs less installation area and its construction cost is lower compared to any other system.

- **BIOPAQ PROCESS**: In this process anaerobic bacteria are used to treat the distillery effluents for the production of biogas. UASB process is utilized here. The separated sludge in this process makes excellent manure. The generated biogas is used to produce steam for the distillation of alcohol and thus it replaces 50-60% of the total required energy in the process of distillation. For a plant having 40-45,000 kg COD/day 75-80% of COD can be reduced and nearly Rs. 25.50 lakhs can be saved annually for a distillery having 300 working days in a year. The generated biogas from UASB reactor of BioPaq process can be collected and be used as a fuel in gas/dual engine. Through suitable coupling the engine can be coupled with the A/C generator for generation of electricity from biogas. For a 45 klpd distillery 11 KV of power is generated which is then utilized in the distillery thus cutting down the power consumption.

- **SULZER' S PROCESS**: The technology of this type of biogas plant is provided by Sulzer Brothers Limited, Switzerland. It is specifically made for Indian conditions. A biogas plant at the distillery of Padmashri Dr. Vitthalrao Vikhe Patil S.S.K. Ltd., Pravaranagar, Ahmednagar District, Maharashtra is based on Sulzer's technology. The capacity of this distillery is 6,000 lpd which generates 900 m3 of spent wash per day. The biogas production is in the range of 16,550 to 21,870 m3 per day. The savings in the cost of fuel is in the range of Rs. 312 lakhs to Rs. 652 lakhs per year.

    - **ECONOMICS OF THE BIOGAS PLANT OF SULZER’S DESIGN**

      These calculations are made for a distillery producing 30,000 litres of alcohol per day. The effluent characteristics are for conventional batch type fermentation process.

    - **EFFLUENT CHARACTERISTICS**

	Before Treatment	After Treatment
Flow m^3/day	450	450
pH	4.0 to 4.5	7.0 to 7.8
BOD mg/l	45,000 to 50,000	6,000 to 8,000
COD mg/l	80,000 to 1000,000	25,000 to 35,000

- **PERFORMANCE**

Reduction of BOD %	80 to 85 %
Reduction of COD %	65 to 70 %
Biogas Production Nm^3/day	12,300
Specific Biogas Production Nm^3/kg of COD degraded	0.4 to 0.5
% of methane in biogas	60 to 65 %

- **ECONOMICS**

Calorific value of biogas	6000 Kcal/ Nm^3
Calorific Value of Coal	4000 Kcal/Kg
Coal equivalent of Biogas per day	18.45 tonnes
Cost of Coal at Rs 1800 per tonne	Rs 33,210 pd
Annual fuel savings	Rs 99.63 lacs
Capital cost of plant	Rs 230 lacs
Interest at 15 % on 75 % of the capital cost**	Rs 26,73,750
Maintenance costs	Rs 2,00,000
Staff Salary	Rs 1,50,000
Power 40 KW at Rs 2/- per unit	Rs 5,76,000
Total Annual Cost	Rs 36,00,000
Net Savings per year	Rs 99.36 – 36 = Rs 63.63 lacs
Total Pay back period	= 230 / 63.63 = 3 to 4 years.

(b) COMPOSTING In this process, press mud generated from sugar mill is utilised to produce compost by mixing distillery effluent. Both anaerobic and aerobic composting systems are practiced. In some plants composting with treated effluent treated through bio-methanation plant is also practiced. This system can achieve zero effluent if the press mud quantity matches with the effluent generated.

- **ECONOMICS OF BIOEARTH COMPOSTING**

Capacity of the Distillery	50 KLPD
Number of working days in a year	
In the Distillery	300
In the Composting Plant	275
Generated spentwash	350 KLPD (Biostil Plant)
Solid content in spentwash	17 %
Spentwash to Press mud Ratio	2.5 KL : 1 MT
Man Power Required	50
Culture Requirement	31.5 MT/annum
Press mud requirement	43,000 MT/ annum
Cost of Culture	Rs 1.75 lakhs per MT
Cost of Press mud	Rs 12 per MT
Man Power cost	Rs 50 per day
Capital Cost	Rs 175 lakhs (excluding land)
Land Requirement	25 acres
Bio Earth Production	38,000 MT per year
Annual Maintenance Costs	1.5 % of equipment costs
% Costs of Funds	20 % per annum

- **OPERATION COSTS**

Cost of Culture	55.13 lakhs
Average Cost of Funds	17.5 lakhs
Cost of Diesel	11.32 lakhs

Cost of Press mud	5.16 lakhs
Cost of Transportation of Press mud	0.00
Annual Man Power Cost	6.88 lakhs
Depreciation (@ 10 %)	15.00 lakhs
Maintenance	2.25 lakhs
Annual Operational Cost of Compost Plant	113.24 lakhs

Cost of One Metric Tonne of Bioearth $= \frac{\text{Annual Operational cost of plant}}{\text{Compost Produced in MT}}$

$= \frac{11324000}{38000}$

= Rs 298.00 per MT

- **NET COST/BENEFIT FOR DIFFERENT SELLING PRICES OF COMPOST**

SP of Bioearth in Rs	Net Cost / Benefit in Rs
0	-11324000.00
100.00	-7524000.00
200.00	-3724000.00
298.00	0.00
350.00	1976000.00
400.00	3876000.00
500.00	7676000.00

Net annual cost/benefit of Compost = Sales value of 38000 MT of compost less annual operating costs

- **COMPUTATION OF PAY BACK PERIOD**

1. SP of Bioearth - Rs 250.00
   Initial cash outflow - Rs 17500000.00
   Net annual cash inflow - Rs 1738000.00
   Pay Back Period - 10.06 Years (17500000/1738000.00)

2. SP of Bioearth - Rs 350.00
   Initial cash outflow - Rs 17500000.00
   Net annual cash inflow - Rs 5226000.00
   Pay Back Period - 3.34 Years (17500000.00/5226000.00)

3. SP of Bioearth - Rs 500.00
   Initial cash outflow - Rs 17500000.00
   Net annual cash inflow - Rs 10926000.00
   Pay Back Period - 1.6 Years (17500000.00/10926000.00)

(c) **POTASH RECOVERY** It is done by incinerating the distillery spent wash. In this process, the raw distillery spent wash is first neutralized with lime and filtered. This is further concentrated to about 60% solids in multiple-effect forcer circulation evaporators. Now this thick liquor from the evaporator is burnt in an incinerator and is converted into ash. The dry solids of the spent wash in the form of coke in the incinerator has an average calorific value of 2 Kcal/kg, which is sufficient for supporting self-combustion of the thick liquor in the incinerator. The resulting ash is found to contain about 37% of potash as potassium oxide on an average. This ash is further leached with water to dissolve the potassium salts. Then it is neutralized with sulphuric acid and is evaporated. The potassium salts are crystallized in a crystallizer. The crystallized mixed potassium salt contains 73.5% of potassium sulphate (K_2SO_4) 16.5% potassium chloride (KCl) and 5% of sodium salts. It is estimated that a distillery discharging about 300 m^3 of spent wash per day could recover 3 tonnes of Potassium as Potassium oxide or about 5.34 tonnes of Potassium sulphate and 1.2 tonnes of Potassium chloride per day. This potassium is used as a fertilizer.

(d) **DISTILLERY WASTEWATER UTILISATION IN AGRICULTURE** Being very rich in organic matters, the utilisation of distillery effluents in agricultural fields creates organic fertilization in the soil which raises the pH of the soil, increases availability of certain nutrients and capability to retain water and also improves the physical structure of soil. Mostly the distillery wastewaters are used for pre-sowing irrigation. The post-harvest fields are filled with distillery effluents. After 15-20 days, when the surface is almost dried, the fields are tilled and the crops are sown and subsequent irrigation is given with fresh water. However, the effluent is diluted 2-3 times before application on crops. Apparently, the irrigation with distillery wastewater seems to be an attractive agricultural practice which not only augments crop yield but also provides a plausible solution for the land disposal of the effluents. One cubic metre of methanated effluent contains nearly 5 kg of potassium, 300 grams of nitrogen and 20 grams of phosphorus. If one centimetre of post methanation effluent is applied on one hectare of agricultural land annually, it will yield nearly 600 kg of potassium, 360 kg of calcium, 100 kg of sulphates, 28 kg of nitrogen and 2 kg of phosphates. The distillery effluent contains 0.6 to 21.5 percent potash as KO, 0.1 to 1.0 percent phosphorus as PO and 0.01 to 1.5 percent Nitrogen as N_2. The irrigational and manorial potential of distillery wastewaters is given below:

i)	Total Volume available in Million m^3/annum	:	6.87	
ii)	Nutrients Contribution Potential (tonnes/annum)	:N	-	69380
		PO	-	11335
		KO	-	27480

- **ECONOMICAL ASPECTS**

When the distillery effluents are used for irrigation in fallow lands, the microbes present in it transform the lands into fertile ones, giving high yields of paddy and sugarcane. Farmers could save nitrogenous fertilisers worth Rs 1335 crores per annum if at least 200 distilleries of out country recycled their wastes to the agricultural fields. However, it is predicted that the utilisation of distillery effluent for irrigation of land would make available nitrogen, phosphorous and potash valued at about Rs 500 crores each year. The added advantage of this application would be that these fertilisers would be available to soil in organic form. As the secondary and tertiary systems for the treatment of distillery effluent are highly energy intensive and according to the estimates of the Union Ministry of Energy a total connected load of 200 M.W. would be required to energising these systems if 246 distilleries endeavour to reduce the BOD level of effluent to the extent possible. The generation of the desired energy would need an installed load of 350 M.W. which would require capital investment of the order of about Rs 1400 crores. So it will be an attractive practice to utilise the distillery effluents for ferti-irrigation of land after primary treatment, as land is available in abundance around the distilleries which are located in the sugarcane belts.

RECOMMENDATIONS

7. Reviewing the magnitude of pollution potential of distillery wastewaters and the experiences gained over years on recovery of residues and treatment of wastewater the following recommendations are made :-

- In-plant control measures for conservation and reuse of water and good house-keeping for prevention of spillage and leakages should be the prerequisite.

- For recovery from the treatment of distillery spentwash, depending on the availability and cost of land in a particular area, simple treatment in anaerobic lagoon to generate biogas followed by treatment in aerated lagoon or oxidation ditch may be considered. Where the availability and cost of land are the main constraints, activated sludge type of aeration treatment in a deep oxidation ditch would be more economical than the conventional or extended aeration sludge process.

- For the treatment of distillery spent wash, removal and/or recovery of yeast should be prerequisite to reduce the load and eliminate certain undue problems in the waste treatment/recovery plants. This recovered yeast can be utilised as a good cattle feed. Recovery of spent grains and yeast and their utilisation as animal feed and feed supplement might be encouraged not only for reducing the pollution load form the wastewaters but also in providing for a reasonable return on their capital investment of the industry.

- Where the availability of land is a severe constraint, evaporation and incineration of distillery spent wash to recover potash would appear to be the only choice. In spite of high capital investment required for such type of plants, heat recovery would defray significantly the organisation and maintenance costs and contribute towards conservation of energy.

- In the countries like ours, where indigenous sources of potash are scarce or not available, recovery of potash from crude ash by evaporation and incineration of spent wash would appear to be an economically attractive alternative. If heat recovery is simultaneously used, the pay back period of the plant can be substantially reduced.

- Anaerobic digestion of spent wash in a closed digester followed by its treatment under an activated sludge process, especially in an oxidation ditch to reduce costs, might be adopted as the most cost-effective system for the distilleries which are located away from sugar factories. Moreover, the treated effluent can be conveniently used for irrigation of cane fields or other crop lands, subsequently.

- Biogas generated from the distillery effluents, can be effectively utilized in production plant boilers thus saving about 50 to 60 percent fuel/steam. The treated effluent having almost all the potash retained in it may be utilised for irrigation purposes.
- The utilisation of the distillery effluent in agricultural fields will not only enrich these further with essential plant nutrients like nitrogen, phosphorous and potash but also compensate the expenditure on fertilizers for crop growth. This practice will result in revenue generation and further lead to offsetting the costs substantially.

- Similarly spentwash utilization in bioearth composting, where adequate land is available, being a simple process and not involving any heavy machinery is also one of the cost effective methods of disposal. Moreover it is feasible alternative for utilization of treated effluent; as the same generates revenue thus offsetting the costs and further leading to reduction in pay back period.

CONCLUSION

8. One of the most important environmental problems faced by the world is management of wastes. Now-a-days emphasis is laid on waste minimization and revenue generation through byproduct recovery. Pollution prevention focuses on preventing the generation of wastes, while waste minimization refers to reducing the volume or toxicity of hazardous wastes by water recycling and reuse, and process modifications and the byproduct recovery as a fall out of manufacturing process creates ample scope for revenue generation thereby offsetting the costs substantially.

9. The cost of effluent treatment in distilleries is likely to be compensated substantially by availability of methane gas. Effluent application will reduce the nutrient requirement through fertilisers. However, high salt load, mainly potassium and sulphur, into the soil system may hamper the sustained crop yields due to continued long-term application of effluents. Therefore the effect on crop productivity has to be visualised on long-term and sustainable basis. Application of post methanation effluent suitably diluted

according to crop requirements and soil conditions seems to be viable alternative. If all the distilleries present in India resort to biomethanation, then approximately 2.0 million cubic metres of biogas shall be generated per day, with a calorific value of approximately 5000 Kcal/m. This is equivalent to saving of 2240 tonnes of coal per day, in turn avoiding CO of about 3100 tonnes per day.

10. The present study coupled with the corresponding techno market survey has been aimed at reviewing the existing technological status of treatment and disposal of distillery spentwash in our country and comparing with that of the contemporary international technologies, thus identifying the gaps in the technologies and suggesting an action plan for overcoming these. Some relative issues in the areas of quality criteria with respect to gaps in technologies and financial implication in implementing the technological options, has been highlighted in this study. It has to be stressed that recovery from the distillery effluents is a better way to reduce the cost of wastewater treatment for decreasing its pollution level which is actually a very costly affair. So this is a matter great importance for the Indian distilleries and breweries. Various recommendations are given for the establishment of recovery plants in India. It has also been elucidated during the study that several technological options that are available in our country need to be exploited to the maximum so that, this will help to control the pollution created by the distillery wastewaters and also enable to derive by-products which are commercially beneficial.

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Symposium nº : 25
Presentation: poster

Residual and cumulative vinasse effect on brasilian sugarcane soil and nitrogen water table pollution

Effet des résidus et des apports de "vinasses de sucreries" sur les sols brésiliens à canne à sucre et la pollution azotée des nappes

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SUMMARY

To study different forms of N leaching in a soil profile and to observe a possible water contamination, a field trial was carried out on a Quartzpsament soil, cropped with sugarcane (third ratoon) during 1994. The same trial was installed in the same place one year before.
The experimental design was a split-split plot in randomized blocks with four replicates. It was used 5 treatments at main plot level (control, mineral fertilizer and 3 doses of vinasse); 4 depths of soil sampling at split-plot level and 3 soil sampling periods at split-split-plot level.

As final conclusion the **vinasse** rates used in this study for 2 years (residual and cumulative effects) which can be considered as usual in commercial sugarcane fields, did not promote increase in N-NO_3, N-NH_4 and N-total in soil profile tested even for 33 weeks after application.

Till the amount of 600 m^3 **vinasse**/ha there was increasing on cane yield, even though pol% and fiber% cane tended to decrease.

INTRODUCTION

In 1996 the 4.3 million ha under sugarcane cultivation in Brazil produced 255 million ton of cane, 9.5 million ton of sugar and 12.5 million m^3 of alcohol, mainly for fuel purposes. Normally each liter of alcohol produce about 12 liters of **vinasse** or stillage, a liquid residue that is applied to cane fields by trucks and/or mainly by sprinkler irrigation using big guns.

The chemical composition of **vinasse** (SILVA & ORLANDO FILHO, 1981) has shown that it is very rich in organic matter (O.M.) and among the mineral nutrients potassium is outstanding. Several studies have been carried out on the influence of **vinasse** on soil properties such as pH, CEC, Ca, Mg and K (MATIAZZO & GLÓRIA 1985; MAZZA *et al.* 1986; NUNES *et al* 1981 & 1982 and ORLANDO FILHO *et al.* 1983). Soil

properties were usually improved through **vinasse** application; nevertheless, the possibility of polluting of N compounds leaching in the soil profile must be considered. REBOUÇAS *et al.* 1986 did not observe any soil NO_3 contamination up to 1 m depth in areas that had received **vinasse**. Recently ORLANDO FILHO *et al.* 1996 indicated that there was no influence of NO_3, NH_4 and other N compounds in soil profile from **vinasse**.

In sugarcane soils where only mineral fertilizers have been applied, N leaching has also been studied by several authors (ELWALI *et al.* 1980; KIEHL *et al.* 1981; KWONG & DEVILLE 1984; SALCEDO & SAMPAIO 1984). The data showed different variations for soil NO_3 and NH_4 contents.

The purpose of this study was to obtain further information about N leaching, up to 1 m depth in sandy soil, that has received doses of **vinasse** during 2 years (residual and cumulative effects).

MATERIAL AND METHODS

In may 1993 a field trial was initiated on a Quartzpsament soil cropped with sugarcane var. RB72454 in second ratoon, using doses of vinasse.

During 1994, the trial was repeated on third ratoon, using the same doses of vinasse, through a split-split plot design, in 4 randomized blocks, as follows:

Treat. at Main Plot Level	**Treat. at Split-plot**	**Treat. at Split-split-plot**
T_1 = control (no fertilizer)	D_1 = 00-25 cm	P_1 = 13 wk
T_2 = 333 kg/ha of 18-00-36	D_2 = 26-50 cm	P_2 = 22 wk
T_3 = 150m_3 vinasse/ha	D_3 = 51-75 cm	P_3 = 33 wk
T_4 = 300 m_3 vinasse/ha	D_4 = 76-100 cm	
T_5 = 600 m_3 vinasse/ha		

Each plot consisted of 10 cane rows 21m long and 1.10m between rows spacing. Vinasse was applied from a tank truck equipped with a 3.5” flexible hose, under 9 psi pressure. The total amount of vinasse used in each plot was measured through the volume variation in the tank. The chemical composition of vinasse was: pH = 4.1, C% =0.83, N=0.41 kg/m_3, P_2O_5 = 0.15 kg/m_3 and K_2O = 3.68 kg/m_3.

All soil samples were obtained from the middle of the central rows during the morning and stored in plastic bags in a box with ice, although the distance between field trial and lab was only 20 km. During the afternoon of the same day, soil NH_4 and NO_3 were extracted with 2N KCl solution, and total N determined by H_2SO_4 digestion, according to BLACK *et al.* 1965.

After 12 months (June 1996) cane was harvested and stalks weighted on a special scale. Samples of 16 stalks from each plot were sent to the lab for pol and fiber % cane determinations.

RESULTS AND DISCUTION

Table 1 shows the general average data for the several main effects (treatments, depths and soil sampling periods) related to dependent variables (NO_3 , NH_4 , N-total and OM). Table 2 gives the corresponding analysis of variance and finally Table 3 shows cane yield, pol and fiber % cane for the treatments. To understand the data better, the results will be presented individually for each variable response:

Soil NO_3

Treatments and depths did not influence soil NO_3. The tendency was that the treatments with vinasse showed lower amounts of soil NO_3 than control and mineral fertilizer. These data are in accordance with those achieved by CALDAS 1960, NUNES *et al.* 1981, who observed that soil NO_3 decreases when vinasse is applied. On the other hand the period after establishment the trial showed a decreasing of soil NO_3. Probably an intense N microbiological fixation occurred, preventing greater NO_3 leaching in the soil profile (KWONG & DEVILLE 1984). VIERTES & BRINHOLI 1992 observed significant variation effects of sampling time in soil NO_3 levels in a oxisol that received several rates of vinasse. In Mauritius cane soils, leaching of Ca and K may be greater than NO_3 (KWONG & DEVILLE 1984). There was a significant interaction between treatments (T) and sampling periods (P) as shown in Table 2.

Soil NH_4

The general average data (Table 1) showed for T_1 (Control) higher soil NH_4 concentration than the other treatments. Despite the statistical difference in depth D_2, it can be said that no vertical ion displacement in the soil NH_4 had occurred. Similar results were obtained by ORLANDO FILHO *et al.* 1996 using vinasse and by SALCEDO & SAMPAIO 1984, applying only mineral fertilizers.

According to increasing the period of soil sampling there was a higher amount of soil NO_3, conversely that was found by ORLANDO FILHO *et al.* 1996, during the first time that vinasse was applied in the soil. KIEHL *et al.* 1981 determined that in a brazilian cane oxisol, the amounts of soil NH_4 ranged from 77 to 93% in the soil mineral content. There were significant interactions involving TxD, TxP and DxP (Table 2).

N-total and Organic Matter (OM)

Differently than observed by ORLANDO FILHO *et al.* 1996, increasing dosages of vinasse, the levels of soil N-total decreased. Similar effect was given by soil OM, but soil OM in treatments with vinasse were higher than the Control (T_1) and mineral fertilizer (T_2). It must be considered that vinasse added to the soil in this trial ranged from 4 to 16 ton OM/ha , but vinasse OM is in colloidal size and tends to decompose quickly. ORLANDO FILHO *et al.* 1996 did not observe substantial increases of soil OM through vinasse application, but soil N-total and OM decreased according to the depth, as was expected. These authors also observed that the better level of soil OM was obtained with treatment T_3, meaning that the superficial soil layer could be OM enriched with vinasse, mainly low rates such 150 m^3/ha . Only the double interactions TxP and DxP for N-total and TxP for OM were significant (Table 2).

Cane and Sugar Yields

As observed in Table 3, vinasse was an excellent input in order to increase cane yield. When 600 m^3 vinasse/ha (T_5) was applied, increase of almost 50 ton cane/ha was obtained, comparing to mineral fertilizer (T_2). Nevertheless high dosages of vinasse not only decreased pol % cane but also fiber % cane. Probably the higher vegetative growth and the excess of K uptake could explain these decreases.

CONCLUSIONS

The **vinasse** rates used in this study for 2 years (residual and cumulative effects) which can be considered as usual in commercial sugarcane fields, did not promote any increase in $N-NO_3$, $N-NH_4$ and N-total in soil profile tested even for 33 weeks after application. Till the amount of 600 m^3 **vinasse**/ha was enough to promote a significant linear increase on cane yield, even though pol and fiber % cane tended to decrease.

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Key words: sugarcane; **vinasse**; nitrogen displacement; water table pollution.

Mots clés : canne à sucre, **vinasse** de sucrerie, déplacement d’azote, pollution de la nappe phréatique

Table 1. General average for treatments, depths and soil sampling periods.

	Dependent Variables			
Sources	**NO_3 (ppm)**	**NH_4 (ppm)**	**N-total**	**OM (%)**

Treatments				
T_1	3.3 **a**(1)	30.6 **a**	316 **a**	0.79 **d**
T_2	3.1 **a**	24.5 **b**	266 **b**	0.85 **c**
T_3	3.0 **a**	24.8 **b**	306 **a**	0.98 **a**
T_4	2.7 **a**	24.8 **b**	245 **b**	0.92 **b**
T_5	2.8 **a**	25.8 **b**	211 **c**	0.82 **cd**
Depths				
D_1	3.1 **a**	27.1 **a**	318 **a**	1.10 **a**
D_2	3.1 **a**	25.3 **b**	274 **b**	0.91 **b**
D_3	2.9 **a**	27.0 **a**	250 **bc**	0.77 **c**
D_4	2.9 **a**	25.0 **b**	235 **c**	0.67 **d**
Periods				
P_1	3.8 **a**	23.0 **b**	320 **a**	0.85 **b**
P_2	2.8 **b**	28.6 **a**	236 **b**	1.00 **a**
P_3	2.4 **c**	26.7 **a**	251 **b**	0.76 **c**

(1) Different letters in columns indicate statistical significance (Student ´t´ test, P=0.05).

Table 2. Mean squares for the dependent variables from the analysis of variance.

Sources of		**Dependent Variables**			
Variation	**d.f.**	**NO_3**	**NH_4**	**N-total**	**OM**
Blocks	3	1.6869	36.42	0.00025*	0.0520*
Treatmens (T)	4	3.4148	311.56*	0.00090**	0.2798**
Residual (a)	12	2.5813	69.20	0.00005	0.0121
Main plots	(19)				
Depths (D)	3	0.9246	71.28	0.00078**	1.9385**
Inter. TxD	12	1.0290	94.44*	0.00009	0.0270
Residual (b)	45	0.9422	40.83	0.00008	0.0140
Split-plots	(79)				
Periods (P)	2	41.4970**	628.73**	0.00157**	1.1103**
Inter. TxP	8	8.07796**	295.54**	0.00025**	0.0668**
Inter. DxP	6	1.3379	231.10**	0.00015*	0.0052
Inter. TxDxP	24	0.9172	117.27*	0.00005	0.0156
Residual (c)	120	1.3011	72.17	0.00006	0.0110
Total	239				

* Significant at 5% probability level

** Significant at 1% probability level

Table 3. Cane yield, pol % cane and fiber % cane for the treatments (third ratoon).

Treatments	ton cane/ha	pol % cane	fiber % cane
T_1	49.4 **a(1)**	15.2 **ab**	17.7 **d**
T_2	81.7 **b**	16.7 **d**	14.9 **c**
T_3	98.8 **c**	16.4 **cd**	12.0 **b**
T_4	106.9 **c**	15.7 **bc**	12.1 **b**
T_5	131.1 **d**	14.6 **a**	11.0 **a**

(1) Different letters in columns indicate statistical significance (Student ´t´ test, P=0.05)

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Bioresource Technology 99 (2008) 1553–1562

BIORESOURCE TECHNOLOGY

Vinasse organic matter quality and mineralization potential, as influenced by raw material, fermentation and concentration processes

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Received 13 September 2006; received in revised form 6 April 2007; accepted 11 April 2007
Available online 19 June 2007

Abstract

Both dilute and concentrated vinasse can be spread on agricultural fields or used as organic fertilizer. The effects of different characteristics of the original raw material on the biochemical composition of vinasse and their C and N mineralization in soil were investigated. Vinasse samples were obtained from similar industrial fermentation processes based on the growth of microorganisms on molasses from different raw material (sugar beet or sugar cane) and vinasse concentration (dilute or concentrated).

The nature of the raw material used for fermentation had the greatest effect on the nature and size of the resistant organic pool. This fraction included aromatic compounds originating from the raw material or from complex molecules and seemed to be quantitatively related to acid-insoluble N. Samples derived from sugar beet were richer in N compounds and induced greater net N mineralization. The effect of evaporation varied with the nature of the raw material. Concentration led to a slight increase in the abundance of phenolic compounds, acid-insoluble fraction, and a slight decrease in the labile fraction of vinasses partly or totally derived from sugar beet. The effect of the dilute vinasse from sugar cane was greater. The concentrated vinasse had a smaller labile fraction, induced N immobilization at the beginning of incubation, and exhibited greater N concentration in the acid-insoluble fraction than the dilute vinasse.

Keywords: Vinasse; Composition; Mineralization; Phenolic compounds

1. Introduction

Industries based on the fermentation of molasses produce various wastewaters. Dilute vinasse (also known as stillage) has the highest organic content and can subsequently be concentrated. Both dilute and concentrated vinasse can be spread on agricultural fields or used as organic fertilizer. In this latter case the agricultural soils are considered as a land treatment system but will also benefit from nutrients present in the vinasse. However, possible adverse environmental impacts such as the enrichment of soil in salt and nitrate leaching need to be considered. Sustainable management of vinasse spreading therefore requires a precise understanding of C and N mineralization kinetics. The wastewaters, including vinasses, from the alcohol distilleries have different compositions and mineralization pathways (Parnaudeau et al., 2006), which could be helpful to understand their subsequent behaviours in soils.

Information available in the literature suggest that the major organic components of sugar cane vinasse are glycerol, lactic acid, ethanol, and acetic acid (Decloux and Bories, 2002; Dowd et al., 1994), whereas sugar beet vinasses also contain glycerol and their main compound is nitrogen-rich betaine (Decloux and Bories, 2002; Troccon and Demarquilly, 1989). In addition to these low molecular

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Abbreviations: CV, concentrated vinasse; DV, dilute vinasse; MOL, molasse.

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doi:10.1016/j.biortech.2007.04.012

weight compounds, vinasses may contain melanoidins and phenolic compounds, which can inhibit or reduce the activity of microorganism (FitzGibbon et al., 1998), and also cellulose and hemicellulose (Benke et al., 1998). These latter authors used 13C CP/MAS NMR and DR-FTIR to investigate the organic matter quality and composition of different fractions of sugar cane distillery vinasse and the dissolved organic carbon (POC and DOC). Given the role of composition on the potential of organic wastes to mineralize in soil, Parnaudeau et al. (2006) demonstrated the importance of determining the effect of C in the liquid phase of wastewater on mineralization. It is well understood that these characteristics are dependent on the raw material and consequently also on the agricultural practices influencing plant composition (Sheehan and Greenfield, 1980).

The vinasses in this study were produced by similar industrial fermentation processes based on the growth of microorganisms on molasses derived from either sugar beet or sugar cane. The biochemical compositions of these materials differed especially with regard to the fibrous fraction. It was assumed that the C and N mineralization of these vinasses would vary according to: (i) the composition of the raw material and hence the different vinasse composition and (ii) the concentration of the vinasse which might result in the volatilization of certain compounds as well as the generation of complex molecules. The aim of this study was to test these hypotheses and identify the composition criteria that might determine C and N mineralization when the vinasses were applied to the soil.

2. Methods

2.1. Vinasse samples

General scheme of molasse-based industrial fermentation process is given in Fig. 1. The concentrated vinasse (CV) results from the thermal concentration of dilute vinasse (DV). Six vinasse samples derived from different fermentation industries were compared and the three corresponding molasses were also sampled. DV0 and CV0 came from a factory using molasses (MOL0) from sugar beet only, DV30 and CV30 were produced in a factory based on molasses from a 30% sugar cane + 70% sugar beet mixture (MOL30) and DV100 and CV100 came from a factory that only used sugar cane molasses (MOL100). The three types of by-product (MOL, DV and CV) from a given factory were sampled from the same production sequence and on the same day.

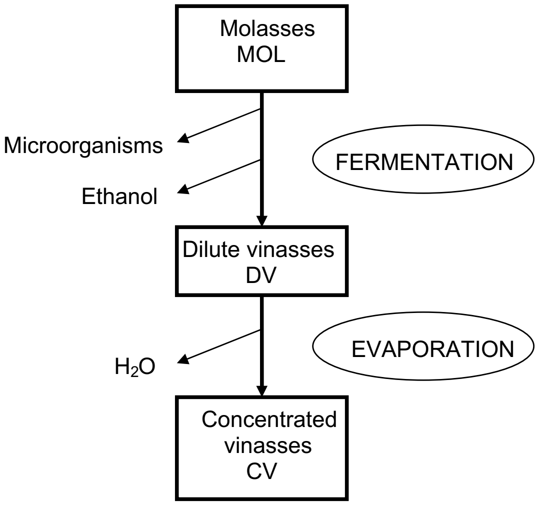

Fig. 1. Industrial fermentation process leading to vinasse generation.

Before analysis and incubation, the dilute vinasses were frozen and stored at −20 °C whereas the concentrated vinasses were only stored at 4 °C: the stability of the concentrated vinasses enabled avoiding freezing that could alter the organic matter. The composition characterizations were carried out on MOL, DV, and CV whereas the liquid/solid separation and incubation experiments were only carried out on DV and CV.

2.2. Fractionation procedures

The vinasses and molasses were fractionated according to the following methods, described in Parnaudeau et al. (2006).

(i) The liquid and solid phases of the vinasses were separated by centrifugation (5200*g*) during 20 min. The solid phase (S) was washed with distilled water and then freeze-dried.
(ii) The molasses and vinasses were fractionated using an adaptation of the method proposed by Bremner (1965) to characterize soil organic nitrogen. Twenty-five milliliters of DV, or 2 g of CV diluted in 25 mL distilled water, were mixed with 25 mL of 12 M HCl and heat-extracted under reflux for 16 h. The acid-insoluble solid residue was then separated by filtration (0.7 μm), washed with distilled water, and dried at 40 °C.
(iii) The Van Soest method (1963) was also applied using the design described by Parnaudeau et al. (2004).

The C and N concentrations and the C to N ratios of all the fractions obtained with the above mentioned methods were either measured (see below) or calculated. The results were then expressed in % vinasse C or N (i.e. as the proportion of vinasse C or N present in each fraction for a given method).

2.3. Carbon and nitrogen determinations

The total C and N concentrations of the solid fractions and acid-insoluble residues were determined using an elemental analyzer (NA 1500; Fisons, Milan, Italy). The total soluble N concentration of the vinasses and molasses was measured using a TN3000 analyzer (Euroglass, Delft, The Netherlands) and method described by Alavoine and Nicolardot (2000). The soluble organic and inorganic C in the vinasses and molasses were determined using a

TOC 1010 analyzer (OI Analytical, College Station, TX). The inorganic N content of the vinasses and molasses were measured by continuous flow colorimetry using an autoanalyzer (TRAACS 2000) and adaptations of the methods proposed by Kamphake et al. (1967) and Krom (1980).

2.4. Biochemical analyses

The nature of the organic carbon in the 9 samples was determined by assessing the low-molecular-weight compounds using the Ionic Chromatography (Dionex DX 600, USA) coupled with: (i) a CARBOPAQ MA1 column with a detector of pulsed amperometry for sugars, polyols and alcohols, (ii) a CARBOPAQ PA1 column with a detector of pulsed amperometry for sugars and polyols, and (iii) an IONPAC AS11 column and a conductimetric detector for organic acids. The concentrations were then expressed as a percentage of the organic C.

Phenolic compounds were assessed by UV spectrophotometry, using a Perkin–Elmer Lambda 14. The 10 products were diluted to the appropriate concentration and their maximum absorbances were measured.

Betaine is a well-known component of sugar beet and, because it is not degraded, it is traditionally monitored during the sugar production process. The concentration of betaine was determined by High Performance Liquid Chromatography (Shimadzu) and then expressed as a percentage of the organic N and in g kg^{-1} d m.

2.5. Soil incubations

The soil used for the incubations was a carbonitic Lithic Rendoll, which corresponds to a hypercalcareous soil, described by Parnaudeau et al. (2004).

The rate of vinasse input was 2 g C kg^{-1} dry soil. A control soil without vinasse input was also included. The concentrated vinasses were highly viscous and were diluted in distilled water before being added to the soil. There were four replicates of each treatment and sampling date. The vinasses were homogeneously mixed with the soil samples one day after application to ensure better infiltration and distribution. To ensure that vinasse decomposition was not limited by inorganic N availability (Recous et al., 1995), KNO_3 was added to the soil to obtain an initial concentration of about 75 mg NO_3^-–N kg^{-1} dry soil. Soil moisture content was maintained at a matrix potential of 0.05 MPa by weighing, and readjusted, if necessary, by adding deionised water. The incubations were carried out at 28 ± 0.5 °C.

C mineralization was assessed during a 6-month incubation. The CO_2 produced by the soil was measured by incubating the equivalent of 50-g dry soil samples. The cumulative C mineralization for all vinasses was then expressed as % vinasse organic C. Equivalent 50-g dry soil samples were also used to study the N mineralization of each vinasse. Net mineralized N was expressed as % added organic N. The method is described in detail in Parnaudeau et al. (2006).

2.6. Data processing

Linear correlations between the mineralization results at different dates and the chemical characterizations of the vinasse were calculated using Statistica software (StatSoft, 2001). The variance analysis and mean classification were performed using the ANAVAR procedure and the Student–Newman–Keuls test in the SAS software (SAS, 2001).

The kinetics of vinasse C mineralization were fitted using a two-compartment model (Delphin, 1988; Gilmour et al., 1998; Thuriès et al., 2001), and the Microsoft Excel® software:

$$\mathrm{CO_2}(t) = A[1 - \exp(-k_1 t)] + (100 - A)[1 - \exp(-k_2 t)]$$

where $\mathrm{CO_2}(t)$ represents the organic carbon of vinasse mineralized by day t (% organic C), and A and $(100 - A)$ are the labile and resistant compartments, respectively (% organic C), and k_1 and k_2 are the decomposition rate constants of the labile and resistant compartments, respectively (d^{-1}).

3. Results and discussion

3.1. Chemical characteristics of the molasse and vinasse samples

The pH of the molasses (MOL) decreased with the proportion of sugar beet in the raw material, and the vinasse pH varied between 4.6 and 7.1 (Table 1). The specific gravity and the dry matter concentration of the molasses were similar whatever their origin. The specific gravity of the dilute vinasses (DV) was about 1 kg L^{-1}, whereas that of the concentrated vinasses (CV) increased from 1.22 to 1.35 kg L^{-1} according to the proportion of sugar cane in the original material. As expected, the dry matter concentrations were much higher in CV than in DV and the dry matter content was higher in the product that partially or totally originated from sugar cane molasses.

Carbon concentrations were higher in molasses from sugar cane, whereas the N concentrations were lower in samples from sugar cane (Table 1). Inorganic C was nearly negligible, and inorganic N was a minor component of the products in relation to organic N. Consequently the organic and total C to N ratio also varied, from 24 to 42 and from 23 to 40, according to the proportion of sugar cane.

The influence of origin of the raw material on vinasse C concentration was less clear as the C concentrations were almost the same in all samples (Table 1). However, the total and organic N concentrations significantly increased with those of sugar beet origin. The effect of the concentration of the vinasse varied with the raw material: the C concentration decreased whereas the N concentration increased when DV0 was concentrated to CV0; both C and N concentrations increased from DV30 to CV30 and both C and N concentrations decreased from DV100 to

Table 1
Carbon and N composition of the molasses and vinasses tested

	pH	Specific gravity ($g\ L^{-1}$)	Dry matter ($g\ kg^{-1}$ d m)	Organic C ($g\ kg^{-1}$ d m)	Inorganic C ($g\ kg^{-1}$ d m)	Total C ($g\ kg^{-1}$ d m)	Organic N ($g\ kg^{-1}$ d m)	NH_4^+–N ($g\ kg^{-1}$ d m)	NO_3^-–N ($g\ kg^{-1}$ d m)	Total N ($g\ kg^{-1}$ d m)	Total C to total N ratio	Organic C to organic N ratio
MOL0	9.2	1.37	700.0	277.6	0.5	278.1	23.8	0.3	0.6	24.7	22.9	23.8
MOL30	6.5	1.35	784.2	306.8	0.2	307.1	17.9	0.2	0.7	18.8	26.5	27.9
MOL100	5.2	1.39	898.4	367.5	0.2	367.6	10.9	0.4	0.0	11.3	40.3	41.6
DV0	4.6	1.00	45.6	377.0	3.1	380.1	38.4	1.2	1.1	40.6	9.4	9.8
DV30	4.7	1.02	62.8	340.6	4.0	344.6	31.7	0.6	0.0	32.3	10.7	10.8
DV100	5.0	1.02	75.4	346.0	6.8	352.8	28.0	1.2	0.0	29.2	12.1	12.4
CV0	5.9	1.22	623.9	359.8	4.1	363.9	44.4	1.0	0.9	46.3	7.9	8.1
CV30	7.0	1.24	717.9	364.0	1.4	365.4	38.3	0.2	0.4	38.9	9.4	9.5
CV100	7.1	1.35	865.1	300.5	3.2	303.6	22.9	0.8	0.0	23.7	12.8	13.1

CV100. The total C to N and organic C to N ratios of both DV and CV increased with the proportion of sugar cane.

3.2. Effect of the raw material on the organic matter composition

This was assessed by considering the characterization results obtained for the molasses (initial organic matter) and for the dilute vinasses produced directly from the molasses fermentation processes, in order to find common features of composition between the two products derived from the same raw material.

3.2.1. Carbon compounds of the molasses and dilute vinasses

3.2.1.1. Molasse composition. The most important carbonaceous component of the different molasses was sucrose, which constituted 64.4%, 69.0% and 57.5% of the MOL0, MOL30 and MOL100 organic C, respectively (Table 2). The sucrose concentration was higher in molasses from sugar beet, confirming previous studies (ADEME and Institut de l'Elevagev). MOL30 and MOL100 also contained some fructose and glucose. The cumulative percentages of organic acid C and alcohol C were low compared to the percentage of carbohydrates in all the molasses but, unlike MOL30 and MOL100, MOL0 contained ethanol. The proportion of total low-molecular-weight C compounds in the molasses was relatively similar regardless of their origin.

Conversely, assessment of the phenolic compounds in molasse solutions by UV spectrophotometry showed that the maximum absorbance varied according to the origin of the molasses (Table 3). Absorbance maxima were observed at 263 nm for MOL0, at 266 nm for MOL30 and at 271 nm for MOL100. The absorbance values also varied with the origin. UV spectrophotometry is probably the commonest and most rapid method for determining phenolic compounds. This method is also very sensitive since the extinction coefficients of aromatic groups are usually high. Together with quantitative information, UV spectroscopy provides information about the chemical structure of the samples studied, since the shapes and absorption maxima of the UV spectra are related to the chemical nature of the chromophoric groups absorbing the UV light. In this study, the UV spectra of the sugar cane- and sugar beet- derived products were very different (Fig. 2). The spectra of the sugar cane-derived products showed an absorbance maximum at 271 nm followed by a smooth decrease in absorbance with a shoulder at 320 nm, whereas the sugar beet-derived products displayed a sharper decrease in absorbance after a maximum at 261–263 nm. This pattern could not be directly related to the plant product absorbing UV light. However the aromatic amino acids responsible for protein absorption exhibit an absorption maximum at a lower wavelength (tryptophane = 280 nm, tyrosine = 274 nm, phenyl alanine = 259 nm) (Pace et al., 1995) but with no shoulder at 320 nm. In contrast cinnamic derivatives can exhibit such absorbance at 320 nm (especially in graminaceous species

Table 2
Biochemical C and N components of the molasses and vinasses tested

	MOL0	MOL30	MOL100	DV0	DV30	DV100	CV0	CV30	CV100
Carbonaceous compounds (% organic C)									
Lactate	1.3	1.0	0.3	4.0	3.5	1.0	5.8	2.9	0.4
Acetate	1.3	0.8	0.3	3.7	2.8	2.6	3.4	2.6	8.4
Propionate	0.0	0.0	0.0	0.1	0.3	0.8	0.0	0.0	3.3
Formate	0.2	0.2	0.1	0.7	0.1	0.3	0.8	0.3	0.5
Butyrate	0.1	0.0	0.0	0.4	0.1	0.1	0.0	0.1	0.9
Pyruvate	0.0	0.0	0.0	2.3	0.3	0.8	0.5	0.1	0.0
Valerate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Malate	0.3	0.3	0.3	2.9	1.0	1.2	2.1	1.4	0.2
Tartrate	0.0	0.0	0.1	0.3	0.2	0.2	0.0	0.1	0.0
Oxalate	0.3	0.4	1.3	7.2	7.9	4.0	1.6	1.8	5.5
Citrate	0.0	0.0	0.1	0.3	0.1	0.1	0.1	0.1	0.0
Iso-citrate	0.0	0.0	0.1	0.1	0.4	0.1	0.1	0.0	0.2
cis-Aconitate	0.2	0.3	0.3	1.1	0.1	1.4	1.0	0.9	0.2
trans-Aconitate	0.0	0.0	0.1	0.0	0.8	0.5	0.0	0.4	6.7
Ethanol	8.8	0.0	0.0	0.0	1.2	0.0	0.0	6.9	0.0
Inositol	0.2	0.2	0.3	0.2	0.1	0.2	2.9	0.2	0.2
Glycerol	0.1	0.2	0.1	3.6	0.0	0.0	8.0	0.3	0.2
Arabitol	0.0	0.0	0.0	0.1	0.1	0.3	0.9	0.1	0.1
Sorbitol	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0
Mannitol	0.1	0.2	0.3	0.3	0.0	0.2	1.5	1.9	0.1
Trehalose	0.0	0.0	0.1	1.6	0.0	0.1	2.4	0.0	0.2
Arabinose	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Galactose	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.0	0.0
Mannose	0.0	0.3	0.4	0.0	0.0	0.0	1.1	0.0	0.0
Lactose	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ribose	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1
Fructose	0.0	5.8	9.4	3.4	0.0	0.1	1.9	0.7	0.0
Glucose	0.0	4.2	4.9	0.3	0.1	0.4	0.7	0.8	0.0
Saccharose	64.4	69.0	57.5	0.1	0.1	0.3	2.8	0.5	1.3
Organic acids	3.7	3.1	3.0	23.1	17.7	13.0	15.5	10.7	27.3
Alcohols and polyols	9.2	0.7	0.7	4.3	1.5	0.7	13.3	9.3	0.6
Carbohydrates	64.6	79.4	72.3	5.6	0.4	1.0	9.8	1.9	1.5
Total	77.5	83.2	75.9	33.0	19.6	14.7	38.6	21.9	29.4
Nitrogenous compounds (% organic N)									
Betain	46.1	34.9	0.0	45.1	45.0	0.0	39.3	37.3	0.0

Table 3
Characterization of the phenolic compounds in the molasses and vinasses tested

	MOL0	MOL30	MOL100	DV0	DV30	DV100	CV0	CV30	CV100
$\lambda_{\max}$	263	267	271	261	271	271	261	271	271
Phenolic compounds absorbance[a]	0.498	1.074	1.575	1.055	2.549	3.702	2.089	2.949	5.507

[a] Absorbance has been expressed on a dry matter basis.

such as sugar cane) and a higher maximum absorption (275–280 nm) (Lin and Dence, 1992). The selective precipitation of protein using ammonium salts and ethanol was attempted but failed to reveal the complex structures of the products. Thus, the UV spectra could only be interpreted as indicating the botanical origin and predominance of one type of component in a complex mixture. Due to the different natures of the revealed compounds, no common absorptivity coefficient could be used to calculate the phenolic concentrations of the solutions. An attempt was made to compare the absorbances of the different products at $\lambda_{\max}$, by expressing them on a dry matter basis (Table 3). Finally, the results of this simple characterization showed that the molasses originating from sugar cane contained lignin-derived phenolic compounds, whereas those originating from sugar beet had protein-derived compounds including aromatic rings. The relative amounts of these phenolic compounds, based on the expression of absorbance on a dry matter basis, also varied with the origin.

Most of the total molasse C was present in the acid soluble fraction (Table 4). The acid hydrolysis also showed that the acid insoluble C increased with the original proportion of sugar cane, which might be due to the presence of the above mentioned-phenolic compounds.

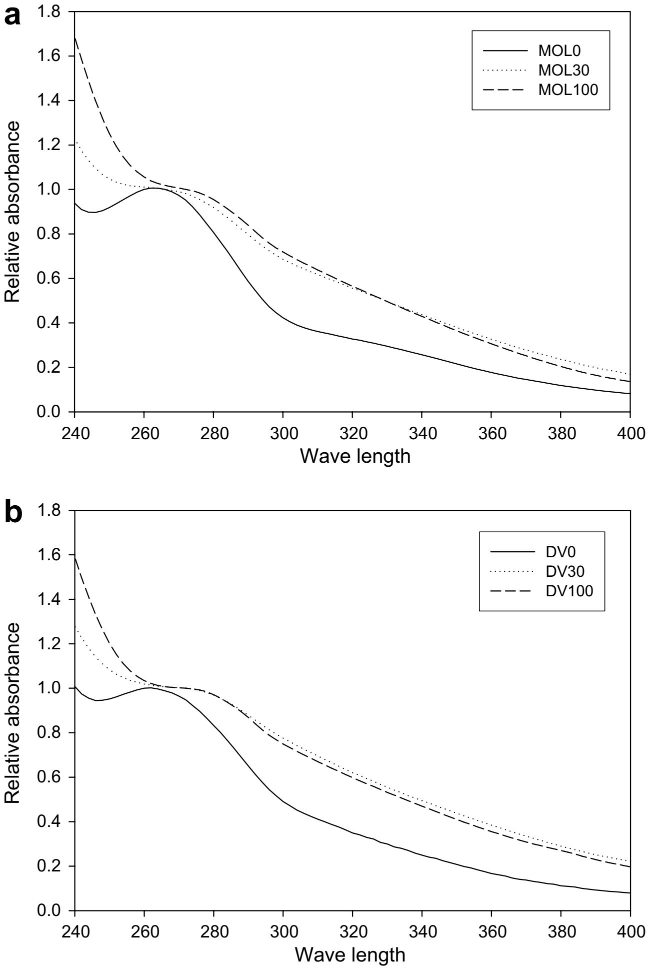

Fig. 2. Relative absorbances obtained for the different molasses (a) and dilute vinasses (b). Relative absorbance = absorbance/absorbance at λ_{max}.

3.2.1.2. Dilute vinasse composition. The proportion of organic acids in DV carbon decreased with the original proportion of sugar cane (Table 2). The most important compounds in all the DV were oxalate, lactate, acetate and malate. DV0 also contained pyruvate. DV contained few alcohol compounds and carbohydrates, except for 3.6% DV0 C in glycerol compounds. The proportion of low-molecular-weight C compounds increased with the original proportion of sugar beet, which was difficult to interpret as related to the different raw materials in view of the similar composition of the molasses. It is more likely to have resulted from the fermentation process.

The maximum absorbances of the vinasse spectra, like the molasses, varied according to molasse origin. Absorbance maxima were observed at 261 nm for DV0, and at 271 nm for DV30 and DV100. The absorbance values also varied with the origin (Table 4). The same differences in nature and amounts of phenolic compounds were observed between the vinasses and molasses originating from sugar beet and those from sugar cane. Other authors detected lignin-derived phenolic compounds, by Pyrolysis-GC/MS for example, in sugar cane vinasses (Gonzalez et al., 2000). Fractionation by Van Soest method showed that the fibre fraction was absent from all vinasses (results not shown), which confirmed that the phenolic compounds in the sugar cane-derived products were probably lignin precursors or lignin moieties rather than intact lignin macromolecules. In contrast to MOL30, DV30, which originated from both sugar beet and sugar cane, only contained lignin-derived phenolic compounds. It is presumed that any protein-derived compounds were degraded by microorganisms during the fermentation process.

Most of the total C in molasses was present in the acid soluble fraction of all the products (Table 4). The proportion of acid insoluble C increased with the original proportion of sugar cane, from 6.6% to 30.1% of the organic C, and was proportional to the acid insoluble C in the molasses.

The liquid and solid fractions were difficult to separate by centrifugation. The solid fraction in all the products was very small but was nevertheless slightly higher in the DV from sugar beet. Visual observation of the solid fraction of sugar beet-derived products revealed mineral grains that could have been soil particles but no further investigations were carried out to confirm this.

3.2.2. Nitrogen compounds and origin

As described above, the molasses and vinasses from sugar beet presented higher N concentrations and lower C to N ratios. These results are consistent with the plant C to N ratios (Moletta, 2002; Wang et al., 2004). A significant proportion of the organic N in MOL0 and MOL30

Table 4
Carbon and N characteristics obtained by fractionation of the molasses and vinasses

		MOL0	MOL30	MOL100	DV0	DV30	DV100	CV0	CV30	CV100
Liquid–solid separation										
Solid fraction C	% organic C	–	–	–	11.4	2.9	3.9	9.0	0.9	2.5
Solid fraction N	% organic N	–	–	–	18.7	3.6	3.8	11.6	0.7	3.7
Solid fraction C to N ratio		–	–	–	5.7	8.5	12.4	6.1	11.7	8.8
Liquid fraction C to N ratio		–	–	–	10.2	10.7	12.1	8.1	9.4	13.0
Acid hydrolysis										
Acid insoluble C	% organic C	13.1	16.2	19.2	6.6	20.6	30.1	10.6	19.8	31.4
Acid insoluble N	% organic N	4.1	9.7	12.5	2.3	9.2	14.1	5.2	9.7	24.7
Acid insoluble C to N ratio		73.7	44.4	62.1	27.0	23.8	25.8	15.9	19.1	16.3
Acid soluble C to N ratio		20.8	24.6	37.2	9.0	9.3	9.8	7.4	8.3	11.7

was due to betaine (46.1% and 34.9%, respectively). As expected, MOL100 did not contain any betaine (Table 2). Approximately 40% of the organic N in all vinasses derived from molasses containing sugar beet was represented by betaine.

Most of the total N was present in the acid soluble fraction of the molasses and dilute vinasses (Table 4). The proportion of insoluble N increased with the original proportion of sugar cane. The C to N ratio of the acid soluble fractions increased with the original proportion of sugar cane in the molasses, but was similar whatever the origin for the dilute vinasses. This trend was different for the C to N ratio of the acid insoluble fraction: the lowest C to N ratios were obtained for the products derived from the sugar beet and sugar cane mix. Moreover the C to N ratios were higher in the acid insoluble fraction than in the acid soluble fraction.

The C to N ratio of the solid fraction varied from 5.7 to 12.4, whereas that of the liquid fraction varied between 8.1 and 13.0.

As indicated by Gonzalez et al. (2000), the nitrogen in dilute vinasses could originate both from the cells of microorganisms and from the original molasses. This molasses origin was confirmed by the relatively similar proportions of acid insoluble N found in MOL and DV which were derived from the same raw material. The presence of betaine in MOL and DV showed that at least part of the dilute vinasse N came directly from the molasses. This molecule is present in sugar beet but not in sugar cane or the biomass, nor is it degraded by fermentation microorganisms. Thus, the difference in N compounds may be ascribed to the nature of the raw material if N is added during the process to simply cover the biomass requirements.

3.3. Evolution of organic matter composition during the process

The evolution of certain compounds during the first step of the vinasse-producing process has already been mentioned. Most small C molecules are assimilated during fermentation and small molecules such as alcohols and organic acids are released. It is not easy to distinguish clearly between the influence of the nature of the raw material and that of the process. The most resistant compounds, i.e. phenolic or acid insoluble ones, present in the molasses, seem to remain or even become concentrated in the DV. Dowd et al. (1994) compared vinasses produced from the fermentation of sugar cane molasses, citrus waste and sweet whey, using gas chromatography/mass spectrometry and high performance liquid chromatography. These authors also found significant differences in the composition of organic compounds of low molecular weight resulting from the different raw materials used for fermentation, and from the actual fermentation process.

The high temperatures during the production of concentrated vinasse (CV) from dilute vinasse (DV) were presumed to induce two types of organic matter modification, notably the evaporation of volatile and the condensation of organic compounds to produce more complex molecules (Maillard, 1912). We observed a variable effect of evaporation on C and N concentrations, as mentioned above. The proportion of organic acids decreased from DV0 to CV0 and from DV30 to CV30, probably due to volatilization, but increased, surprisingly, from DV100 to CV100 (Table 2). This might be due to some micro-organisms in the dilute vinasse still being active at the beginning of evaporation. Similarly, the observed increase in the concentration of alcohols and carbohydrates from DV0 to CV0 and from DV30 to CV30 was also unexpected.

The maximum absorbances in the concentrated vinasse spectra (Fig. 2) varied according to the origin of the molasse, and the wavelength of the concentrated vinasse was the same as for the corresponding dilute vinasse (Table 3). The absorbance values increased when the vinasses were concentrated. As the nature of the phenol compounds was the same for a given vinasse origin, it can be deduced that the concentration of phenol compounds increased from DV to CV. The carbon concentrations in dilute and concentrated vinasses were similar, and neither lignin-derived nor protein-derived compounds were expected to be generated during the evaporation process. Consequently it was assumed that the increased absorbance of the CV solutions could have been due to melanoidin formation, as the conditions would have favored the Maillard reaction (Maillard, 1912).

The acid hydrolysis results were different for the source materials. Acid insoluble C and N increased from DV0 to CV0 (Table 4) and could also be ascribed to melanoidin formation (Maillard, 1912), because of the high temperature and the presence of proteins and reducing sugars. However, no such results were observed with DV30 and CV30. Considerable increase in acid insoluble N between DV100 and CV100, although the acid-insoluble C remained the same, is difficult to explain. If the decrease in C and N concentrations from DV100 to CV100 is considered as well as the increase in organic acids concentration, one explanation could be that persistent biological activity in DV100 at the beginning of evaporation might initiate mineralization-denitrification which would be favored in this aqueous medium by the high temperatures and presence of labile organic C. Another more probable explanation would be the presence of specific phenol compounds such as tannins which could be linked with peptide N (Monties, 1980).

3.4. Factors influencing mineralization of the products

3.4.1. Labile and resistant organic compounds

The mineralization of carbon in the three dilute vinasses was extremely rapid during the first 2 weeks, then slowed down until it nearly stopped at the end of the 6-month period (Fig. 3a,c,e). Cumulative mineralization was similar for both DV30 and DV100 (71% at the end of the incubation

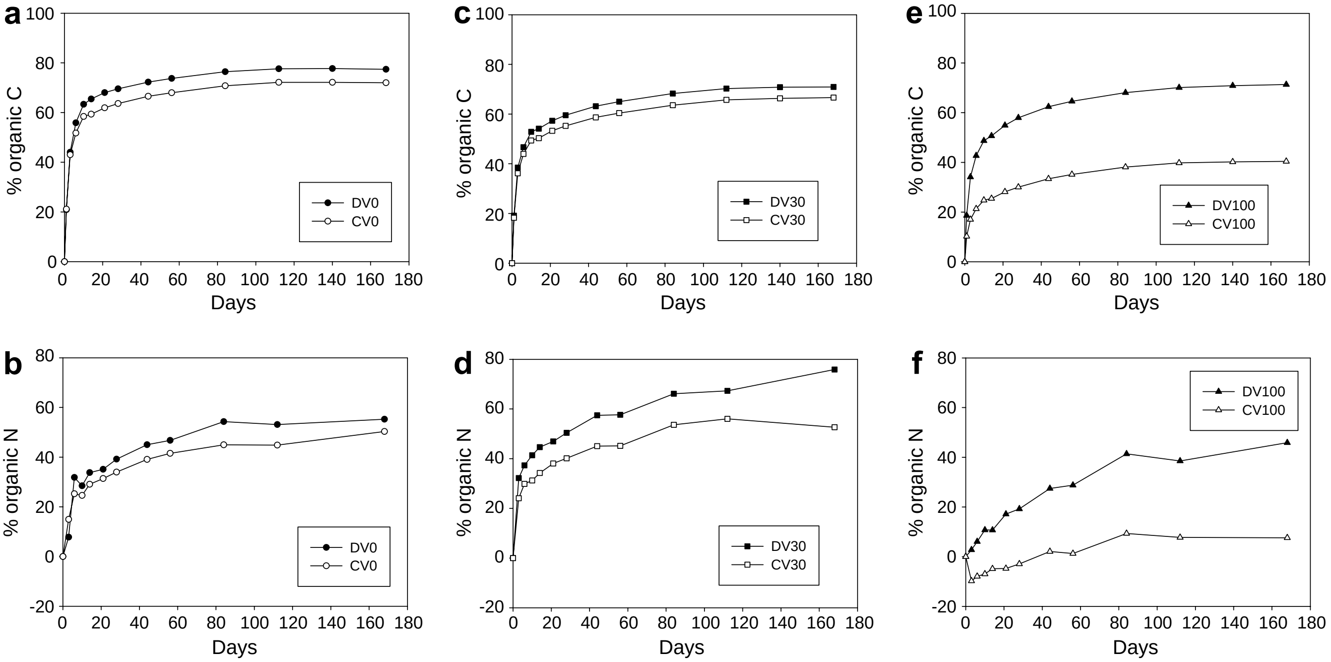

Fig. 3. Carbon and net N mineralization kinetics of the different vinasses. (a) C mineralization of sugar beet-based vinasses; (b) net N mineralization of sugar beet-based vinasses; (c) C mineralization of sugar beet and sugar cane-based vinasses; (d) net N mineralization of sugar beet and sugar cane-based vinasses; (e) C mineralization of sugar cane-based vinasses; (f) net N mineralization of sugar cane-based vinasses.

period). From the very start of incubation, carbon mineralization was slightly higher in DV0, and accounted for 77% of the organic C at the end of the experiment. The fitted C mineralization kinetics (Table 5) indicate that the percentage of organic C in the labile compartment (a) decreased from 66% to 27% according to the proportion of sugar beet in the original mixture. The k_1 coefficient of this compartment decreased from 0.395 to 0.299 d^{-1}. In contrast, the resistant compartment increased with decreasing proportion of sugar beet, whereas the variation in k_2 was apparently not linked with the original plant material.

Comparison of DV0 and CV0, and of DV30 and CV30 revealed the same trend (Fig. 3a–d). Net C and N mineralization were slightly but significantly higher for the dilute vinasse treatments than for the concentrated vinasse treatments ($p = 0.05$). Carbon mineralization in DV100 derived from sugar cane molasses, was much higher than that of the CV100 (Fig. 3e). The fitted C mineralization kinetics showed that the labile compartment A was similar in size for DV0 and CV0, and for DV30 and CV30, but differed between DV100 and CV100.

Table 5
Parameters of the 2-compartment C mineralization model

	A (% organic C)	k_1 (d^{-1})	k_2 (d^{-1})
DV0	66	0.337	0.0034
DV30	54	0.377	0.0035
DV100	51	0.331	0.0041
CV0	59	0.395	0.0030
CV30	50	0.392	0.0030
CV100	27	0.299	0.0016

No significant relationship was observed between the size of labile compartment A and the presence of low-molecular-weight organic compounds. However strong positive correlations were found between A and C mineralization rates and the proportion of organic N present in the acid-soluble fraction (Table 6). A and the C mineralization rates were also negatively linked with the absorbance of phenol compounds measured by UV spectrophotometry. Acid soluble N is probably readily decomposed by soil micro-organisms and may consist of free amino-acids and protein. Conversely, acid-insoluble N might be included in aggregates, the cell walls of micro-organisms or complex molecules such as lignin-derived compounds or melanoidins, which are assessed during absorbance measurements. These resistant and complex molecules need further investigation, because as they remain in soil, they are probably also resistant to the biological treatment carried out on vinasses prior to their release into surface water (FitzGibbon et al., 1998). Phenolic compounds, for example, are well-known inhibitors of anaerobic digestion, which is why vinasses are subjected to a fungal pretreatment to decrease their phenol content (Jimenez et al., 2003).

3.4.2. Factors of composition influencing N dynamics

The kinetics of net N mineralization differed with regard to the origin of the products (Fig. 3b,d,f). The net N mineralization of DV0 and DV30 was very rapid during the first few days and then slowed down. The final values at the end of incubation were 55% and 76% of DV0 and DV30 organic N, respectively. In contrast, the net N mineralization of DV100 slowly increased and finally attained

Table 6
Significant correlations ($^*p = 0.01$) between composition criteria and C and N mineralization rates

		A	C mineralization rate			Net N mineralization rate		
			Day 6	Day 56	Day 168	Day 6	Day 56	Day 168
			% organic C			% organic N		
Total C	g kg^{-1} d m	0.94*	0.94*	0.93*	0.92*	0.75	0.77	0.69
Betaine	g kg^{-1} d m	0.78	0.81	0.70	0.66	0.92*	0.83	0.72
Acid soluble N	% vinasse N	0.98*	0.99*	0.94*	0.92	0.87	0.86	0.79
Acid insoluble N	% vinasse N	−0.98*	−0.99*	−0.94*	−0.92	−0.87	−0.86	−0.79
Phenolic compounds	g kg^{-1} d m	−0.97*	−0.97*	−0.93*	−0.90	−0.87	−0.85	−0.78

46% of the organic N. Net nitrogen mineralization rates for the products derived from sugar beet were slightly but significantly higher in the dilute vinasse than in the concentrated vinasse ($p = 0.05$). The net N mineralization pattern was very different for CV100, inducing net N immobilization during the first 40 days of incubation and slow net N mineralization after this period (Fig. 3f). The final net N mineralization values were 46% and 8% for DV100 and CV100, respectively.

Nitrogen dynamics in vinasse-treated soil are driven partly by the kinetics of vinasse decomposition and partly by the availability of nitrogen present in the decomposed organic molecules (Swift et al., 1979). In our study no significant correlation ($p = 0.01$) was obtained between N mineralization during incubation and the composition criteria, except for net N mineralization on day 6 which was positively linked with betaine concentration (Table 6).

4. Synthesis and conclusion

For these vinasse samples, the nature of the raw material used for fermentation had the greatest effect on the nature and size of the resistant organic pool. The fractions in this pool included aromatic compounds, especially phenol compounds originating from the raw plant material or from complex molecules such as melanoidins, induced by the physico-chemical conditions. Acid-insoluble N seemed to be quantitatively related to this vinasse fraction. The size of the labile fraction was higher in the vinasses derived from sugar beet molasses, but the composition of this fraction and the extent to which it depended on the nature of the raw material, was not showed in this study. The size of this fraction was related to the acid-soluble N that probably consisted of free amino-acids, peptides and proteins which are suitable substrates for soil microorganisms. As for N dynamics, the sugar beet-derived samples were richer in N compounds and induced greater net N mineralization.

The effect of evaporation varied according to the nature of the raw material. Concentration led to a slight increase in the abundance of phenol compounds and the acid-insoluble fraction, and to a slight decrease in the labile fraction of the vinasses partially or totally derived from sugar beet. The effect of concentration on the dilute vinasse from sugar cane was even greater. The corresponding concentrated vinasse had a smaller labile fraction, induced N immobilization at the beginning of incubation, and exhibited greater N concentration in the acid-insoluble fraction than the dilute vinasse. Although this could be ascribed to the association of protein or peptides with cane phenolic compounds, as can occur with plant residues or soil organic matter, this assumption requires more detailed investigation.

Acknowledgements

The authors thank Bernard Cathala for his help in characterizing the phenol compounds and interpreting the results, and Marie-Jeanne Herre, Sylvie Millon and Gonzague Alavoine for their technical assistance.

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Risk assessment
Vinasse (beet-, cane-)

Version: 20-10-2006
Code: 4004J

Product Board Animal Feed

Content

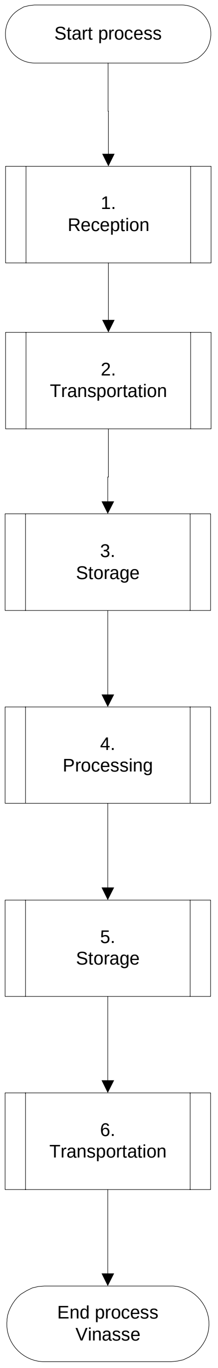
Datasheet

Product	Definition
Vinasse (beet-, cane-), alcohol production *(NL: Vinasse (biet-, riet-), alcoholbereiding)* *(DU: Vinasse (rüben-, rohr-), Alkoholbereitung)*	Byproduct obtained after fermentation of (sugar from) beet- or cane molasses during the production of alcohol.
Vinasse (beet-, cane-), yeast production *(NL: Vinasse (biet-, riet-), gistbereiding)* *(DU: Vinasse (rüben-, rohr-), Hefebereitung)*	Byproduct obtained after fermentation of (sugar from) beet- or cane molasses during the production of yeast.
Vinasse (beet-, cane-), amino- and organic acid production *(NL: Vinasse (biet-, riet-), amino- en organische zuren bereiding)* *(DU: Vinasse (rüben-, rohr-), Amino- und organischer Säurenbereitung)*	Byproduct obtained after fermentation of (sugar from) beet- or cane molasses during the production of citric acid or other organic matters.

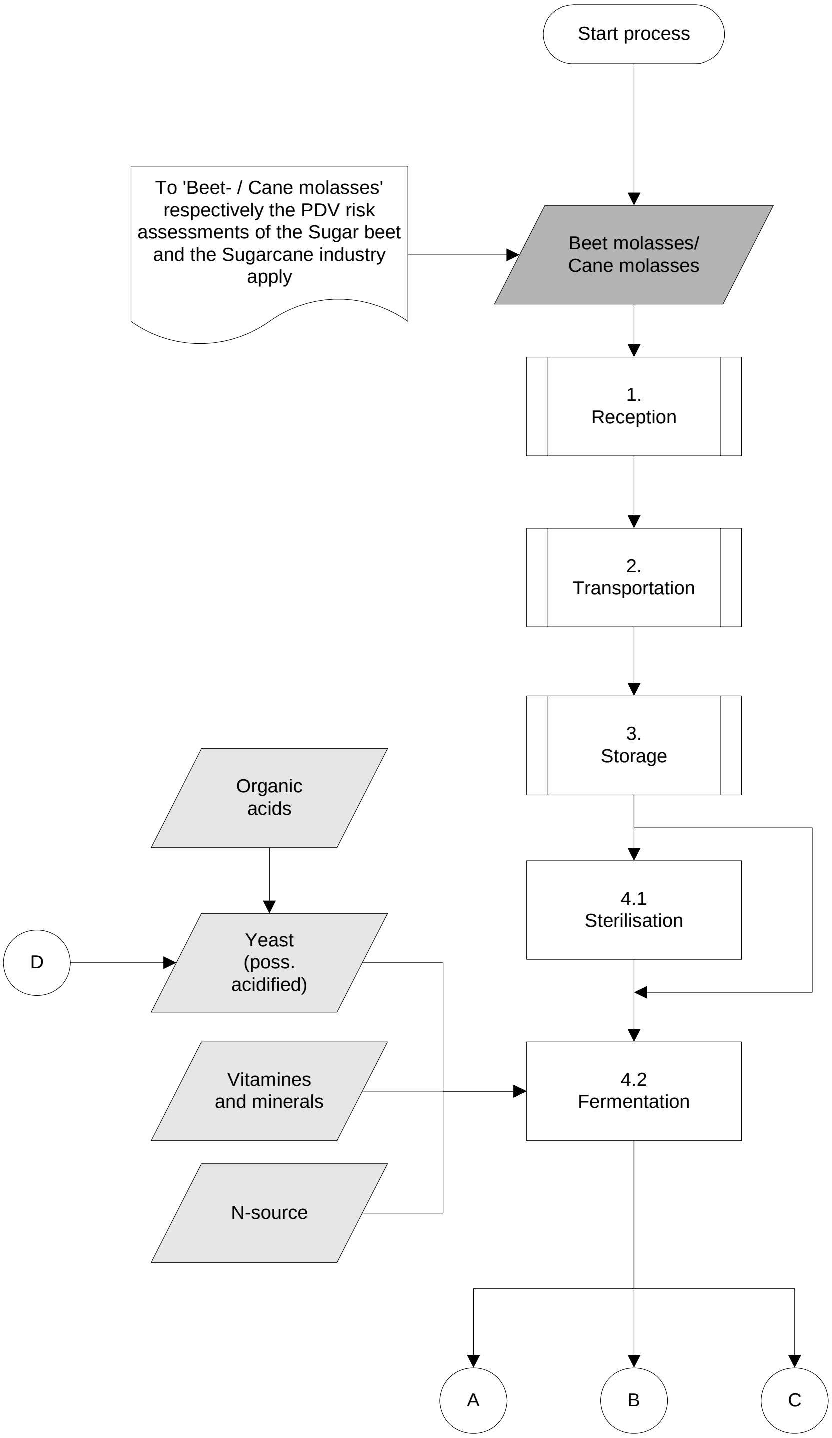
Processing aids used during processing
Organic acids
Yeast
Vitamines
Minerals
N-source

Global

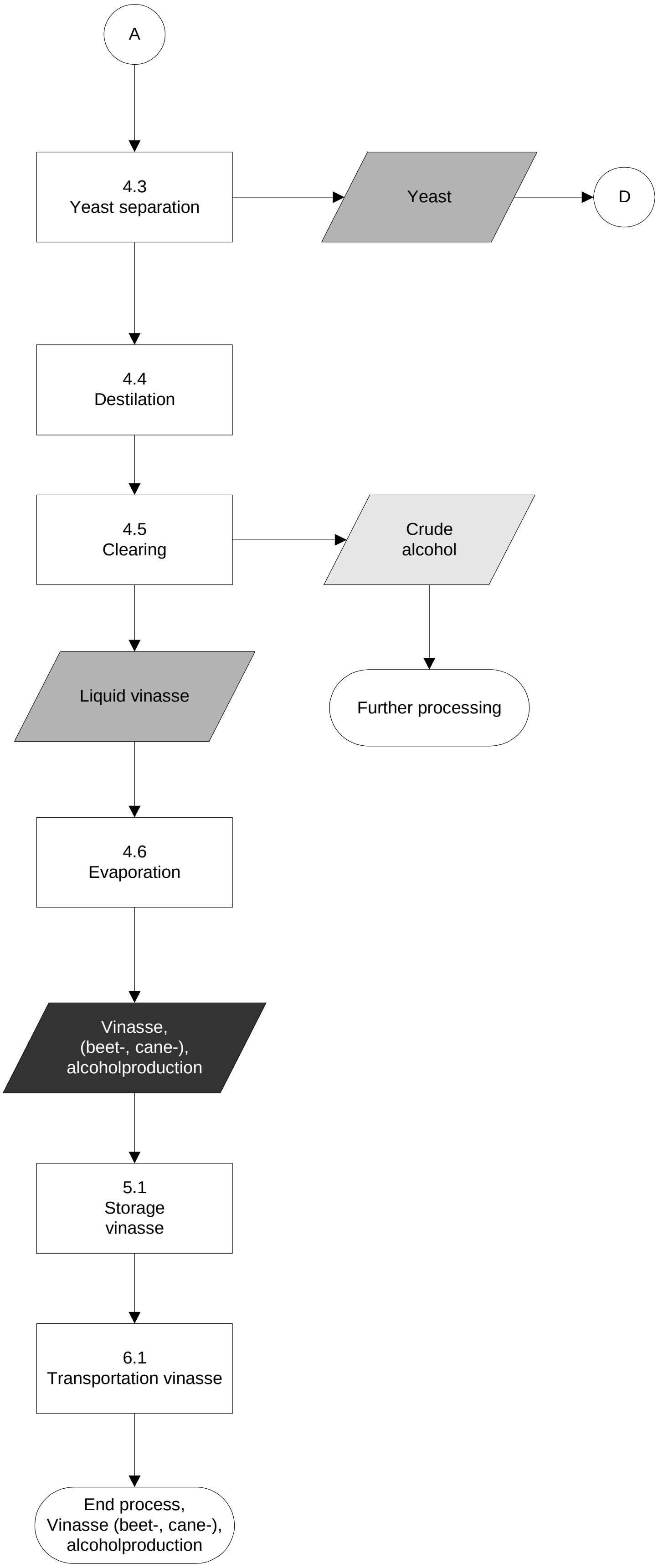
Process diagram Vinasse



Deatil 1
Process diagram Vinasse

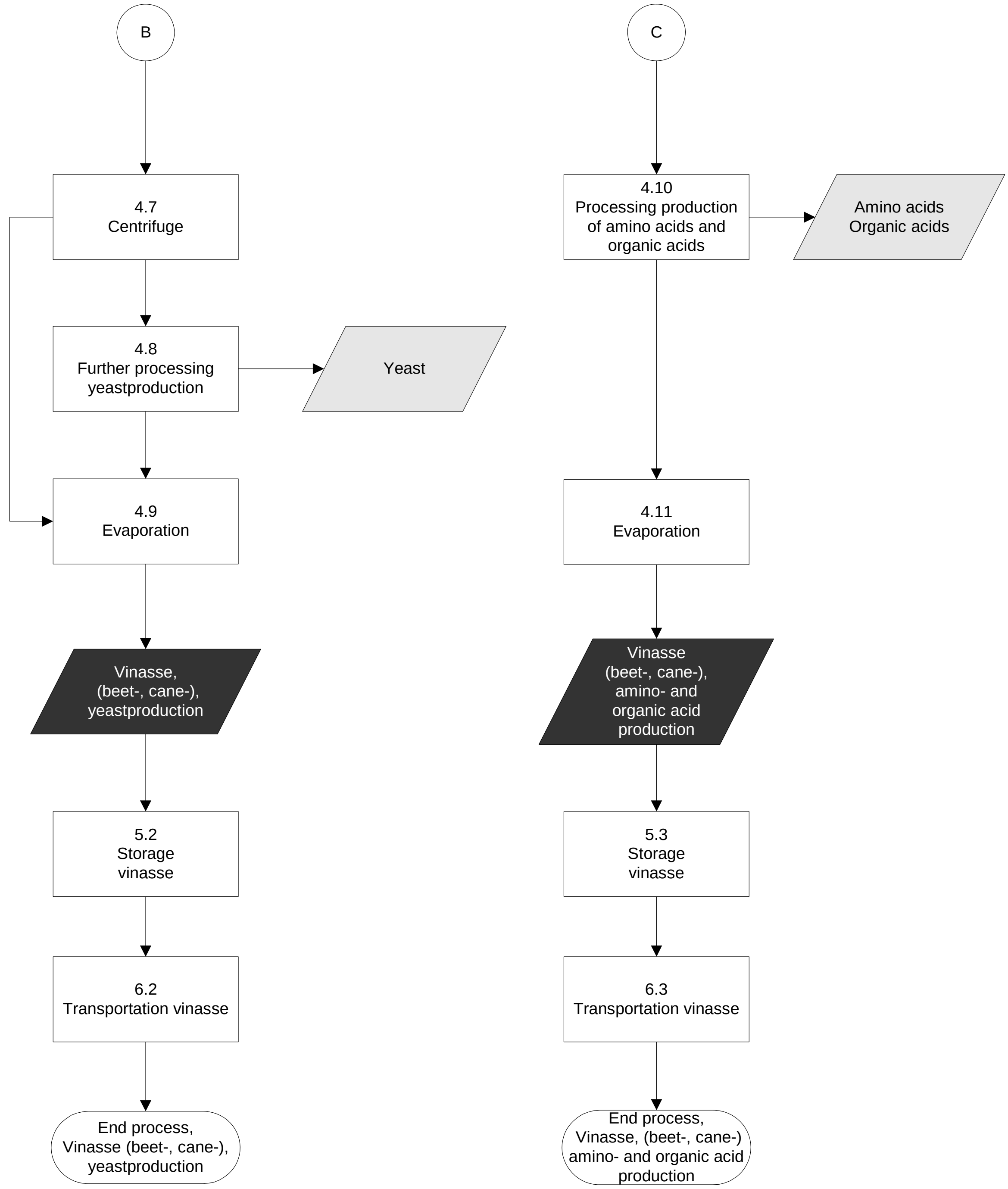


<u>Detail 2</u>
Process diagram Vinasse



Detail 3

Process diagram Vinasse



Raw material name	**Hazard**	**Risk ranking**					**Critical Control Point (CCP) Point of attention (POA)**		**Suggestion of control measure**	**Possible source or database**
Vinasse (beet-, cane-)		**Cat.**	**Chance**	**Serious-ness**	**Risk**	**AF Act / GMP Reference to standard**		**Reference in proces diagram**		
For the risks concerning the input (beet-. cane molasses) the PDV risk assessments of the relevant processing industries applies.										
Transport / storage	**Contamination with physical components:**	P	small					1, 2, 3, 5, 6	Purchase conditions	T
	- Preserved wood			large	3	GMP^{+}-2006 Appendix 3	POA			
	- Glass			large	3		POA			
	- Synthetic materials			medium	2	GMP^{+}-2006 Appendix 1				
	- Metal particles			large	3		POA			
	- Sand, small stones			medium	2					
	- Packing materials:			medium	2	Directive 91/516/EEG,				
	- Polyvinylchloride					GMP^{+}-2006 Appendix 3				
	- Polystyrene									
	- Dibutyl phthalate									
	- Polyethylene					GMP^{+}-2006 Appendix 1				
	- Di(2-ethylhexyl) phthalate									
	Presence of insects / vermin:	M	small					1, 2, 3, 5, 6	Vermin control	T, MV
	- Insects			medium	2					
	- Birds, rats, mice			large	3		POA			
	Pest- and disease control during storage: - Fungicides - Insecticides - Rodenticides	C	small	large	3		POA	1, 2, 3, 5, 6	Monitoring	Lit
	Microbiological contamination by soiling with excreta or remainders of refuse from inadequately cleaned means of transport: Enterobacteriaceae : - Salmonella - Escherichia coli (E coli) - Shigella spp. - Yersinia Enterocolitica	M	small	large	3	GMP^{+}-2006 Appendix 1	POA	2, 6	GMP-Transport + monitoring	T, DB-CVB, Lit, DB-EU, MV
	Fungi and yeasts	M	small	medium	2	GMP^{+}-2006 Appendix 1		3, 5	Monitoring of pH, temperature and AW-value	T, DB-CVB, DB-EU, MV
	Contamination with banned substances:		small	large	3	GMP^{+}-2006 Appendix 3	POA	1, 2, 3, 5, 6	GMP-Transport + monitoring	DB-EU, PDV, Lit
	- Faeces and urine	M/C								
	- Waste fats and sludge	C								

Raw material name	**Hazard**	**Risk ranking**					**Critical Control Point (CCP) Point of attention (POA)**		**Suggestion of control measure**	**Possible source or database**
Vinasse (beet-, cane-)		**Cat.**	**Chance**	**Serious-ness**	**Risk**	**AF Act / GMP Reference to standard**		**Reference in proces diagram**		
Transport / storage (cont.)	**Other contaminants:**		small					1, 2, 3, 5, 6		MV, T
	- Waste water	C		large	3	Regulation 98/83/EG	POA			
	- Hydrocarbons C10 – C40, PCB's	C		large	3	GMP$^+$-2006 Appendix 1	POA		Machine maintenance	
	- Disinfectants	C		large	3		POA			
	- Remainders from a previous load	M/C/P		large	3	GMP$^+$-2006 Appendix 14	POA			
	- Cleaning agents	C		large	3		POA		Feed/ Food grade agents	
	- Remainders of refuse as a result of an inadequately cleaned installation	C/P		medium	2					

Raw material name	**Hazard**	**Risk ranking**					**Critical Control Point (CCP) Point of attention (POA)**		**Suggestion of control measure**	**Possible source or database**
Vinasse (beet-, cane-)		**Cat.**	**Chance**	**Serious-ness**	**Risk**	**AF Act / GMP Reference to standard**		**Reference in proces diagram**		
Processing / handling	**Forming of or contamination with toxic components as a result of: direct drying, inadequate combustion, soiled fuels or burning of the product:**	C	small					4.6, 4.9, 4.11	Control measure T. When using mineral oil, coal or other sources: independent inspection and monitoring once per year	Lit, MV, DB-AM
	- Dioxins and dioxin-like PCB's			large	3	GMP^{+}-2006 Appendix 1	POA			
	- Polycyclic Aromatic Hydrocarbons (PAH's)			medium	2	GMP^{+}-2006 Appendix 1				
	- Polychlorinated Biphenyls (PCB's)			large	3	GMP^{+}-2006 Appendix 1	POA			
	- Heavy metals (Ash particles)			large	3		POA			DB-AM, MV, Lit, T, DB-EU
	- Acrylamid			large	3		POA			
	Contamination via processing aids	C/F/M	small	large	3		POA	4.2	Purchase conditions, certified supplier	
	Contamination with organic components:	C	small	large	3		POA	4	GMP-Transport + monitoring	DB-EU, PDV, Lit
	- Untreated process water					Directive 90/667/EEG				
	- Other fats and oils					GMP^{+}-2006 Appendix 3				
	Contamination with physical components:	P	small					4	Purchase conditions	T
	- Glass			large	3		POA			
	- Synthetic materials			medium	2	GMP^{+}-2006 Appendix 1				
	- Metal particles			large	3		POA			
	- Sand, small stones			medium	2					
	- Packing materials:			medium	2	GMP^{+}-2006 Appendix 3, Directive 91/516/EEG			Feed / Food grade materials	
	- Polyvinylchloride									
	- Polystyrene									
	- Dibutyl phthalate									
	- Polyethylene					GMP^{+}-2006 Appendix 1				
	- Di(2-ethylhexyl) phthalate									
	Other contaminants:		small					4		MV, T
	- Waste water	C		large	3	Regulation 98/83/EG	POA			
	- Microbial contaminants	M		large	3		POA			
	- Hydrocarbons C10 – C40, PCB's	C		large	3	GMP^{+}-2006 Appendix 1	POA		Machine maintenance	
	- Disinfectants	C		large	3		POA		Feed/ Food grade agents	
	- Cleansing agents	C		large	3		POA		Feed/ Food grade agents	
	- Remainders of refuse as a result of an inadequately cleaned installation	C/P		medium	2					

TATE & LYLE
CONSISTENTLY FIRST IN RENEWABLE INGREDIENTS

MATERIAL SAFETY DATA SHEET	Page: 1 Revision nr. 2	Tate & Lyle, Thames Refinery, Factory Road, Silvertown, London E16 2EW
CONDENSED MOLASSES SOLUBLES (CMS)	Date: 1/3/2005 Supersedes 15/11/2004	Tel: +44(0)20 7540 1118, Fax: +44(0)20 7540 1848

1. Identification of the product and the Company

Product name : Condensed Molasses Solubles or CMS
Product code : SAP Material Number 10338
Product type : Animal feed ingredient, liquid fertiliser component
Supplier : Tate & Lyle
Contact number for technical information : See above heading

2. Composition and Process

The condensed by-product of yeast or alcohol production by fermentation of beet and/or cane molasses
A dark brown syrupy liquid with earthy caramel-like, non-pungent smell

3. Hazards Identification

- Inhalation : Not applicable
- Skin contact : None under normal ambient conditions
- Eye contact : None under normal conditions
- Ingestion : None under normal conditions

4. First Aid Measures

- Skin: : May cause slight irritation, wash area with soap and water
- Eyes: : May cause irritation, flood eye with water

5. Fire-fighting Measures

Not applicable, not combustible when spilled or transported

6. Accidental Release Measures

Personal precautions : None under normal conditions.
Environmental precautions : Biodegradable, increases BOD and COD – see **12.**
After spillage/leakage : Contain spills with sand and shovel into salvage container for disposal. Hose down small spillages or residue (slippery when wet) into sewers serviced by wastewater plant with plenty of water. Prevent direct discharge into watercourses or lakes due to high BOD. If this does occur, inform Local Authorities at once.

7. Handling and Storage

Handling : Avoid contact with skin, eyes and clothing. Wear recommended PPE.
Storage : store in ventilated tanks (mild steel, stainless steel, polyethylene, PVC) at ambient temperatures. Avoid microbiological contamination or dilution with water.

8. Exposure controls/personal protection

Personal protection : None under normal conditions
- Respiratory protection : Not applicable
- Hand protection : Not required, butyl rubber gloves advised
- Eye protection : Safety glasses or goggles may be desirable when emptying containers or drums.

9. Physical and chemical properties

Physical state at 25^{o}C : Low viscosity liquid
Colour : Very dark brown
Odour : Weak caramel non-pungent
pH value as is : About 5.4
Initial boiling point (^{o}C) : >100
Flammability, Flash point (^{o}C) : Not applicable
Explosion limits (lower) (kg/ m^{3}) : Not applicable
Relative Density at 20 ^{o}C (kg/l) : About 1.33
Viscosity (cps) at 20^{o}C : About 100
Solubility in water (% weight) : Forms infinite aqueous solution
Vapour pressure (hPa) : Not applicable

10. Stability and reactivity

Hazardous decomposition products : Burning can produce CO_2 and water, N compounds
Materials to avoid : Strong acids and alkalis, oxidising agents
Microbiological stability : Stable unless diluted with >5% water when yeast, mould and some harmless bacterial (eg Lactobacillus spp.) growth may occur in warm temperatures. Pathogens will not grow, indeed are killed.

11. Toxicological information

Acute toxicity : None, non toxic
Chronic toxicity : None

12. Ecological information

No significant environmental hazard or adverse effect from human or animal exposure resulting from accidental release of this material is anticipated. Its components are used in food and feed and there is no LD_{50} .

- COD (mgO_2/g ds) : About 350
- BOD (mgO_2/g ds) : About 300
-Ecotoxicity : Due to its high BOD, accidental discharge of large quantities into rivers or lakes will cause temporary algal growth ('bloom') and dissolved oxygen reduction with possible serious or deleterious effects on fish.

13. Disposal considerations

Disposal : See Section **6**

14. Transport information

No special requirements or precautions applicable

15. Regulatory information

Feed legislation : Complies with the Feeding Stuffs Regulations 2000 and Amendments

16. Other information

Symbol(s) : None
R and or S phrases : None

The contents and format of this MSDS are in accordance with EC Commission Directive 91/155/EC, as amended by Directive 93/112/EC.

DISCLAIMER OF LIABILITY

The information in this MSDS was obtained from sources which we believe to be reliable. However, the information is provided without any warranty, express or implied, regarding its correctness. The conditions or methods of handling, storage, use or disposal of the product are beyond our control and may be beyond our knowledge. For this, and other reasons, we do not assume responsibility and expressly disclaim liability for loss, damage or expense arising out of or in any way connected with the handling, storage, use or disposal of the product.

This MSDS was prepared and is to be used only for this product. If the product is used as a component in another product, this MSDS information may not be applicable.

End of document

Technisches Datenblatt : VINASSE MPCV 01

Bezeichnung:

- Rohstoff für Futtermittel
- Rüben- / Rohrvinasse, teilweise entkalisiert

Zusammensetzung	%	**Mini** %	**Maxi** %
Trockensubstanz (Methode Karl Fischer)	66	65	
Feuchtigkeit	34		35
Rohprotein (Methode Kjeldahl, N x 6,25)	25,5	23,5	
Rohasche	23		24

Anwendungsvorschriften: Siehe Sicherheitsdatenblatt für Rübenvinasse

Orientierende Analysen aus repräsentativem Muster:
(Werte auf Frischsubstanz, orientierend, nicht kontraktlich)

1 – chemisch (in g/100 g)

Trockensubstanz : 66%

Stickstoffverbindungen (Rohprotein) : 25,5%

- Gesamtstickstoff : 4,07%
- Ammoniakalischer Stickstoff : 0,81%
- Organischer Stickstoff (als Differenz) : 3,26%

Rohasche : 23%

- Kalium : 6,5%
- Schwefel : 0,6%
- Natrium : 2,8%
- Calcium : 0,2%
- Phosphor : 0,05%
- Magnesium : 0,1%
- Salzgehalt : 3,7%

Nicht stickstoffhaltige Inhaltsstoffe : 18%
davon

- fetthaltige Stoffe : 0,4%
- Gesamtzucker : 2,5%

2 – physikalisch

- pH : 6,0
- Viskosität : 300 cps bei 20 °C (Brookfield)
- spezifisches Gewicht : 1,30

Organic Amendment Based on Fresh and Composted Beet Vinasse: Influence on Soil Properties and Wheat Yield

M. Tejada,* C. Garcia, J. L. Gonzalez, and M. T. Hernandez

ABSTRACT

Industry byproducts present an alternative to inorganic fertilizer use. Fresh and composted organic wastes (non-depotassified beet [*Beta vulgaris* L. subsp. *Vulgaris*] vinasse [BV]compost, BV, and a cotton gin crushed compost [CGCC], which was also included as structural agent in the first compost) were applied for 4 yr to a Typic Xerofluvent in dryland conditions near Sevilla (Guadalquivir Valley, Andalusia, Spain). The effect on the soil's physical properties, soil microbial biomass, and five soil enzymatic activities (dehydrogenase activity, protease activity, β-glucosidase activity, arylsulfatase activity, and phosphatase activity) and the yield parameters of wheat (*Triticum aestivum* cv. Cajeme) were determined. Organic wastes were applied at 5, 7.5, and 10 Mg organic matter ha^{-1} rates, respectively. The application of fresh BV had a detrimental impact on the soil's physical (structural stability, bulk density), chemical (exchangeable sodium percentage), and biological (microbial biomass, soil respiration, and enzymatic activities) properties and the wheat yield parameters, probably because high quantities of monovalent cations, such as Na, and fulvic acids were introduced into the soil by the vinasse, thus destabilizing its structure. However when non-depotassified BV was co-composted with a CGCC, the resulting compost had a positive effect on the physical, chemical, and biological properties of the soil. The application of fresh BV resulted in a significant decrease in wheat yield (30% after 4 yr when compared with composted BV.

In the last decade the application of wastes with a high organic matter content, such as animal manure (Haynes and Naidu, 1998), sewage sludge (Fließbach et al., 1994; Albiach et al., 2001), city refuse (Giusquiani et al., 1995; Eriksen et al., 1999), compost (Sikora and Enkiri, 1999; Tejada and Gonzalez, 2003a), crop residues (De Neve and Hofman, 2000; Trinsoutrot et al., 2000), and industrial byproducts (Madejon et al., 2001; Tejada and Gonzalez, 2003b, 2004), to soil has been performed in an effort to reclaim degraded soils, supply plant nutrients at a reduced cost and to maintain soil organic matter levels.

Organic byproducts originating from industrial processes represent an important source of nutrients, especially for organic farming. In this respect, BV, a final byproduct of the sugar industry, is a product of great agricultural interest, because of its organic matter content, N and K concentrations (Madejon et al., 2001). Sugar beet is processed to produce crystalline sugar, pulp and molasses, the last being fermented to produce alcohol. After removal of the alcohol by distillation the remaining material is known as vinasse. In SW Spain, the annual production is about 5 × 10^3 Mg (Madejon et al., 2001).

Despite the nutrients contained in the vinasse, under dryland conditions this byproduct may negatively affect soil structure, nutrient uptake, and crop yield and quality (Alba, 2001; Tejada and Gonzalez, 2005), although other studies have indicated that such negative effects are not observed with irrigated maize (Tejada and Gonzalez, 2001). Some authors have suggested that the problems associated with fresh residues (such as BV) may be overcome by co-composting with solid agricultural wastes (Madejon et al., 1996; Madejon et al., 2001).

The objective of this field study was to evaluate the effects of using fresh non-depotassified BV, CGCC, and BV compost (using CGCC as a bulking agent), as soil amendments at different rates on some physical and chemical soil properties, soil microbial activity, and the yield of wheat grown in a semiarid Mediterranean agro-ecosystem.

MATERIALS AND METHODS

Site and Properties of the Organic Wastes

The study was conducted from October 1999 to October 2003 near Sevilla (Guadalquivir Valley, Andalusia, Spain) on a Typic Xerofluvent with a 2% slope. The general properties of this soil (0–25 cm) are shown in Table 1.

The organic wastes applied were: fresh non-depotassified BV, a CGCC, and a compost obtained by mixing of CGCC and BV (CV) at a 1:1 rate (weight/weight).

The CV compost was obtained by submitting the CGCC-BV mixture to an aerobic digestion in heaps of approximately 2 by 1 by 0.5 m^3, turning at intervals and controlling the temperature to be never above 60 to 65°C and the moisture (not lower than 40%) controlled by adding water when necessary. The temperature of 60 to 65°C was not exceeded to prevent possible alterations in the microflora and losses of NH_4^+–N. The composting process was allowed to progress for 157 d, when the C/N ratio and the temperature had become constant.

The general properties of the organic wastes used are shown in Table 2. Organic matter content was determined by dry combustion method (MAPA, 1986). To determine humic and fulvic acids-C, BV were extracted with 0.1 *M* sodium pyrophosphate and 0.1 sodium hydroxide. The supernatant, was acidified to pH 2 with HCl and allowed to stand for 24 h at room temperature. To separate humic acids from fulvic acids, the solution was centrifuged and the precipitate containing

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Published in Soil Sci. Soc. Am. J. 70:900–908 (2006).
Soil Biology & Biochemistry
doi:10.2136/sssaj2005.0271

677 S. Segoe Rd., Madison, WI 53711 USA

Abbreviations: BV, beet vinasse; CGCC, crushed cotton gin compost; CV, compost obtained by mixing of CGCC and BV.

Table 1. Main soil characteristics (data are the means of five samples).

pH	Determined in distilled water with a glass electrode (soil/H_2O ratio 1:1).	7.6
Clay, g kg^{-1}	Determined by Robinson's pipette method (Soil Survey of England and Wales, 1982).	180
Silt, g kg^{-1}	Determined by Robinson's pipette method (Soil Survey of England and Wales, 1982).	131
Sand, g kg^{-1}		689
Instability index, log 10Is	Determined by the Hénin and Monnier method (1956) and classified by Baize's criteria (Baize, 1988).	1.38 (Slightly stable)
Bulk density, Mg m^{-3}	Determined by MAPA methods (1986).	1.48
Total N, g kg^{-1}	Determined by Kjeldahl method (MAPA, 1986).	0.8
Total C, g kg^{-1}	Determined by Sims and Haby (1971) method.	9.7
Cation exchange capacity, $cmol_c$ kg^{-1}	Determined with 1 *M* ammonium chloride solution in ethanol/water (60:40 v/v) at pH 8.2 (Tucker, 1954).	6.92
Exchangeable Na, $cmol_c$ kg^{-1}	Determined with 1 *M* ammonium acetate at pH 7 (Richards, 1954).	0.16
ESP		2.3
SMB, Biomass-C (μg C g^{-1} dry soil)	Soil microbial biomass, determined by the method of Vance et al. (1987).	146
Dehydrogenase activity, μg INTF g^{-1} h^{-1}	Determined by the method of Garcia et al. (1993).	8.6
BBA protease activity, μmol NH_4 g^{-1} h^{-1}	Determined by the method of Nannipieri et al. (1980).	0.11
β-glucosidase activity, μmol PNP g^{-1} h^{-1}	Determined by the method of Tabatabai (1982).	0.8
Arylsulfatase activity, μg PNF g^{-1} h^{-1}	Determined by the method of Tabatabai and Bremner (1970).	8.3
Phosphatase activity, μmol PNP g^{-1} h^{-1}	Determined by the method of Nannipieri et al. (1980).	20
	INTF: 2-*p*-iodo-3-nitrophenyl; PNF: *p*-nitrophenyl; PNP: *p*-nitrophenol.	

humic acids was dissolved with sodium hydroxide (Yeomans and Bremner, 1988). The C content of humic acid and fulvic acids was determined by the method of Sims and Haby (1971). For BV, inorganic soluble P ($PO_4H_2^-$ principally) were determined by Willians and Stewart method, described by Guitian and Carballas (1976). For CGCC and CV, inorganic soluble P were determined by Willians and Stewart method, described by Guitian and Carballas (1976) after nitric and perchloric acid digestion. For BV, K and Na were determined by atomic emission spectrometer, and Ca, Mg, Fe, Cu, Mn, Zn, Cd, Ni, Cr, and Hg were determined by atomic absorption spectrometer. For CGCC and CV, Ca, Mg, Fe, Cu, Mn, Zn, Cd, Pb, Ni, Cr and Hg were determined by atomic absorption spectrometer after nitric and perchloric acid digestion. Potassium and Na were determined by atomic emission spectrometer after nitric and perchloric acid digestion.

Table 2. Characteristics of organic wastes used and standard deviation in parenthesis (data are the means of five samples).

	CGCC	BV	CV
pH(H_2O)	7.0 (0.2)	4.9 (0.1)	8.6 (0.2)
Density, Mg m^{-3}		1.25 ()	
Organic matter, g kg^{-1}	356 (21)	398 (18)	549 (24)
Humic acid-C, g kg^{-1}	89.8 (2.9)	0.64 (0.17)	51.8 (3.1)
Fulvic acid-C, g kg^{-1}	0.96 (0.19)	81.0 (5.6)	56.2 (4.8)
Total N, g kg^{-1}	13.2 (1.2)	32.5 (2.4)	39.7 (2.5)
P, g kg^{-1}	6.3 (0.7)	0.3 (0.1)	5.9 (0.8)
Ca, mg kg^{-1}	275 (22)	39 (7)	286 (19)
Mg, mg kg^{-1}	30 (7)	15 (3)	39 (5)
Na, g kg^{-1}	<0.1 (<0.01)	21 (4)	11 (3)
K, g kg^{-1}	54 (8)	126 (11)	90 (12)
Fe, mg kg^{-1}	3.9 (0.6)	226 (15)	167 (23)
Cu, mg kg^{-1}	0.1 (0.02)	2.1 (0.6)	1.6 (0.3)
Mn, mg kg^{-1}	0.6 (0.08)	3.4 (0.7)	2.8 (0.4)
Zn, mg kg^{-1}	0.5 (0.09)	12 (1)	8.9 (0.8)
Cd, mg kg^{-1}	<0.1 (<0.01)	<0.1 (<0.01)	<0.1 (<0.01)
Pb, mg kg^{-1}	<0.1 (<0.01)	<0.1 (<0.01)	<0.1 (<0.01)
Ni, mg kg^{-1}	<0.1 (<0.01)	<0.1 (<0.01)	<0.1 (<0.01)
Cr, mg kg^{-1}	<0.01 (<0.001)	<0.01 (<0.001)	<0.01 (<0.001)
Hg, mg kg^{-1}	<0.001 (<0.0001)	<0.001 (<0.0001)	<0.001 (<0.0001)

Experimental Layout and Treatments

The experimental layout was a randomized complete block design with 10 treatments and 3 replicates per treatment. The plot size was 7 by 6 m. The treatments were the following: (1) nonfertilized control plot; (2, 3, and 4) fertilized with 14.04 Mg ha^{-1} of CGCC (5 Mg organic matter ha^{-1}, fresh matter), 21.06 Mg ha^{-1} of CGCC (7.5 Mg organic matter ha^{-1}, fresh matter), 28.08 Mg ha^{-1} of CGCC (10 Mg organic matter ha^{-1}, fresh matter); (5, 6, and 7) fertilized with 12.56 Mg ha^{-1} of BV (5 Mg kg organic matter ha^{-1}, fresh matter, 10 050 L ha^{-1}), 18.84 Mg ha^{-1} of BV (7.5 Mg organic matter ha^{-1}, fresh matter, 15075 L ha^{-1}), and 25.12 Mg ha^{-1} of BV (10 Mg kg organic matter ha^{-1}, fresh matter, 20 100 L ha^{-1}); (8, 9, and 10) fertilized with 9.11 Mg ha^{-1} of CV (5 Mg organic matter ha^{-1}, fresh matter), 13.66 Mg ha^{-1} of CV (7.5 Mg organic matter ha^{-1}, fresh matter), and 18.21 Mg ha^{-1} of CV (10 Mg organic matter ha^{-1}, fresh matter).

Table 3. Instability index (log 10 Is) in soils amended with of organic wastes.

Treatments†	2000		2001		2002		2003	
Mg ha^{-1} OM	20 Apr.	15 Oct.	18 Apr.	16 Oct.	20 Apr.	14 Oct.	21 Apr.	15 Oct.
(1) Control soil	1.38a‡	1.37a	1.37a	1.37a	1.36a	1.37a	1.36a	1.36a
(2) 5 Mg CGCC	1.36a	1.35a	1.33a	1.32a	1.30a	1.29a	1.27a	1.26a
(3) 7.5 Mg CGCC	1.35a	1.33a	1.30a	1.28a	1.25a	1.23a	1.20a	1.18a
(4) 10 Mg CGCC	1.33a	1.30a	1.27a	1.25a	1.22a	1.20a	1.18a	1.15a
(5) 5 Mg BV	1.38a	1.37a	1.37a	1.36a	1.35a	1.33a	1.32a	1.32a
(6) 7.5 Mg BV	1.39a	1.40ab	1.43ab	1.45ab	1.49ab	1.51ab	1.55ab	1.58ab
(7) 10 Mg BV	1.41ab	1.44ab	1.48ab	1.51ab	1.55ab	1.60ab	1.69ab	1.73b
(8) 5 Mg CV	1.37a	1.36a	1.34a	1.32a	1.31a	1.29a	1.28a	1.27a
(9) 7.5 Mg CV	1.36a	1.34a	1.32a	1.29a	1.27a	1.25a	1.21a	1.19a
(10) 10 Mg CV	1.35a	1.32a	1.29a	1.26a	1.24a	1.21a	1.19a	1.17a

‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost. Soil structural stability classification according to Baize criteria (1998): very stable, log 10 Is < 1.00; stable, log 10 Is = 1.00–1.30; slightly stable, log 10 Is = 1.30–1.70; unstable, log 10 Is = 1.70–2.00; very unstable, log 10 Is > 2.00.

Table 4. Bulk density (Mg m^{-3}) in soils amended with organic wastes.

Treatments†	2000		2001		2002		2003	
Mg ha^{-1} OM	20 Apr.	15 Oct.	18 Apr.	16 Oct.	20 Apr.	14 Oct.	21 Apr.	15 Oct.
(1) Control soil	1.48ab‡	1.49ab	1.48ab	1.48ab	1.46ab	1.47ab	1.47ab	1.46ab
(2) 5 Mg CGCC	1.47ab	1.46ab	1.44a	1.43a	1.41a	1.40a	1.38a	1.37a
(3) 7.5 Mg CGCC	1.47ab	1.45a	1.43a	1.41a	1.38a	1.36a	1.31a	1.27a
(4) 10 Mg CGCC	1.46ab	1.43a	1.40a	1.38a	1.35a	1.32a	1.28a	1.17a
(5) 5 Mg BV	1.48ab	1.48ab	1.49ab	1.50ab	1.50ab	1.52ab	1.53ab	1.55ab
(6) 7.5 Mg BV	1.49ab	1.50ab	1.53ab	1.55ab	1.59ab	1.62ab	1.66ab	1.68ab
(7) 10 Mg BV	1.50ab	1.53ab	1.57ab	1.59ab	1.63ab	1.65ab	1.69ab	1.71b
(8) 5 Mg CV	1.47ab	1.47ab	1.45a	1.44a	1.42a	1.42a	1.39a	1.38a
(9) 7.5 Mg CV	1.46ab	1.46ab	1.44a	1.42a	1.39a	1.36a	1.33a	1.28a
(10) 10 Mg CV	1.46ab	1.44a	1.41a	1.39a	1.37a	1.33a	1.29a	1.20a

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.
‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

Beet Vinasse was mixed with 2000 L ha^{-1} of water with the objective to decrease the density of the byproduct and to facilitate their handling in field. The organic wastes were surface applied on 15 Oct. 1999, 16 Oct. 2000, 17 Oct. 2001, and 15 Oct. 2002, respectively. The plots received surface broadcasted NH_4NO_3 fertilizer on 13 Oct. 1999, 14 Oct. 2000, 15 Oct. 2001, and 13 Oct. 2002, respectively. Organic wastes and NH_4NO_3 fertilizer were incorporated to a 25-cm depth by chisel plowing and disking the day after application.

Wheat was seeded at a rate of 150 kg ha^{-1}, which is the common practice in the area. The sowing dates were 7 Nov. 1999, 10 Nov. 2000, 10 Nov. 2001, and 11 Nov. 2002, respectively.

Soil Sampling and Analytical Determinations

Soil samples (0–25 cm) were collected from each plot over a period of 4 yr (2000–2003) with a gauge auger (30-mm diam.) (20 Apr. 2000, 15 Oct. 2000, 18 Apr. 2001, 16 Oct. 2001, 20 Apr. 2002, 14 Oct. 2002, 21 Apr. 2003 and 15 Oct. 2003).

After air drying, the soil samples were ground to pass a 2-mm sieve and stored in sealed polyethylene bags at 4°C until analysis.

Soil structural stability was determined by the Hénin and Monnier method (1956) and classified according to Baize criteria (1998). The aggregate-size fraction < 2 mm was used. The proportions (%, w/w) of stable Ag, Ag_a and Ag_b aggregates (corresponding to untreated, alcohol-treated, and benzene-treated aggregates, respectively) were calculated, and the instability index, Is, was obtained using the equation:

$$\mathrm{Is} = \frac{(\% < 20\mu\mathrm{m})\ \mathrm{max}}{\dfrac{\mathrm{Ag} + \mathrm{Ag_a} + \mathrm{Ag_b}}{3} - 0.9(\%\mathrm{CS})}$$

where (% < 20 μm) max indicates the largest proportion of suspended particles < 20 μm determined for the three samples treatments, and % CS is the largest proportion of coarse sand (the 0.2–2 mm fraction) forming part of the stable aggregates.

Soil bulk density was determined using the core method. Metal cores of 6.1-cm length and 7.6-cm diam. were used to collect soil-core samples at 6.1-cm depth. The soil was weighed and dried at 105°C for 48 h before determining bulk density as the ratio between soil dry weight and the ring volume, according to the official methods of the Spanish Ministry of Agriculture (MAPA, 1986).

The exchangeable sodium percentage (ESP) was also determined, using the formula:

$$\mathrm{ESP} = 100 \times \left(\frac{\mathrm{Na_x}}{\mathrm{CEC}}\right)$$

where Na_x is the exchangeable sodium (cmol kg^{-1}) and CEC is the cation exchange capacity of the soil (cmol kg^{-1}). Exchangeable sodium (Na_x) was determined with 1 *M* ammonium acetate at pH 7 (Richards, 1954) and the cation exchange capacity was determined with 1 *M* ammonium chloride solution in ethanol/water (60:40 v/v) at pH 8.2 (Tucker, 1954). Extracted Na was determined by flame photometry.

Soil microbial biomass was determined using the $CHCl_3$ fumigation-extraction method (Vance et al., 1987). Samples of moist soil (10 g) were used, and K_2SO_4–extractable C was determined using dichromate digestion. Microbial biomass-C was calculated (Vance et al., 1987) using the equation: biomass C = $2.64E_C$, where E_C = (organic-C in K_2SO_4 from fumigated soil) − (organic-C in K_2SO_4 from nonfumigated soil).

The levels of five enzymatic activities in the soil were measured: (1) dehydrogenase activity was measured by reduction of 2-*p*-iodo-3-nitrophenyl 5-phenyl tetrazolium chloride to iodonitrophenylformazan (Garcia et al., 1993), (2) protease activity (BBA protease) was measured using N-α-benzoyl-L-argininamide as substrate (Nannipieri et al., 1980), (3) β-glucosidase activity using *p*-nitrophenyl- β-D-glucopyranoside

Table 5. Exchangeable sodium percentage (ESP) in soils amended with organic wastes.

Treatments†	2000		2001		2002		2003	
Mg ha^{-1} OM	20 Apr.	15 Oct.	18 Apr.	16 Oct.	20 Apr.	14 Oct.	21 Apr.	15 Oct.
(1) Control soil	2.3a‡	2.3a	2.2a	2.3a	2.3a	2.4a	2.4a	2.3a
(2) 5 Mg CGCC	2.6a	2.6a	2.5a	2.6a	2.7a	2.7a	2.7a	2.8a
(3) 7.5 Mg CGCC	2.9a	2.9a	3.0a	2.9a	3.0a	3.1a	3.1a	3.2a
(4) 10 Mg CGCC	3.1a	3.1a	3.2a	3.1a	3.0a	3.2a	3.3a	3.2a
(5) 5 Mg BV	6.7b	6.9b	7.5b	7.8b	8.2b	8.5bc	8.9bc	9.2bc
(6) 7.5 Mg BV	7.2b	7.9b	8.7bc	9.8bc	10.7bc	11.4c	12.2c	13.6c
(7) 10 Mg BV	7.6b	8.1b	9.4bc	10.5bc	11.3c	12.6c	13.7c	15.1c
(8) 5 Mg CV	2.5a	2.4a	2.4a	2.4a	2.5a	2.6a	2.6a	2.7a
(9) 7.5 Mg CV	2.7a	2.8a	2.8a	2.8a	2.9a	2.9a	3.0a	3.0a
(10) 10 Mg CV	3.0a	2.9a	3.0a	3.0a	3.1a	3.1a	3.1a	3.2a

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.
‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

Table 6. Microbial biomass C (μg C g^{-1} dry soil) in soils amended with organic wastes.

Treatments†	2000		2001		2002		2003	
Mg ha^{-1} OM	20 Apr.	15 Oct.	18 Apr.	16 Oct.	20 Apr.	14 Oct.	21 Apr.	15 Oct.
(1) Control soil	142ab‡	125ab	133ab	116a	125a	110a	115a	119a
(2) 5 Mg CGCC	161ab	193ab	227ab	259ab	295b	319b	376b	406b
(3) 7.5 Mg CGCC	208ab	249ab	274b	305b	349b	381b	444b	493bc
(4) 10 Mg CGCC	237ab	288b	318b	355b	408b	458b	496bc	563bc
(5) 5 Mg BV	146ab	137ab	125a	110a	91a	80a	70a	59a
(6) 7.5 Mg BV	139ab	126a	109a	92a	80a	67a	59a	50a
(7) 10 Mg BV	127ab	110a	98a	86a	69a	57a	51a	48a
(8) 5 Mg CV	158ab	188ab	215ab	240ab	288b	307b	355b	397b
(9) 7.5 Mg CV	198ab	235ab	266b	297b	330b	366b	431b	466bc
(10) 10 Mg CV	221ab	270b	304b	339b	389b	437b	477bc	527bc

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.

‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

as substrate (Tabatabai, 1982), (4) arylsulfatase activity using *p*-nitrophenylsulphate as substrate (Tabatabai and Bremner, 1970), and (5) phosphatase activity using *p*-nitrophenyl phosphate disodium as substrate (Nannipieri et al., 1980).

In the laboratory, and in the samples at the end of the experiment (2003 season), soil respiration for all treatments was measured by incubation for 0, 3, 7, 15, 30, 45, 60, 90, and 120 d. Total C-CO_2 collected in the NaOH flasks was determined by the addition of an excess of 1.5 M $BaCl_2$ followed by titration with standardized HCl using a phenolphthalein indicator (Zibilske, 1994).

Crop Yield Parameters

The number of spikes m^{-2}, number of grains spike^{-1} and crop yield (kg ha^{-1}) were determined on samples collected from each plot on 14 June 2000, 13 June 2001, 10 June 2002, and 11 June 2003, respectively.

Statistical Analysis

Analysis of variance (ANOVA) was performed using the Statgraphics v. 5.0 software package (Statistical Graphics Corporation, 1991). The means were separated by Tukey's test, considering a significance level of $P < 0.05$ throughout the study.

RESULTS

Structural Stability, Bulk Density, and Exchangable Sodium Percentage in Soils

Structural stability increased in soils amended with CGCC and CV but decreased in soils amended with high rates, Treatments 6 and 7, of BV (Table 3). Soil bulk density decreased in CGCC and CV amended soils during the experimental period but increased in BV amended soils (Table 4). Statistical analysis showed differences between the treatments at the end of experimental period, principally for Treatment 7. The soil without organic amendment (control soil) showed higher structural stability than the soil amended with fresh BV, but lower than the soil with CV.

Because the same amount of organic matter was added to the soils, the variability in the results obtained in the soil structural stability and soil bulk density must have been due to the different chemical nature of the various organic wastes added to the soil (Table 2).

Exchangeable sodium percentage increased significantly in BV-amended soils when compared with the CGCC and CV amended soils during the experimental period (Table 5). For CGCC and CV amended soils, ESP did not reach the critical sodicity value of around 15 mentioned by Richards (1954). However, for BV amended soils ESP had reached critical sodicity values (ESP = 15.1) at the end of the experimental period. The control soil presented the lowest ESP value of all treatments assayed.

Soil Microbial Properties

Tables 6 and 7 show microbial biomass and cumulative C-CO_2 values determined in the soil during the experimental period. At first sight, the results for microbial biomass and cumulative C-CO_2 respiration rates values (Tables 6 and 7) seem contradictory since the data for these parameters differ substantially for the same rate of organic matter applied to the soil. The soil microbial biomass and soil respiration values for CGCC and CV amended soils were similar between treatments, and different from the values obtained for the BV amended soils, both parameters increasing in the first two cases and decreasing in the third. For all organic treatments, Treatment 7 (BV, high dose) presented the lowest values and Treatments 4 and 10 (CGCC and CV, high dose) the highest values, at the end of experimental period. The control soil showed similar values to the BV-amended soil.

The highest enzymatic activities values were observed for CGCC amended soils, followed by CV and BV amended soils, respectively, all at the end of experimental period (Tables 8–12).

Table 7. Cumulative C-CO_2 (mg kg soil^{-1}) during incubation in soils amended with organic wastes.

Treatments†	Incubation days								
Mg ha^{-1} OM	0	3	7	15	30	45	60	90	120
(1) Control soil	0	151	397	463	641	703	762	824	861a‡
(2) 5 Mg CGCC	0	238	562	931	1182	1463	1602	1798	1995b
(3) 7.5 Mg CGCC	0	269	601	1106	1304	1586	1726	1894	2089b
(4) 10 Mg CGCC	0	287	684	1221	1415	1724	1910	2101	2306b
(5) 5 Mg BV	0	192	493	598	726	834	896	925	986a
(6) 7.5 Mg BV	0	177	421	501	686	712	783	811	864a
(7) 10 Mg BV	0	146	399	446	600	659	710	782	802a
(8) 5 Mg CV	0	219	529	889	1097	1375	1577	1687	1886b
(9) 7.5 Mg CV	0	244	588	1006	1268	1499	1668	1793	1948b
(10) 10 Mg CV	0	276	661	1155	1387	1679	1877	2003	2201b

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.

‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

Table 8. Dehydrogenase activity (μg INTF g^{-1} h^{-1}; INTF, 2-*p*-iodo-3-nitrophenyl) in soils amended with organic wastes.

Treatments†	2000		2001		2002		2003	
Mg ha^{-1} OM	20 Apr.	15 Oct.	18 Apr.	16 Oct.	20 Apr.	14 Oct.	21 Apr.	15 Oct.
(1) Control soil	8.1a‡	7.4a	6.5a	5.8a	4.9a	4.4a	4.1a	3.8a
(2) 5 Mg CGCC	33ab	59ab	76b	91b	122b	140bc	167bc	183bc
(3) 7.5 Mg CGCC	48ab	68b	89b	109b	139bc	161bc	178bc	193c
(4) 10 Mg CGCC	59ab	77b	100b	121b	146bc	179bc	199c	208c
(5) 5 Mg BV	27ab	21a	17a	14a	12a	10a	8.9a	8.0a
(6) 7.5 Mg BV	23ab	15a	8.5a	6.7a	5.2a	4.6a	4.0a	3.4a
(7) 10 Mg BV	16a	8.4a	6.7a	5.9a	4.8a	4.0a	3.7a	3.0a
(8) 5 Mg CV	29ab	48ab	68b	82b	109b	125bc	150bc	174bc
(9) 7.5 Mg CV	40ab	59ab	75b	93b	121b	149bc	161bc	188bc
(10) 10 Mg CV	49ab	68b	80b	106b	130bc	160bc	189c	197c

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.
‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

Crop Yield Parameters

The yield characteristics and yield parameters increased with increasing quantities of CGCC and CV applied to soil (Table 13). However, when BV was applied to the soil, the yield characteristics and yield parameters decreased during the experimental period. For example, there was a significant decrease in the number of grains $spike^{-1}$ (11% for the first experimental season, 18% for the second, 24% for the third, and 29% for the fourth experimental season compared with the values obtained with CV). Similarly, the application of BV led to a significant decrease in the number spikes m^{-2} (2.3% for the first experimental season, 3.8% for the second, 5.6% for the third, and 8.1% for the fourth experimental season, again compared with CV). Lastly, there was a significant decrease in wheat yield of 9% for the first experimental season, 15% for the second, 20% for the third, and 30% for the fourth experimental season with respect to the yield obtained with CV.

These results broadly reflect the results obtained for soil structural stability, bulk density, microbial biomass, and enzymatic activities. The yield characteristics and yield parameters were lower in Treatment 4 (BV, low dose) than in Treatment 1 (control soil). The statistical analysis indicated substantial differences for all parameters at each data and treatment.

DISCUSSION

Physical and Chemical Properties

The results obtained for CGCC and CV-amended soils (in which the organic matter increased the soil structural stability, especially at high organic waste rates and at the end of the experimental period) are similar to those of Chenu et al. (2000), Puget et al. (2000), and Tejada and Gonzalez (2003b, 2004) who found that a good soil structure depended on the content and nature of the organic matter added. Organic matter promotes flocculation of clay minerals, which is an essential condition for the aggregation of soil particles. In addition, bulk density is decreased as a result of the dilution of the denser soil mineral fraction and soil aeration increases because of the increase in soil porosity accompanying structural stability. This increase was especially evident for the high rates of CGCC and CV and at the end of the experimental period and was similar to the results of Kay and VandenBygaart (2002) and Tejada and Gonzalez (2003b, 2004).

The negative effect of vinasse on the soil structure may be due to its nature, since BV contains a high concentration of Na^+ and fulvic acids (Tejada and Gonzalez, 2005). This interpretation would agree with Haynes and Naidu (1998) and Grahan et al. (2002), who also found that adding large quantities of organic manures to soils destroyed the soil structure presumably because of the high amounts of Na^+ transported into the soil. Furthermore, ESP increased during the experimental period at the highest BV doses. According to Mamedov et al. (2002), this increase points to dispersibility and aggregate disintegration in these soils.

It is well known that the less oxidized, higher molecular weight humic matter is more important in the process of aggregate stabilization than the more oxidized humic substances of lower molecular weight. Chaney and Swift (1984) and Piccolo and Mbagwu (1990) sug-

Table 9. BBA protease activity (μg NH_4 g^{-1} h^{-1}) in soils amended with organic wastes.

Treatments†	2000		2001		2002		2003	
Mg ha^{-1} OM	20 Apr.	15 Oct.	18 Apr.	16 Oct.	20 Apr.	14 Oct.	21 Apr.	15 Oct.
(1) Control soil	0.11a‡	0.93a	0.91a	0.86a	0.82a	0.78a	0.75a	0.71a
(2) 5 Mg CGCC	59.3b	68.9b	75.7b	84.8b	96.8b	109.7bc	122.7bc	139.4bc
(3) 7.5 Mg CGCC	65.1b	74.0b	82.9b	89.3b	106.9bc	119.3bc	136.8bc	145.3c
(4) 10 Mg CGCC	71.7b	79.4b	88.6b	95.9b	119.5bc	132.2bc	144.1bc	151.2c
(5) 5 Mg BV	45.8ab	39.9ab	32.7ab	27.3ab	22.3ab	20.1ab	18.2ab	16.3ab
(6) 7.5 Mg BV	39.9ab	30.8ab	25.9ab	19.2ab	16.0ab	13.8a	10.1a	8.0a
(7) 10 Mg BV	31.6ab	26.6ab	18.4ab	14.0a	10.4a	8.1a	6.4a	4.0a
(8) 5 Mg CV	54.2ab	66.1b	70.6b	80.6b	90.4b	99.2bc	111.2bc	124.2b
(9) 7.5 Mg CV	60.3b	70.9b	78.8b	83.2b	97.8bc	106.9bc	120.6bc	138.6bc
(10) 10 Mg CV	68.5b	80.6b	85.3b	92.2b	106.1bc	120.8bc	131.1bc	142.0c

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.
‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

Table 10. β-glucosidase activity (μmol PNP g^{-1} h^{-1}; PNP, *p*-nitrophenol) in soils amended with organic wastes.

Treatments†	2000		2001		2002		2003	
Mg ha^{-1} OM	20 Apr.	15 Oct.	18 Apr.	16 Oct.	20 Apr.	14 Oct.	21 Apr.	15 Oct.
(1) Control soil	0.8a‡	0.7a	0.7a	0.6a	0.6a	0.5a	0.5a	0.5a
(2) 5 Mg CGCC	19.2ab	17.3ab	34.4ab	31.8ab	59.6b	50.1ab	84.3b	71.1b
(3) 7.5 Mg CGCC	37.6ab	31.9ab	50.8ab	47.3ab	74.3b	68.3b	109.3bc	93.7b
(4) 10 Mg CGCC	39.6ab	34.3ab	64.5b	59.2b	89.1b	79.6b	120.2bc	118.2bc
(5) 5 Mg BV	17.6ab	16.4a	17.0ab	10.5a	9.1a	5.9a	4.8a	2.9a
(6) 7.5 Mg BV	13.0a	8.6a	10.6a	6.7a	8.9a	4.6a	3.7a	1.9a
(7) 10 Mg BV	11.4a	8.3a	9.3a	8.4a	8.6a	4.8a	3.2a	1.1a
(8) 5 Mg CV	27.3ab	20.8ab	30.9ab	28.2ab	50.6b	44.2b	87.7b	71.6b
(9) 7.5 Mg CV	30.4ab	24.2ab	45.0ab	39.1ab	67.4b	57.5b	102.2bc	90.8b
(10) 10 Mg CV	35.2ab	29.1ab	59.1b	45.8ab	79.9b	61.3b	115.0bc	102.1bc

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.
‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

gested that the aggregate stability is significantly correlated with humic but not fulvic acid concentration, because the humic acids are directly involved in the clay-organic complex formation, whereas fulvic acids are not. Beet vinasse is a byproduct that has a low humic acid-C content and high fulvic acid-C concentrations. Fulvic acids are macromolecules with a lower polymerization index than humic acids. Hence, the applied organic matter may not have flocculated with clay minerals (essential condition for the aggregation of soil particles), for which reason thus aggregates formed under this treatment may not have been stable (Piccolo and Mbagwu, 1990; Porta et al., 1994). We assume that with the high doses of vinasse, not only the monovalent cations but also the fulvic acids were responsible for the degradation of the soil structure.

Microbial Activity in Amendment Soil

The supply of readily metabolizable C in the organic byproduct is likely to have been the most influential factor contributing to the biomass-C increases. In this respect and according to De Neve and Hofman (2000), Trinsoutrot et al. (2000), and Tejada and Gonzalez (2003a, 2003b, 2004), soil microbial biomass responds rapidly, in terms of activity, to additions of readily available C.

Our results indicated that an increase in soil microbial biomass lowered the soil instability index (log 10Is). Several studies have reported that soil microbial processes are directly and indirectly influenced by soil structure. The presence of small pores reduces accessibility of organic materials to decomposers, causing the physical protection of C and a reduction in N mineralization (Van Veen and Kuikman, 1990). The spatial distribution of microbes and soil mesofauna has been shown to be partially associated with the size distribution of aggregates (Jastrow and Miller, 1991).

Soil enzymes are biological catalysts of specific reactions and these reactions, in turn, depend on a variety of factors (Burns, 1978), such as the presence or absence of inhibitors, type of amendment, crop type, etc. Soil enzymes are good markers of soil fertility since they are involved in the cycling of the most important nutrients. The incorporation of organic amendments to soil influences soil enzymatic activities because the added material may contain intra- and extracellular enzymes and may also stimulate microbial activity in the soil (Goyal et al., 1993; Pascual et al., 1998). The development of microbial populations, which is favored by the root exudates of plants, may also be responsible for the dehydrogenase activity stimulation. The greater dehydrogenase activity noted at the high dosage suggests that the added compost did not include compounds which were toxic for this activity (Pascual et al., 1998). During each experimental season, dehydrogenase activity decreased. This may be due to microbial death because substrates were no longer available to sustain microbial biomass or to the fact that intracellular enzyme complexes were degraded by the microorganisms inhabiting amended soils (Pascual et al., 1998).

It is clear that N cycle functioning was improved in the soils treated with both composts assayed (CGCC and CV). The stimulation of protease activity BAA related

Table 11. Arylsulfatase activity (μmol PNP g^{-1} h^{-1}) in soils amended with organic wastes.

Treatments†	2000		2001		2002		2003	
Mg ha^{-1} OM	20 Apr.	15 Oct.	18 Apr.	16 Oct.	20 Apr.	14 Oct.	21 Apr.	15 Oct.
(1) Control soil	8.3a‡	7.9a	7.5a	7.0a	6.8a	6.4a	6.2a	6.0a
(2) 5 Mg CGCC	15.3ab	16.8ab	18.2ab	19.9ab	21.2ab	22.8ab	24.6ab	26.3ab
(3) 7.5 Mg CGCC	16.9ab	18.1ab	19.6ab	20.9ab	22.4ab	26.5ab	28.8b	30.7b
(4) 10 Mg CGCC	19.3ab	21.4ab	23.9ab	25.5ab	29.9b	33.6b	37.8b	40.6b
(5) 5 Mg BV	13.8a	11.5a	9.8a	8.7a	7.7a	6.4a	5.3a	4.2a
(6) 7.5 Mg BV	11.9a	9.5a	8.4a	7.3a	6.7a	5.6a	4.4a	3.8a
(7) 10 Mg BV	9.8a	7.9a	6.7a	5.8a	5.0a	4.5a	3.9a	3.1a
(8) 5 Mg CV	14.0a	16.0ab	17.5ab	18.8ab	20.4ab	21.6ab	23.5ab	25.9ab
(9) 7.5 Mg CV	15.6ab	17.5ab	18.4ab	19.5ab	21.2ab	25.4ab	27.0ab	28.8b
(10) 10 Mg CV	18.1ab	20.9ab	22.2ab	23.8ab	27.9b	32.1b	36.1b	39.8b

PNP, *p*-nitrophenol.
† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.
‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

Table 12. Phosphatase activity (μmol PNP g^{-1} h^{-1}; PNP, *p*-nitrophenol) in soils amended with organic wastes.

Treatments†	2000		2001		2002		2003	
Mg ha^{-1} OM	20 Apr.	15 Oct.	18 Apr.	16 Oct.	20 Apr.	14 Oct.	21 Apr.	15 Oct.
(1) Control soil	18a‡	15a	12a	11a	9a	9a	10a	9a
(2) 5 Mg CGCC	49ab	60ab	75b	87b	106b	119b	135bc	142bc
(3) 7.5 Mg CGCC	65ab	78b	92b	109b	122b	133b	151bc	162bc
(4) 10 Mg CGCC	71b	89b	108b	120b	134bc	148bc	168bc	182c
(5) 5 Mg BV	44ab	39ab	32a	27a	25a	20a	19a	17a
(6) 7.5 Mg BV	39ab	30a	25a	18a	15a	12a	10a	8a
(7) 10 Mg BV	31a	26a	18a	14a	11a	10a	8a	7a
(8) 5 Mg CV	44ab	55ab	70ab	80b	94b	112b	128b	136bc
(9) 7.5 Mg CV	60ab	69b	81b	99b	111b	126b	144bc	150bc
(10) 10 Mg CV	67ab	79b	96b	111b	120b	139b	157bc	171bc

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.
‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

with the N cycle suggests that the treatment used (compost) does not include compounds toxic for this activity, or that microbial growth and/or the addition of microbial cells or enzymes with the amendment counteract any inhibitory effect due to toxic compounds. The demand for N by both, plants and soil microorganisms, was probably responsible for the increase of this enzyme activity. Garcia et al. (1994) studied the influence of some toxic compounds contained in organic amendments, such as municipal solid wastes, on soil microbial activity in semiarid zones. These authors determined that the positive effect of the organic matter on biological soil quality counteracted the negative effect produced by these toxic compounds. Organic amendment by the composts studied had a positive effect on the activity of these enzymes, particularly when the amendment was at the high rate, probably due to the higher microbial biomass produced in response.

Soil arylsulfatase activity and soil phosphatase activity were higher in the CGCC amended soils than in CV amended soils. The demand for P by plants and soil microorganisms can be responsible for the stimulation of the synthesis of this enzyme (Garcia et al., 1994). In addition, the processes related to degradation of organic matter may be followed through hydrolases such as phosphatase. According to Rao and Tarafdar (1992), increases in phosphatase activity (as we have detected in the treated soils) indicate changes in the quantity and quality of soil phosphoryl substrates. The supply of readily metabolizable C in the organic byproduct is likely to have been the most influential factor contributing to the soil arylsulfatase activity and soil phosphatase activity increases.

For BV-amended soils, the effect on soil parameters is very different from compost amended soils: when fresh BV was added the soil microbial biomass, soil respiration, and soil enzymatic activities all decreased. For same authors, the application of organic wastes decreased soil microbial biomass. Brendecke et al. (1993), Fließbach et al. (1994), and Filip and Bielek (2002) reported a decrease of soil microbial biomass after a 10-yr application of 5 and 15 Mg ha^{-1} yr of fresh organic matter (sewage sludges). These authors indicated that the presence of high quantities of heavy metals (Cd, Cr, Hg, Pb, etc.) in this byproduct may counterbalance the positive effects of organic matter in soil microbial biomass. The BV analyses indicated very low concentrations of Cd, Cr, Hg, and Pb; for this reason, the observed inhibition cannot be due to the heavy metal content. Perhaps this inhibition could have been caused by labile organic toxic compounds and/or an increase of the electrical conductivity in soil with the BV addition (Garcia and Hernandez, 1996). Composting process can eliminate toxic organic compounds by mineralization (Mena et al., 2003); in our case, CV compost reduced the electrical conductivity due to the dilution effect since this compost is made with a mixture with CGCC of low electrical conductivity.

Our data indicated that increasing the dose of BV to the soil, decreased the soil structural stability, soil microbial biomass and soil respiration, which increased the soil bulk density. According to Tate III (2002) oxygen

Table 13. Wheat yield parameters.

Treatments†	2000			2001			2002			2003		
Mg ha^{-1} OM	No Grain $spike^{-1}$	No Spikes m^{-2}	Yield	No Grain $spike^{-1}$	No Spikes m^{-2}	Yield	No Grain $spike^{-1}$	No Spikes m^{-2}	Yield	No Grain $spike^{-1}$	No Spikes m^{-2}	Yield
			kg ha^{-1}			kg ha^{-1}			kg ha^{-1}			kg ha^{-1}
(1) Control soil	41a‡	297a	4097a	40a	299a	4165a	40a	300a	4101a	41a	300a	4088
(2) 5 Mg CGCC	42a	298a	4268a	43a	300a	4429ab	43a	302a	4597ab	44ab	303a	4726ab
(3) 7.5 Mg CGCC	44ab	300a	4415ab	45ab	302a	4610ab	46ab	305ab	4793ab	46ab	307ab	4944b
(4) 10 Mg CGCC	45ab	302a	4597	45ab	302a	4712ab	46ab	308ab	4906ab	47ab	309ab	5106b
(5) 5 Mg BV	41a	296a	4144a	40a	295a	4202a	39a	293a	4200a	38a	291a	4180a
(6) 7.5 Mg BV	40a	295a	4101a	40a	293a	4121a	38a	290a	4096a	37a	287a	3986a
(7) 10 Mg BV	39a	293a	4099a	38a	290a	4083a	37a	288a	4001a	35a	284a	3882a
(8) 5 Mg CV	42a	298a	4168ab	43b	299a	4355ab	42ab	301a	4493ab	42a	302a	4666ab
(9) 7.5 Mg CV	43a	299a	4386ab	43b	300a	4576ab	45ab	303a	4688ab	45ab	305ab	4872ab
(10) 10 Mg CV	44ab	300a	4526ab	45ab	301a	4688ab	46ab	304ab	4824ab	45ab	307ab	5028b

† OM: Organic matter; CGCC: cotton gin crushed compost; BV: beet vinasse; CV: beet vinasse compost.
‡ Different letters following the figures indicate a significant difference at $P < 0.05$.

concentration in soil can affect the metabolic status of the enzyme-producing cells. Disruption of soil aggregates negatively alters the oxygen diffusion rate from the atmosphere above the soil into the soil matrix as well as the rate of its consumption.

It is not easy to determine the reason for enzyme activity inhibition by BV addition; for example, phosphatase inhibition could be caused either by an excess of inorganic P (Nannipieri et al., 1990), or by heavy metals incorporated into the soil with the organic waste. However, in our case, the BV did not have a high quantity of neither P nor heavy metals. We think that this inhibition is probably due to the decrease in soil structural stability and the increase of salinity.

Wheat Yield Crop

Since soil enzymatic activities are responsible for important cycles such as C, N, P, and S, wheat yield parameters increased significantly when a higher dose of CGCC and CV was applied to the soil. These values are similar to the values reported by Gonzalez et al. (1992) for the same wheat variety fertilized with pig slurry compost in the Guadalquivir Valley (similar pedoclimatic conditions). Also, wheat yield parameters of the fourth experimental season were higher than those of the third, second, and first experimental seasons respectively, due to the residual effect of the organic matter of each organic waste after their application in the third, second, and first experimental seasons. Since the decrease in microbial diversity may reduce microbial functionality of soil and therefore decrease the N, P, and S available levels by plants, wheat yield parameters decreased significantly when a higher dose of BV were applied to the soil.

CONCLUSIONS

The application of fresh BV at doses studied under dryland conditions caused a decrease in soil physical and biological properties and wheat yield, in spite of having a high organic matter content. Perhaps the increase in monovalent cations (Na and K), and labile organic matter (possible inhibitor compounds) are responsible for this behavior. However, when non depotassified BV was co-composted with solid agricultural wastes, an increase in soil physical and biological properties and wheat yield was obtained.

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9.10.1.1 Sugarcane Processing

9.10.1.1.1 General[1-5]

Sugarcane processing is focussed on the production of cane sugar (sucrose) from sugarcane. Other products of the processing include bagasse, molasses, and filtercake. Bagasse, the residual woody fiber of the cane, is used for several purposes: fuel for the boilers and lime kilns, production of numerous paper and paperboard products and reconstituted panelboard, agricultural mulch, and as a raw material for production of chemicals. Bagasse and bagasse residue are primarily used as a fuel source for the boilers in the generation of process steam. Thus, bagasse is a renewable resource. Dried filtercake is used as an animal feed supplement, fertilizer, and source of sugarcane wax. Molasses is produced in two forms: inedible for humans (blackstrap) or as an edible syrup. Blackstrap molasses is used primarily as an animal feed additive but also is used to produce ethanol, compressed yeast, citric acid, and rum. Edible molasses syrups are often blends with maple syrup, invert sugars, or corn syrup.

Sugarcane is produced and harvested for two purposes: production of cane sugar and use as seed for subsequent plantings. In the United States, sugarcane is produced, harvested, and processed in four states: Florida, Louisiana, Texas, and Hawaii. Cane sugar is refined in eight states: Florida, Louisiana, Texas, Hawaii, California, New York, Maryland, and Georgia.

In the following sections, unrefined, or raw sugar is referred to as “cane sugar”. Following refining, the sugar is called “refined sugar”.

9.10.1.1.2 Process Description[3]

9.10.1.1.2.1 Cane Sugar Production -

Hand cutting is the most common harvesting method throughout the world but some locations (e. g., Florida, Louisiana and Hawaii) have used mechanical harvesters for several years. After cutting, the cane is loaded by hand, mechanical grab loaders, or continuous loaders. Cane is transported to the mills using trailers, trucks, railcars, or barges, depending upon the relative location of the cane fields and the processing plants. When the cane is cut, rapid deterioration of the cane begins. Therefore, unlike sugarbeets, sugarcane cannot be stored for later processing without excessive deterioration of the sucrose content.

A simplified process flow diagram for a typical cane sugar production plant is shown in Figure 9.10.1.1-1. The cane is received at the mill and prepared for extraction of the juice. At the mill, the cane is mechanically unloaded, placed in a large pile, and, prior to milling, the cane is cleaned. The milling process occurs in two steps: breaking the hard structure of the cane and grinding the cane. Breaking the cane uses revolving knives, shredders, crushers, or a combination of these processes. For the grinding, or milling, of the crushed cane, multiple sets of three-roller mills are most commonly used although some mills consist of four, five, or six rollers in multiple sets. Conveyors transport the crushed cane from one mill to the next. Imbibition is the process in which water or juice is applied to the crushed cane to enhance the extraction of the juice at the next mill. In imbibition, water or juice from other processing areas is introduced into the last mill and transferred from mill to mill towards the first two mills while the crushed cane travels from the first to the last mill. The crushed cane exiting the last mill is called bagasse. The juice from the mills is strained to remove large particles and then clarified. In raw sugar production, clarification is done almost exclusively with heat and lime (as milk of lime or

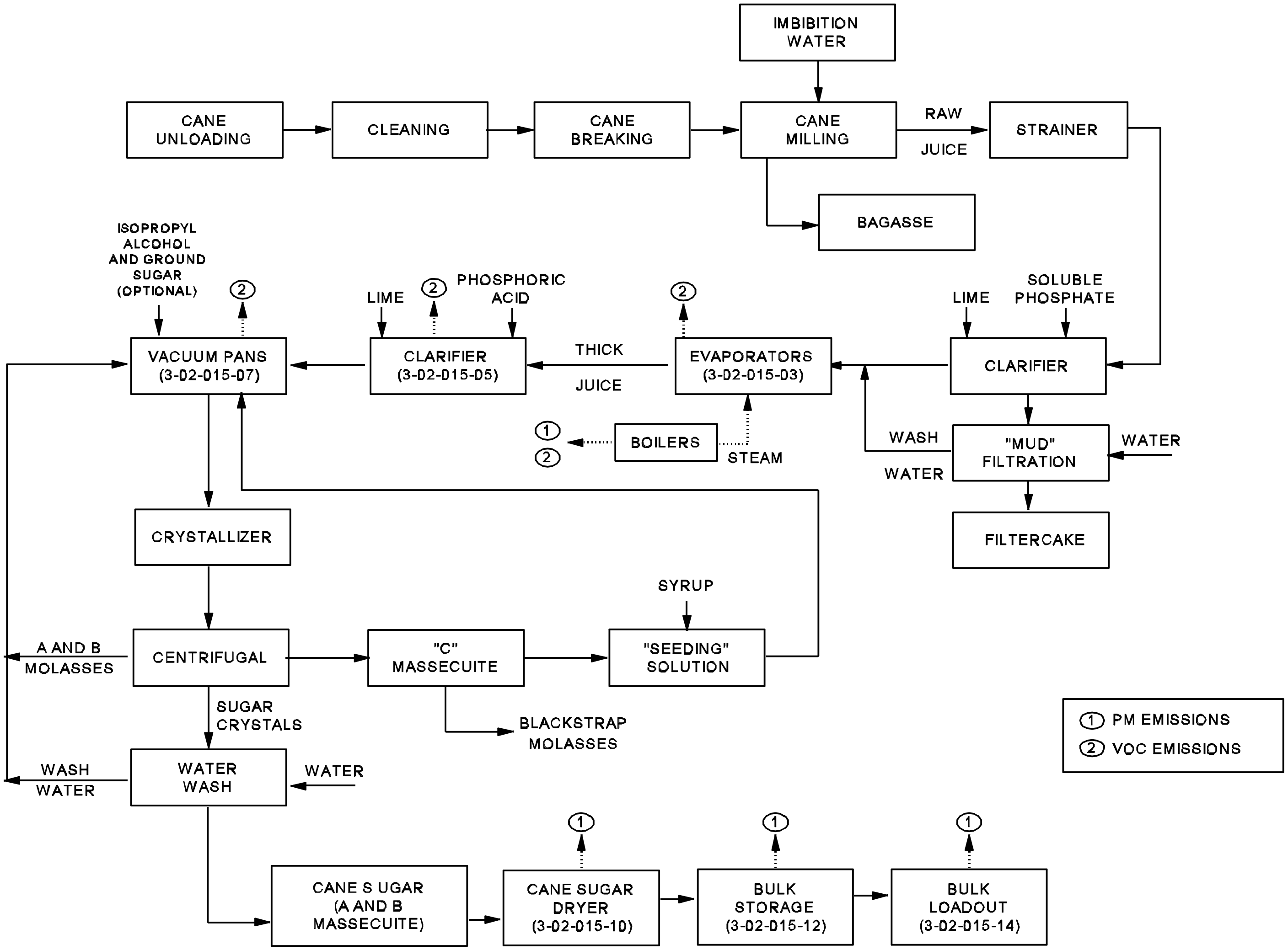

Figure 9.10.1.1-1. Simplified process flow diagram for cane sugar production.
(Source Classification Codes in parentheses.)

lime saccharate); small quantities of soluble phosphate also may be added. The lime is added to neutralize the organic acids, and the temperature of the juice raised to about 95°C (200°F). A heavy precipitate forms which is separated from the juice in the clarifier. The insoluble particulate mass, called "mud", is separated from the limed juice by gravity or centrifuge. Clarified juice goes to the evaporators without additional treatment. The mud is filtered and the filtercake is washed with water.

Evaporation is performed in two stages: initially in an evaporator station to concentrate the juice and then in vacuum pans to crystallize the sugar. The clarified juice is passed through heat exchangers to preheat the juice and then to the evaporator stations. Evaporator stations consist of a series of evaporators, termed multiple-effect evaporators; typically a series of five evaporators. Steam from large boilers is used to heat the first evaporator, and the steam from the water evaporated in the first evaporator is used to heat the second evaporator. This heat transfer process continues through the five evaporators and as the temperature decreases (due to heat loss) from evaporator to evaporator, the pressure inside each evaporator also decreases which allows the juice to boil at the lower temperatures in the subsequent evaporator. Some steam is released from the first three evaporators, and this steam is used in various process heaters in the plant. The evaporator station in cane sugar manufacture typically produces a syrup with about 65 percent solids and 35 percent water. Following evaporation, the syrup is clarified by adding lime, phosphoric acid, and a polymer flocculent, aerated, and filtered in the clarifier. From the clarifier, the syrup goes to the vacuum pans for crystallization.

Crystallization of the sugar starts in the vacuum pans, whose function is to produce sugar crystals from the syrup. In the pan boiling process, the syrup is evaporated until it reaches the supersaturation stage. At this point, the crystallization process is initiated by "seeding" or "shocking" the solution. When the volume of the mixture of liquor and crystals, known as massecuite, reaches the capacity of the pan, the evaporation is allowed to proceed until the final massecuite is formed. At this point, the contents of the vacuum pans (called "strike") are discharged to the crystallizer, whose function is to maximize the sugar crystal removal from the massecuite. Some mills seed the vacuum pans with isopropyl alcohol and ground sugar (or other similar seeding agent) rather than with crystals from the process. From the crystallizer, the massecuite (A massecuite) is transferred to high-speed centrifugal machines (centrifugals), in which the mother liquor (termed "molasses") is centrifuged to the outer shell and the crystals remain in the inner centrifugal basket. The crystals are washed with water and the wash water centrifuged from the crystals.

The liquor (A molasses) from the first centrifugal is returned to a vacuum pan and reboiled to yield a second massecuite (B massecuite), that in turn yields a second batch of crystals. The B massecuite is transferred to the crystallizer and then to the centrifugal, and the raw sugar is separated from the molasses. This raw sugar is combined with the first crop of crystals. The molasses from the second boiling (B molasses) is of much lower purity than the first molasses. It is reboiled to form a low grade massecuite (C massecuite), which goes to a crystallizer and then to a centrifugal. This low-grade cane sugar is mingled with syrup and is sometimes used in the vacuum pans as a "seeding" solution. The final molasses from the third stage (blackstrap molasses) is a heavy, viscous material used primarily as a supplement in cattle feed. The cane sugar from the combined A and B massecuites is dried in fluidized bed or spouted bed driers and cooled. After cooling, the cane sugar is transferred to packing bins and then sent to bulk storage. Cane sugar is then generally bulk loaded to trucks, railcars, or barges.

9.10.1.1.2.2 Refined Sugar Production -

A simplified process flow diagram for refined sugar production is shown in Figure 9.10.1.1-2. Cane sugar is refined either at the same location where it was produced as part of an integrated facility or at separate raw sugar refineries. The initial step in cane sugar refining is washing the sugar, called affination, with warm, almost saturated syrup to loosen the molasses film. This is followed by separation of the crystals from the syrup in a centrifugal and washing of the separated crystals with hot water or a high

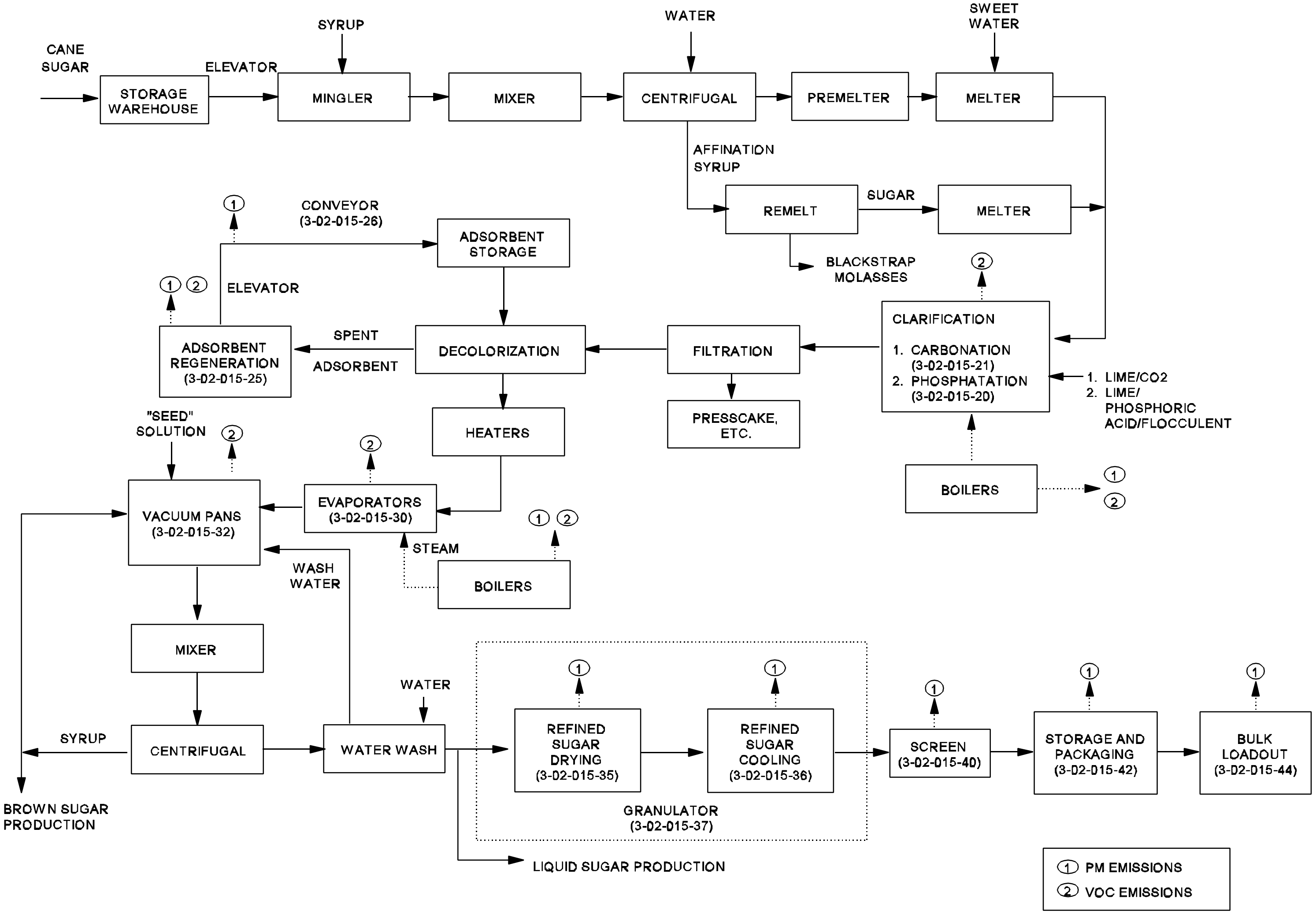

Figure 9.10.1.1-2. Simplified process flow diagram for refined sugar production.
(Source Classification Codes in parentheses.)

purity sweetwater. If the refinery is part of the cane sugar production facility, the cane sugar may be washed more heavily in previous steps and the affination step omitted.

The washed raw sugar is sent to a premelter and then to a melter, where it is mixed with high-purity sweetwaters from other refinery steps and is steam heated. The resultant syrup is passed through a screen to remove any particulate in the syrup and sent to the clarification step. The syrup from the crystal washing, called affination syrup, is transferred to a remelt processing station or reused in the raw sugar washing step. In the remelt station, the syrup volume is reduced to form the massecuite, and the sugar crystals are separated from the syrup. The separated liquor is blackstrap molasses. The sugar crystals are sent to a melter and then to the clarification step. Two clarification methods are commonly used: pressure filtration and chemical treatment; chemical clarification is the preferred method. Two chemical methods are commonly used: phosphatation and carbonation; both processes require the addition of lime. The phosphatation uses phosphoric acid, lime (as lime sucrate to increase solubility), and polyacrylamide flocculent to produce a calcium phosphate floc. Air flotation is usually used to separate the floc from the liquor and the floc skimmed from the liquor surface. Carbonation consists of adding lime to the raw melter liquid and then bubbling carbon dioxide (CO_2) through the liquor to produce a calcium carbonate precipitate. The source of CO_2 is boiler flue gas, which contains about 12 percent CO_2 by volume. The clarifier systems yield either presscakes, muds, or scums which are treated to remove entrapped sugar, and then sent to disposal.

The next step is decolorization, which removes soluble impurities by adsorption. The two most common adsorbents are granular activated carbon and bone char, manufactured from degreased cattle bones. Powdered carbon and synthetic resins are less commonly used. Bone char or activated carbon are used in either fixed or moving bed systems. Spent adsorbent is removed from the bed, regenerated, and stored for reuse.

The decolorized sugar liquor is sent to heaters (at some refineries), followed by multiple-effect evaporators, and then to the vacuum pans; this is the same sequence used in cane sugar manufacture. Basic operation of the evaporators and vacuum pans is the same as for cane sugar. The sugar liquor from the evaporators (thick juice) is transferred to the vacuum pans to further reduce the liquor volume and form the massecuite. In refined sugar production, the most common boiling system is the four-strike system. When the liquor in the pans has reached the desired level of supersaturation, the liquor is “seeded” to initiate formation of sugar crystals. At this point, the strike is discharged to a mixer and then to the centrifugal. In the centrifugal, the white sugar is retained in the inner basket and the liquor centrifuged to the outer shell. The sugar liquor is returned to a vacuum pan for further volume reduction and white or brown sugar production.   The white sugar is washed one time in the centrifugal; the separated wash water, containing liquor and dissolved sugar, is returned to the vacuum pans. The moist sugar from the centrifugals contains about 1 percent water by weight.

To produce refined granulated sugar, white sugar is transported by conveyors and bucket elevators to the sugar dryers. The most common sugar dryer is the granulator, which consists of two drums in series. One drum dries the sugar and the other cools the dried sugar crystals. Dryer drums typically operate at a temperature of about 110°C (230°F). Fluidized bed dryers/coolers are used at some facilities in place of the conventional rotary drum granulators. From the granulators, the dried white sugar crystals are mechanically screened by particle size using a sloping, gyrating wire mesh screen or perforated plate. After screening, the finished, refined granulated sugar is sent to conditioning bins, and then to storage bins prior to packaging or bulk loadout. Almost all packaged sugar uses either multiwall paper containers, cardboard cartons, or polyethylene bags; bulk loadout is the loadout of the sugar to specially designed bulk hopper cars or tank trucks.

In addition to granulated sugar, other common refined sugar products include confectioners' (powdered) sugar, brown sugar, liquid sugar, and edible molasses. There are about six other less common sugar products.

9.10.1.1.3 Emissions and Controls[3-7]

Particulate matter (PM), combustion products, and volatile organic compounds (VOC) are the primary pollutants emitted from the sugarcane processing industry. Combustion products include nitrogen oxides (NO_x), carbon monoxide (CO), CO_2, and sulfur oxides (SO_x). Potential emission sources include the sugar granulators, sugar conveying and packaging equipment, bulk loadout operations, boilers, granular carbon and char regeneration kilns, regenerated adsorbent transport systems, lime kilns and handling equipment (at some facilities), carbonation tanks, multi-effect evaporator stations, and vacuum boiling pans. Potential emissions from lime kilns and boilers are addressed in AP-42 Section 11.15 (Lime Manufacturing) and Sections 1.1 through 1.4 and 1.8 (Combustion), respectively, and are not included in this discussion. Potential sources of PM emissions include the granular carbon and char regeneration kilns, regenerated adsorbent transporting systems, sugar granulators, granulated sugar transport systems, and sugar packaging operations. The multi-effect evaporators and vacuum boiling pans are a potential source of VOC emissions from the juice. However, only the first three of five evaporators (in a typical five-stage evaporator) release exhaust gases and the gases are used as a heat source for various process heaters before release to the atmosphere. Emissions from the carbonation tanks are primarily water vapor but may contain small quantities of VOC and may also include CO_2 and other combustion gases from the boilers.

The exhaust from granulators typically is vented to cyclones to remove large PM and is then passed through a wet cyclone system (e. g., Rotoclone) to remove smaller particles. Fabric filters are sometimes used to control PM emissions from sugar handling operations and from fluidized bed drying and cooling systems. Particulate matter emissions from boilers typically are controlled with cyclones. Wet scrubbers are sometimes used as primary or secondary control devices for boilers. Some natural gas-fired boilers are not equipped with controls. Emissions from the carbonation tanks, evaporators, and vacuum boiling typically are not controlled.

Two emission test reports were identified for sugarcane processing. Both tests were conducted at sugar refineries. The first test report documents testing of a sugar granulator that is controlled by a Rotoclone wet cyclone system. The average filterable PM emission factor for the granulator (SCC 3-02-015-37) is 0.095 lb/ton. In AP-42 Section 9.10.1.2, Sugarbeet Processing, the filterable PM emission factor for a granulator equipped with a Rotoclone control was 0.064 lb/ton. Because the granulators in cane sugar and beet sugar production are expected to be similar, it is not surprising that the two emission factors are comparable. The second test report includes measurements of filterable PM emissions at the outlet of a gravity collector that controls PM emissions from a bone char conveyor transfer point (SCC 3-02-015-26). The average emission factor for this test is 0.26 lb/ton of char transferred.

The use of emission factors based on a single test is not recommended. If necessary, the average filterable PM emission factors can be used, but would be rated E.

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9.10.1.2 Sugarbeet Processing

9.10.1.2.1 General[1-2]

Sugarbeet processing is the production of sugar (sucrose) from sugarbeets. Byproducts of sugarbeet processing include pulp and molasses. Most of the molasses produced is processed further to remove the remaining sucrose. The pulp and most of the remaining molasses are mixed together, dried, and sold as livestock feed.

9.10.1.2.2 Process Description[1-4]

Figures 9.10.1.2-1 and 9.10.1.2-2 are flow diagrams for a typical sugarbeet processing plant. Figure 9.10.1.2-1 shows preprocessing and livestock feed production operations, and Figure 9.10.1.2-2 shows the beet sugar production operations. Mechanically harvested sugarbeets are shipped to processing plants, where they are typically received by high-speed conveying and screening systems. The screening systems remove loose dirt from the beets and pinch the beet tops and leaves from the beet roots. The conveyors transport the beets to storage areas and then to the final cleaning and trash removal operations that precede the processing operations. The beets are usually conveyed to the final cleaning phase using flumes, which use water to both move and clean the beets. Although most plants use flumes, some plants use dry conveyors in the final cleaning stage. The disadvantage of flume conveying is that some sugar leaches into the flume water from damaged surfaces of the beets. The flumes carry the beets to the beet feeder, which regulates the flow of beets through the system and prevents stoppages in the system. From the feeder, the flumes carry the beets through several cleaning devices, which may include rock catchers, sand separators, magnetic metal separators, water spray nozzles, and trash catchers. After cleaning, the beets are separated from the water, usually with a beet wheel, and are transported by drag chain, chain and bucket elevator, inclined belt conveyor, or beet pump to the processing operations.

Sugarbeet processing operations comprise several steps, including diffusion, juice purification, evaporation, crystallization, dried-pulp manufacture, and sugar recovery from molasses. Descriptions of these operations are presented in the following paragraphs.

Prior to removal of the sucrose from the beet by diffusion, the cleaned and washed beets are sliced into long, thin strips, called cossettes. The cossettes are conveyed to continuous diffusers, in which hot water is used to extract sucrose from the cossettes. In one diffuser design, the diffuser is slanted upwards and conveys the cossettes up the slope as water is introduced at the top of the diffuser and flows countercurrent to the cossettes. The water temperature in the diffuser is typically maintained between 50° and 80°C (122° and 176°F). This temperature is dependant on several factors, including the denaturization temperature of the cossettes, the thermal behavior of the beet cell wall, potential enzymatic reactions, bacterial activity, and pressability of the beet pulp. Formalin, a 40 percent solution of formaldehyde, was sometimes added to the diffuser water as a disinfectant but is not used at the present time. Sulfur dioxide, chlorine, ammonium bisulfite, or commercial FDA-approved biocides are used as disinfectants. The sugar-enriched water that flows from the outlet of the diffuser is called raw juice and contains between 10 and 15 percent sugar. This raw juice proceeds to the juice purification operations. The processed cossettes, or pulp, leaving the diffuser are conveyed to the dried-pulp manufacture operations.

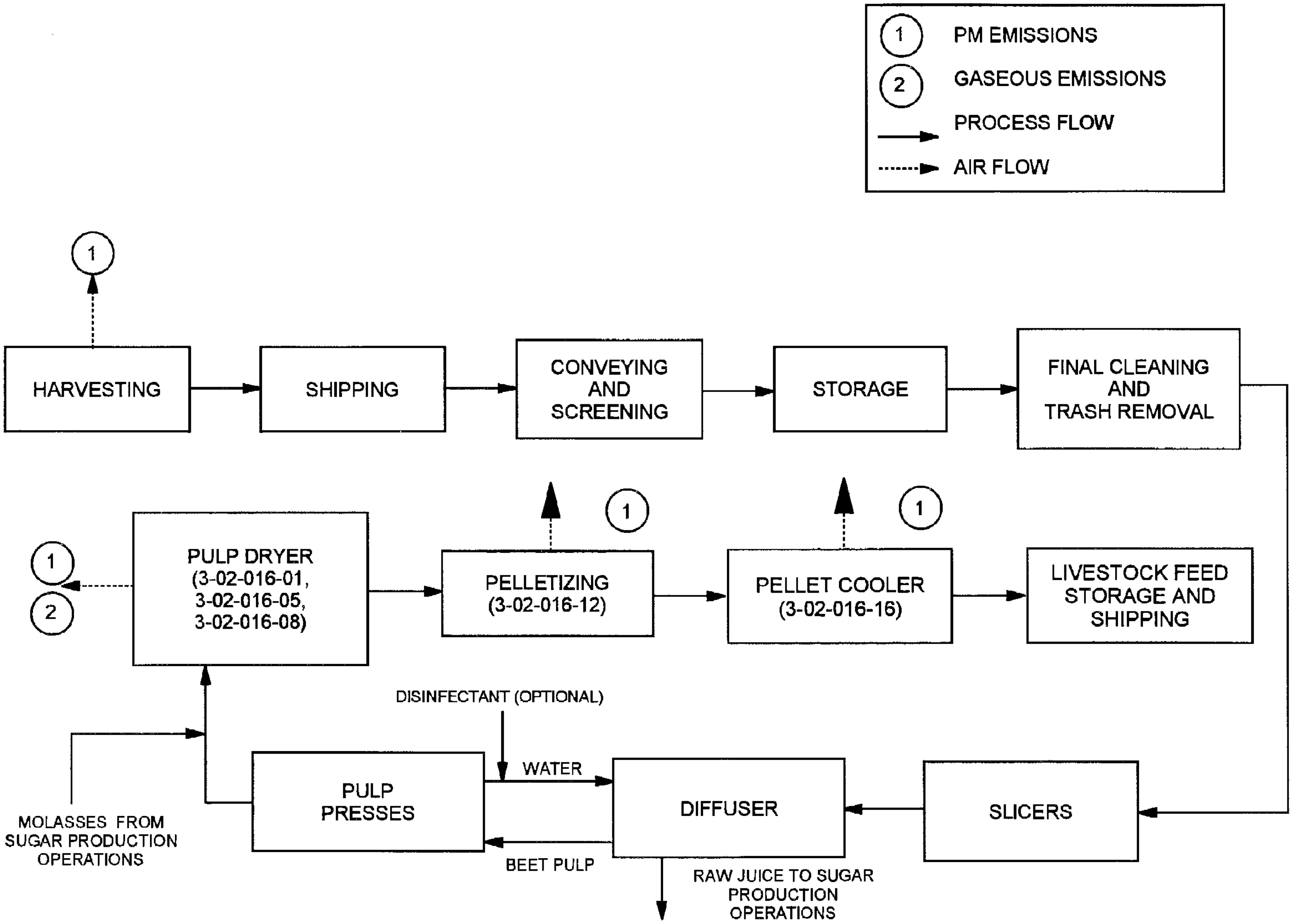

Figure 9.10.1.2-1. Preprocessing and livestock feed production operations at a sugarbeet processing plant.
(Source Classification Code in parentheses.)

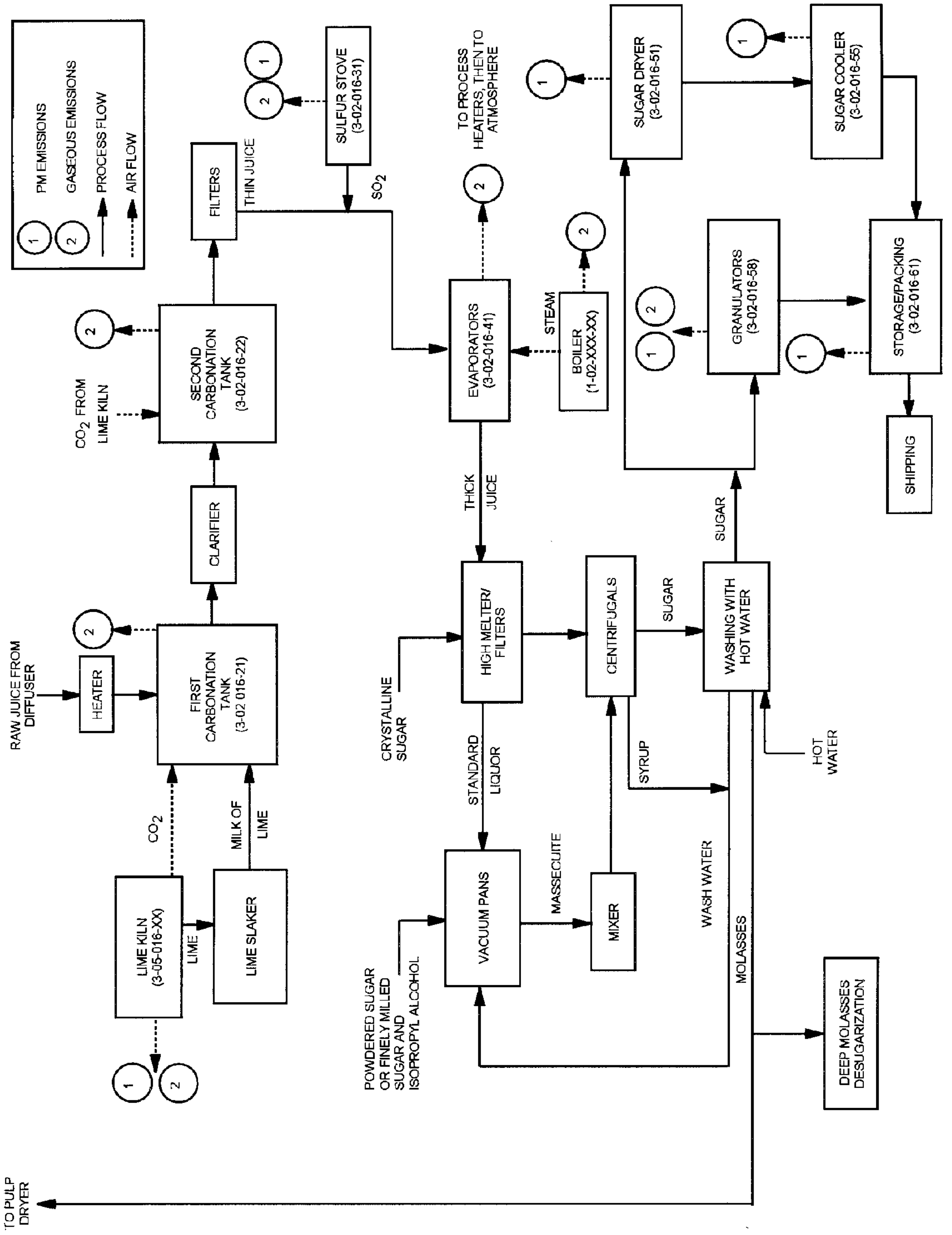

Figure 9.10.1.2-2. Sugar production operations at a sugarbeet processing plant. (Source Classification Code in parentheses.)

In the juice purification stage, non-sucrose impurities in the raw juice are removed so that the pure sucrose can be crystallized. First, the juice passes through screens to remove any small cossette particles. Then the mixture is heated to 80° to 85°C (176° to 185°F) and proceeds to the first carbonation tank. In some processes, the juice from the screen passes through a pre-limer, heater, and main limer prior to the first carbonation tank. In the first carbonation tank, milk of lime [$Ca(OH)_2$] is added to the mixture to adsorb or adhere to the impurities in the mixture, and carbon dioxide (CO_2) gas is bubbled through the mixture to precipitate the lime as insoluble calcium carbonate crystals. Lime kilns are used to produce the CO_2 and lime used in carbonation; the lime is converted to milk of lime in a lime slaker. The small, insoluble crystals (produced during carbonation) settle out in a clarifier, after which the juice is again treated with CO_2 (in the second carbonation tank) to remove the remaining lime and impurities. The pH of the juice is lower during this second carbonation, causing large, easily filterable, calcium carbonate crystals to form. After filtration, a small amount of sulfur dioxide (SO_2) is added to the juice to inhibit reactions that lead to darkening of the juice. Most facilities purchase SO_2 as a liquid but a few facilities produce SO_2 by burning elemental sulfur in a sulfur stove. Following the addition of SO_2, the juice (known as thin juice) proceeds to the evaporators.

The evaporation process, which increases the sucrose concentration in the juice by removing water, is typically performed in a series of five evaporators. Steam from large boilers is used to heat the first evaporator, and the steam from the water evaporated in the first evaporator is used to heat the second evaporator. This transfer of heat continues through the five evaporators, and as the temperature decreases (due to heat loss) from evaporator to evaporator, the pressure inside each evaporator is also decreased, allowing the juice to boil at the lower temperatures provided in each subsequent evaporator. Some steam is released from the first three evaporators, and this steam is used as a heat source for various process heaters throughout the plant. After evaporation, the percentage of sucrose in the "thick juice" is 50-65 percent. Crystalline sugars, produced later in the process, are added to the juice and dissolved in the high melter. This mixture is then filtered, yielding a clear liquid known as standard liquor, which proceeds to the crystallization operation.

Sugar is crystallized by low-temperature pan boiling. The standard liquor is boiled in vacuum pans until it becomes supersaturated. To begin crystal formation, the liquor is either "shocked" using a small quantity of powdered sugar or is "seeded" by adding a mixture of finely milled sugar and isopropyl alcohol. The seed crystals are carefully grown through control of the vacuum, temperature, feed-liquor additions, and steam. When the crystals reach the desired size, the mixture of liquor and crystals, known as massecuite or fillmass, is discharged to the mixer. From the mixer, the massecuite is poured into high-speed centrifugals, in which the liquid is centrifuged into the outer shell, and the crystals are left in the inner centrifugal basket. The sugar crystals are then washed with pure hot water and are sent to the granulator, which is a combination rotary drum dryer and cooler. Some facilities have separate sugar dryers and coolers, which are collectively called granulators. The wash water, which contains a small quantity of sucrose, is pumped to the vacuum pans for processing. After cooling, the sugar is screened and then either packaged or stored in large bins for future packaging.

The liquid that was separated from the sugar crystals in the centrifugals is called syrup. This syrup serves as feed liquor for the "second boiling" and is introduced back into the vacuum pans along with standard liquor and recycled wash water. The process is repeated once again, resulting in the production of molasses, which can be further desugarized using an ion exchange process called deep molasses desugarization. Molasses that is not desugarized can be used in the production of livestock feed or for other purposes.

Wet pulp from the diffusion process is another product of sugarbeet processing. The pulp is first pressed, typically in horizontal double-screw presses, to reduce the moisture content from about 95 percent to about 75 percent. The water removed by the presses is collected and used as diffusion water. After pressing, molasses is added to the pulp, which is then dried in a direct-fired horizontal rotating drum known as a pulp dryer. The pulp dryer, which can be fired by oil, natural gas, or coal, typically provides entrance temperatures between 482° and 927°C (900° and 1700°F). As the pulp is dried, the gas temperature decreases and the pulp temperature increases. The exit temperature of the flue gas is typically between 88° and 138°C (190° and 280°F). The resulting product is usually pelletized, cooled, and sold as livestock feed.

9.10.1.2.3 Emissions And Controls[1,3-4]

Particulate matter (PM), combustion products, and volatile organic compounds (VOC) are the primary pollutants emitted from the sugarbeet processing industry. The pulp dryers, sugar granulators and coolers, sugar conveying and sacking equipment, lime kilns and handling equipment, carbonation tanks, sulfur stoves, evaporators, and boilers, as well as several fugitive sources are potential emission sources. Potential emissions from boilers are addressed in AP-42 Sections 1.1 through 1.4 (Combustion) and those from lime kilns are addressed in AP-42 Section 11.17, Lime Manufacturing. Potential sources of PM emissions include the pulp dryer, sugar granulators and coolers, sugar conveying and sacking equipment, sulfur stove, and fugitive sources. Fugitive sources include unpaved roads, coal handling, and pulp loading operations. Although most facilities purchase SO_2, a few facilities still use sulfur stoves. The sulfur stove is a potential source of SO_2 emissions, and the pulp dryers may be a potential source of nitrogen oxides (NO_x), SO_2, CO_2, carbon monoxide (CO), and VOC. Evaporators may be a potential source of CO_2, ammonia (NH_3), SO_2, and VOC emissions from the juice. However, only the first three of five evaporators (in a typical five-stage system) release exhaust gases, and the gases are used as a heat source for various process heaters before release to the atmosphere. Emissions from carbonation tanks are primarily water vapor but contain small quantities of NH_3, VOC, and may also include CO_2 and other combustion gases from the lime kiln. There are no emission test data available for ammonia emissions from carbonation tanks.

Particulate matter emissions from pulp dryers are typically controlled by a cyclone or multiclone system, sometimes followed by a secondary device such as a wet scrubber or fabric filter. Particulate matter emissions from granulators are typically controlled with wet scrubbers, and PM emissions from sugar conveying and sacking as well as lime dust handling operations are controlled by hood systems that duct the emissions to fabric filtration systems. Emissions from carbonation tanks and evaporators are not typically controlled.

Table 9.10.1.2-1 presents emission factors for filterable PM, PM-10, and condensible PM emissions from sugarbeet processing operations. Table 9.10.1.2-2 presents emission factors for volatile organic compounds (VOC), methane, NO_x, SO_2, CO, and CO_2 emissions from sugarbeet processing operations, and Tables 9.10.1.2-3 and 9.10.1.2-4 present emission factors for organic pollutants emitted from coal-fired dryers, carbonation tanks, and first evaporators.

Table 9.10.1.2-1. PARTICULATE MATTER EMISSION FACTORS FOR SUGARBEET PROCESSING OPERATIONS[a]

Source	Type of Control	Filterable PM				Condensible PM					
		PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Inorganic	EMISSION FACTOR RATING	Organic	EMISSION FACTOR RATING	Total	EMISSION FACTOR RATING
Coal-fired pulp dryer[b] (SCC 3-02-016-01)	None	4.4	D	ND		ND		ND		ND	
	Multiclone	0.66[c]	B	ND		ND		0.084[d]	C	ND	
	Wet scrubber	0.49	D	ND		0.050[f]	D	0.35[e]	D	0.40[g]	D
Natural gas-fired pulp dryer (SCC 3-02-016-08)	Multiclone[h]	0.69	D	ND		ND		ND		ND	
	Wet scrubber	0.19	D	ND		0.018[k]	D	ND		ND	
Fuel oil-fired pulp dryer (SCC 3-02-016-05)	Cyclone	1.4	C	ND		0.24[n]	C	0.076[m]	C	0.32[n]	C
	Dry scrubber and cyclone	1.1	D	0.83[p]	D	0.24[n]	C	ND		ND	
	Multiclone[q]	0.60	D	ND		ND		ND		ND	
Sugar granulator (SCC 3-02-016-58)	Mechanical centrifugal separator with water sprays[r]	0.064	D	ND		ND		0.0037	D	ND	
Sugar cooler (SCC 3-02-016-55)	Mechanical centrifugal separator with water sprays[r]	0.13	D	ND		ND		0.0043	D	ND	
	Venturi scrubber[s]	0.065	D	ND		0.0047	D	0.0042	D	0.0089	D
Sugar conveying and sacking (SCC 3-02-016-61)	Fabric filter	ND		ND		ND		ND		ND	
Sulfur stove (SCC 3-02-016-31)	None	ND		ND		ND		ND		ND	
Pellet Cooler (SCC 3-02-016-16)	None	ND		ND		ND		ND		ND	
Sugar Dryer (SCC 3-02-016-51)	None	ND		ND		ND		ND		ND	

Table 9.10.1.2-1 (cont.).

Source	Type of Control	Filterable PM				Condensible PM					
		PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Inorganic	EMISSION FACTOR RATING	Organic	EMISSION FACTOR RATING	Total	EMISSION FACTOR RATING
Pelletizer (SCC 3-02-016-12)	None	ND		ND		ND		ND		ND	

[a] Emission factor units are lb/ton of pressed wet pulp to the dryer, unless noted. Factors represent uncontrolled emissions unless noted. To convert from lb/ton to kg/Mg, multiply by 0.5. SCC = Source Classification Code. ND = no data.

[b] Reference 17.

[c] References 7,16-17,19,21.

[d] References 16-17,19,21.

[e] References 3,13.

[f] Reference 13.

[g] Reference 3.

[h] References 22-23; both of these facilities utilize gas recirculation systems operating at different rates.

[j] References 8-12.

[k] References 11-12,25.

[m] References 4-6.

[n] References 4-6,14. Includes condensible organic PM data from dryers controlled by cyclones and dryers controlled by a dry scrubber and cyclone combination.

[p] Reference 14.

[q] References 15,24; fuel gas aspiration systems used at both facilities.

[r] Reference 20. Emission factor units are lb/ton of sugar output.

[s] Reference 18. Emission factor units are lb/ton of sugar output.

Table 9.10.1.2-2. EMISSION FACTORS FOR VOC, METHANE, AND INORGANIC POLLUTANT EMISSIONS FROM SUGARBEET PROCESSING OPERATIONS[a]

EMISSION FACTOR RATING: D

Source	lb/ton					
	VOC[b]	Methane	NO_x	SO_2	CO	CO_2
Coal-fired pulp dryer[c] (SCC 3-02-016-01)	1.2[d]	ND	0.66[e]	0.79[f]	2.3[d]	370[g]
Natural gas-fired pulp dryer[c] (SCC 3-02-016-08)	ND	ND	ND	ND	ND	156[h]
Fuel oil-fired pulp dryer[c] (SCC 3-02-016-05)	0.11[j]	0.028[j]	0.60[j]	1.0[k]	1.0[j]	430[m]
First evaporator (SCC 3-02-016-41)	ND	ND	ND	ND	ND	ND
Sulfur stove (SCC 3-02-016-31)	ND	ND	ND	ND	ND	ND
First carbonation tank (SCC 3-02-016-21)	ND	ND	ND	ND	ND	ND
Second carbonation tank (SCC 3-02-016-22)	ND	ND	ND	ND	ND	ND

[a] Emission factor units are lb/ton of pressed wet pulp to the dryer, unless noted. Factors represent uncontrolled emissions unless noted. To convert from lb/ton to kg/Mg, multiply by 0.5. SCC = Source Classification Code. ND = no data.
[b] Volatile organic compounds as methane.
[c] Data for pulp dryers equipped with cyclones, multiclones, wet scrubbers, or a combination of these control technologies are averaged together because these control technologies are not specifically designed to control VOC, methane, NO_x, SO_2, CO, or CO_2 emissions.
[d] Reference 19.
[e] References 16,19.
[f] References 7,19.
[g] References 7,13,16-17,19,21. EMISSION FACTOR RATING: B.
[h] References 8-12,22-23,25. EMISSION FACTOR RATING: C.
[j] Reference 4.
[k] References 14-15.
[m] References 4-6,14,24. EMISSION FACTOR RATING: C.

Table 9.10.1.2-3. EMISSION FACTORS FOR ORGANIC POLLUTANT EMISSIONS FROM PULP DRYERS[a]

EMISSION FACTOR RATING: E

Source	Pollutant		Emission Factor, lb/ton
	CASRN	Name	
Coal-fired pulp dryer with wet scrubber (SCC 3-02-016-01)	75-07-0	Acetaldehyde	0.015
	107-02-8	Acrolein	0.0076
	123-73-9	Crotonaldehyde	0.0020
	50-00-0	Formaldehyde	0.0071
	91-57-6	2-methylnaphthalene	1.7×10^{-5}
	88-75-5	2-nitrophenol	0.00018
	95-48-7	2-methylphenol	3.4×10^{-5}
	105-67-9	2,4-dimethylphenol	2.5×10^{-5}
	106-44-5	4-methylphenol	0.00013
	100-02-7	4-nitrophenol	0.00014
	208-96-8	Acenaphthylene	1.7×10^{-6}
	100-52-7	Benzaldehyde	0.0014
	65-85-0	Benzoic acid	0.0028
	100-51-6	Benzyl alcohol	7.1×10^{-5}
	117-81-7	Bis(2-ethylhexyl)phthalate	0.0015
	84-74-2	Di-n-butylphthalate	5.2×10^{-5}
	132-64-9	Dibenzofuran	1.1×10^{-5}
	84-66-2	Diethylphthalate	9.8×10^{-6}
	91-20-3	Naphthalene	0.00011
	98-95-3	Nitrobenzene	1.9×10^{-5}
	85-01-8	Phenanthrene	1.2×10^{-5}
	108-95-2	Phenol	0.00032

[a] Reference 3. Emission factor units are lb/ton of pressed wet pulp to the dryer. To convert from lb/ton to kg/Mg, multiply by 0.5. SCC = Source Classification Code. CASRN = Chemical Abstracts Service Registry Number.

Table 9.10.1.2-4. EMISSION FACTORS FOR ORGANIC POLLUTANT EMISSIONS FROM CARBONATION TANKS AND EVAPORATORS[a]

Source	Pollutant CASRN	Pollutant Name	Emission Factor, lb/1,000 gal	EMISSION FACTOR RATING
First carbonation tank[b] (SCC 3-02-016-21)	91-57-6	2-methylnaphthalene	5.1×10^{-7}	D
	51-28-5	2,4-dinitrophenol	ND	D
	106-44-5	4-methylphenol	6.6×10^{-7}	D
	83-32-9	Acenaphthene	ND	D
	100-52-7	Benzaldehyde	1.1×10^{-4}	D
	65-85-0	Benzoic acid	8.4×10^{-6}	D
	100-51-6	Benzyl alcohol	5.0×10^{-6}	D
	117-81-7	Bis(2-ethylhexyl)phthalate	1.2×10^{-5}	D
	91-20-3	Naphthalene	2.0×10^{-6}	D
	85-01-8	Phenanthrene	1.4×10^{-6}	D
	108-95-2	Phenol	1.3×10^{-6}	D
Second carbonation tank[b] (SCC 3-02-016-22)	75-07-0	Acetaldehyde	0.0043	E
	107-02-8	Acrolein	2.4×10^{-4}	E
	123-73-9	Crotonaldehyde	3.0×10^{-5}	E
	50-00-0	Formaldehyde	1.6×10^{-5}	E
First evaporator[c] (SCC 3-02-016-41)	75-07-0	Acetaldehyde	6.7×10^{-5}	E
	107-02-8	Acrolein	4.2×10^{-7}	E
	123-73-9	Crotonaldehyde	1.4×10^{-7}	E
	50-00-0	Formaldehyde	7.0×10^{-7}	E
	106-44-5	4-methylphenol	ND	E
	100-52-7	Benzaldehyde	2.2×10^{-6}	E
	65-85-0	Benzoic acid	ND	E
	100-51-6	Benzyl alcohol	1.8×10^{-7}	E
	117-81-7	Bis(2-ethylhexyl)phthalate	3.7×10^{-7}	E
	84-74-2	Di-n-butylphthalate	1.1×10^{-9}	E
	132-64-9	Dibenzofuran	ND	E
	84-66-2	Diethylphthalate	ND	E
	78-59-1	Isophorone	ND	E
	91-20-3	Naphthalene	2.5×10^{-8}	E
	85-01-8	Phenanthrene	1.6×10^{-8}	E
	108-95-2	Phenol	1.2×10^{-8}	E
	110-86-1	Pyridine	3.4×10^{-8}	E

[a] Reference 3. SCC = Source Classification Code. CASRN = Chemical Abstracts Service Registry Number. ND = no data.

[b] Emission factor units are lb per 1,000 gallons of raw juice produced.

[c] Emission factor units are lb per 1,000 gallons of thin juice produced.

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21. *Unit Nos. 1 And 2 Pulp Dryer Stacks Emission Testing Results For The February 22-26, 1993, Testing Of Particulate Conducted At The American Crystal Sugar Company, Crookston, Minnesota*, Bay West, Inc., St. Paul, MN, April 15, 1993.

22. *Particulate Emission Study For Michigan Sugar Company, Caro, Michigan*, Swanson Environmental, Inc., Farmington Hills, MI, December 14, 1989.

23. *Particulate Emission Study For Michigan Sugar Company, Carrollton, Michigan*, Swanson Environmental, Inc., Farmington Hills, MI, November 1989.

24. *Particulate Emission Study--Michigan Sugar Company, Croswell, Michigan*, Swanson Environmental, Inc., Farmington Hills, MI, November 19, 1990.

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9.12.3 Distilled Spirits

9.12.3.1 General[1-2]

The distilled spirits industry includes the production of whisky, gin, vodka, rum, and brandy. The production of brandy is discussed in AP-42 Section 9.12.2, "Wines and Brandy". Distilled spirits production also may include the production of secondary products such as distillers dried grains used for livestock feed and other feed/food components.

Distilled spirits, including grain spirits and neutral spirits, are produced throughout the United States.[1] The Bureau of Alcohol, Tobacco, and Firearms (BATF) has established "standards of identity" for distilled spirits products.[2]

9.12.3.2 Process Description[3-4]

Distilled spirits can be produced by a variety of processes. Typically, in whisky production, grains are mashed and fermented to produce an alcohol/water solution, that is distilled to concentrate the alcohol. For whiskies, the distilled product is aged to provide flavor, color, and aroma. This discussion will be limited to the production of Bourbon whisky. Figure 9.12.3-1 is a simple diagram of a typical whisky production process. Emission data are available only for the fermentation and aging steps of whisky production.

9.12.3.2.1 Grain Handling And Preparation -

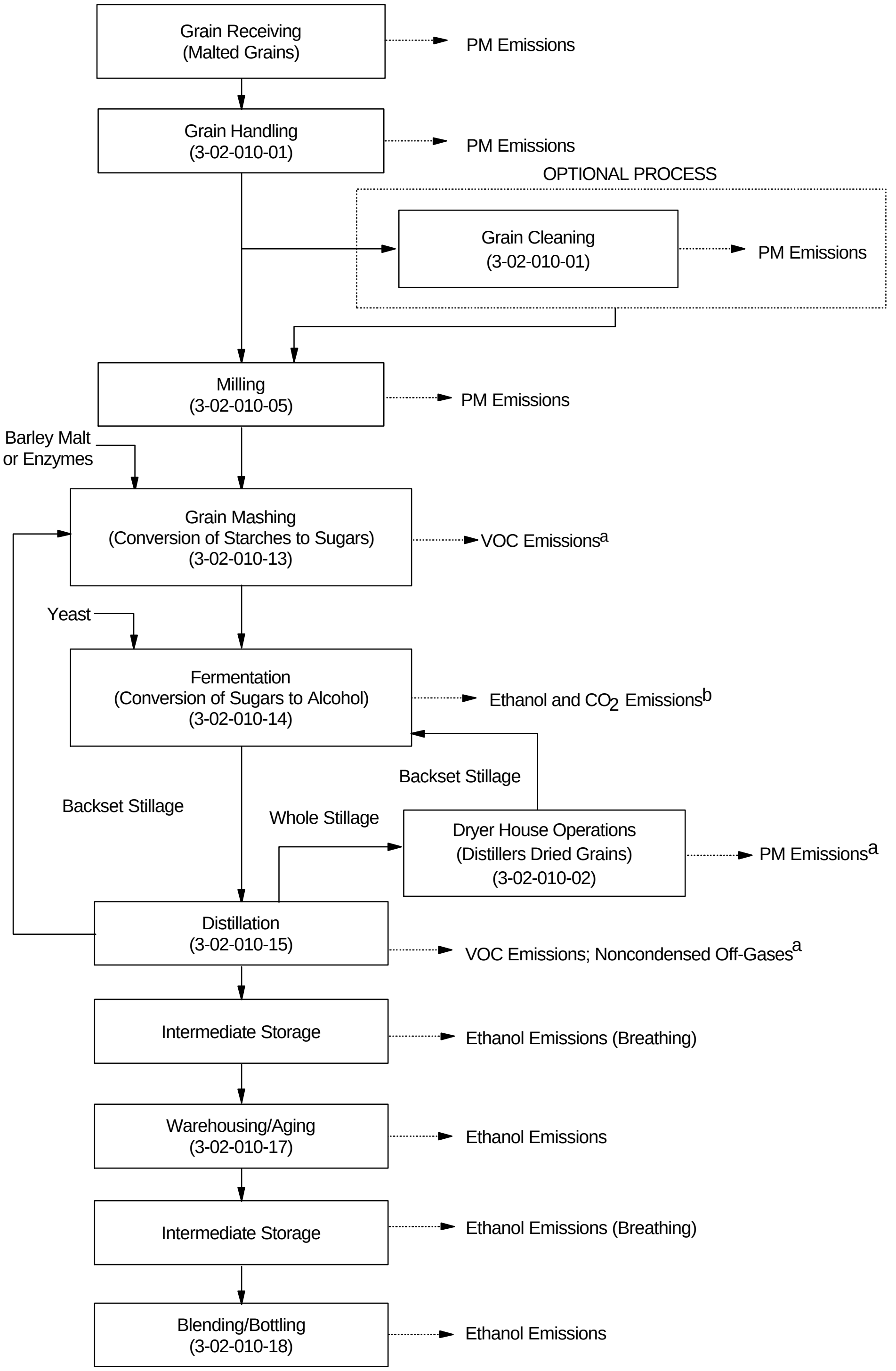
Distilleries utilize premium cereal grains, such as hybrid corn, rye, barley, and wheat, to produce the various types of whisky and other distilled spirits. Grain is received at a distillery from a grain-handling facility and is prepared for fermentation by milling or by malting (soaking the grains to induce germination). All U.S. distillers purchase malted grain instead of performing the malting process onsite.

9.12.3.2.2 Grain Mashing -

Mashing consists of cooking the grain to solubilize the starch from the kernels and to convert the soluble starch to grain sugars with barley malt and/or enzymes. Small quantities of malted barley are sometimes added prior to grain cooking. The mash then passes through a noncontact cooler to cool the converted mash prior to entering the fermenter.

9.12.3.2.3 Fermentation -

The converted mash enters the fermenter and is inoculated with yeast. The fermentation process, which usually lasts 3 to 5 days for whisky, uses yeast to convert the grain sugars into ethanol and carbon dioxide. Congeners are flavor compounds which are produced during fermentation as well as during the barrel aging process. The final fermented grain alcohol mixture, called "beer", is transferred to a "beer well" for holding. From the beer well, the beer passes through a preheater, where it is warmed by the alcohol vapors leaving the still, and then to the distillation unit. The beer still vapors condensed in the preheater generally are returned to the beer still as reflux.



[a] Processes require heat. Emissions generated (e.g., CO, CO_2, NO_x, SO_2, PM, and VOCs) will depend on the source of fuel.

[b] Other compounds can be generated in trace quantities during fermentation including ethyl acetate, fusel oil, furfural, acetaldehyde, sulfur dioxide, and hydrogen sulfide. Acetaldehyde is a hazardous air pollutant (HAP).

Figure 9.12.3-1. Whisky production process.
(Source Classification Codes in parentheses).

9.12.3.2.4 Distillation -

The distillation process separates and concentrates the alcohol from the fermented grain mash. Whisky stills are usually made of copper, especially in the rectifying section, although stainless steel may be used in some stills. Following distillation, the distilled alcohol spirits are pumped to stainless steel tanks and diluted with demineralized water to the desired alcohol concentration prior to filling into oak barrels and aging. Tennessee whisky utilizes a different process from Bourbon in that the distillate is passed through sugar maple charcoal in mellowing vats prior to dilution with demineralized water.

9.12.3.2.5 Grain And Liquid Stillage ("Dryer House Operations") -

In most distilleries, after the removal of alcohol, still bottoms (called whole stillage), are pumped from the distillation column to a dryer house. Whole stillage may be sold, land applied (with permitting), sold as liquid feed, or processed and dried to produce distillers dried grains (DDG) and other secondary products. Solids in the whole stillage are separated using centrifuges or screens; the liquid portion (thin stillage) may be used as a backset or concentrated by vacuum evaporation. The concentrated liquid may be recombined with the solids or dried. Drying is typically accomplished using either steam-heated or flash dryers.

9.12.3.2.6 Warehousing/Aging -

Aging practices differ from distiller to distiller, and even for the same distiller. Variations in the aging process are integral to producing the characteristic taste of a particular brand of distilled spirit. The aging process, which typically ranges from 4 to 8 years or more, consists of storing the new whisky distillate in oak barrels to encourage chemical reactions and extractions between the whisky and the wood. The constituents of the barrel produce the whisky's characteristic color and distinctive flavor and aroma. White oak is used because it is one of the few woods that holds liquids while allowing breathing (gas exchange) through the wood. Federal law requires all Bourbon whisky to be aged in charred new white oak barrels.

The oak barrels and the barrel environment are key to producing distilled spirits of desired quality. The new whisky distillate undergoes many types of physical and chemical changes during the aging process that removes the harshness of the new distillate. As whisky ages, it extracts and reacts with constituents in the wood of the barrel, producing certain trace substances, called congeners, which give whisky its distinctive color, taste, and aroma.

Barrel environment is extremely critical in whisky aging and varies considerably by distillery, warehouse, and even location in the warehouse. Ambient atmospheric conditions, such as seasonal and diurnal variations in temperature and humidity, have a great affect on the aging process, causing changes in the equilibrium rate of extraction, rate of transfer by diffusion, and rate of reaction. As a result, distillers may expose the barrels to atmospheric conditions during certain months, promoting maturation through the selective opening of windows and doors and by other means.

Distillers often utilize various warehouse designs, including single- or multistory buildings constructed of metal, wood, brick, or masonry. Warehouses generally rely upon natural ambient temperature and humidity changes to drive the aging process. In a few warehouses, temperature is adjusted during the winter. However, whisky warehouses do not have the capability to control humidity, which varies with natural climate conditions.

9.12.3.2.7 Blending/Bottling -

Once the whisky has completed its desired aging period, it is transferred from the barrels into tanks and reduced in proof to the desired final alcohol concentration by adding demineralized water.

Following a filtration process that renders it free of any solids, the whisky is pumped to a tank in the bottling house, bottled, and readied for shipment to the distributors.

9.12.3.3 Emissions And Controls[3-6]

9.12.3.3.1 Emissions -

The principal emissions from whisky production are volatile organic compounds (VOCs), principally ethanol, and occur primarily during the aging/warehousing stage. In addition to ethanol, other volatile compounds, including acetaldehyde (a HAP), ethyl acetate, glycerol, fusel oil, and furfural, may be produced in trace amounts during aging. A comparatively small source of ethanol emissions may result from the fermentation stage. Smaller quantities of ethyl acetate, isobutyl alcohol, and isoamyl alcohol are generated as well; carbon dioxide is also produced during fermentation. Particulate matter (PM) emissions are generated by the grain receiving, handling, drying, and cleaning processes and are discussed in more detail in AP-42 Section 9.9.1, Grain Elevators and Processes. Other emissions, including SO_2, CO_2, CO, NO_x, and PM may be generated by fuel combustion from power production facilities located at most distilled spirits plant.

Ethanol and water vapor emissions result from the breathing phenomenon of the oak barrels during the aging process. This phenomenon of wood acting as a semipermeable membrane is complex and not well understood. The emissions from evaporation from the barrel during aging are not constant. During the first 6 to 18 months, the evaporation rate from a new barrel is low because the wood must become saturated (known as "soakage") before evaporation occurs. After saturation, the evaporation rate is greatest, but then decreases as evaporation lowers the liquid level in the barrel. The lower liquid level decreases the surface area of the liquid in contact with the wood and thus reduces the surface area subject to evaporation. The rate of extraction of wood constituents, transfer, and reaction depend upon ambient conditions, such as temperature and humidity, and the concentrations of the various whisky constituents. Higher temperatures increase the rate of extraction, transfer by diffusion, and reaction. Diurnal and seasonal temperature changes cause convection currents in the liquid. The rate of diffusion will depend upon the differences in concentrations of constituents in the wood, liquid, and air blanketing the barrel. The rates of reaction will increase or decrease with the concentration of constituents. The equilibrium concentrations of the various whisky components depend upon the humidity and air flow around the barrel.

Minor emissions are generated when the whisky is drained from the barrels for blending and bottling. Residual whisky remains in the used barrels both as a surface film ("heel") and within the wood ("soakage"). For economic reasons, many distillers attempt to recover as much residual whisky as possible by methods such as rinsing the barrel with water and vacuuming. Generally, barrels are refilled and reentered into the aging process for other distilled spirits at the particular distiller or sealed with a closure (bung) and shipped offsite for reuse with other distilled spirits. Emissions may also be generated during blending and bottle filling, but no data are available.

9.12.3.3.2 Controls -

With the exception of devices for controlling PM emissions, there are very few emission controls at distilleries. Grain handling and processing emissions are controlled through the use of cyclones, baghouses, and other PM control devices (see AP-42 Section 9.9.1). There are currently no current control technologies for VOC emissions from fermenters because the significant amount of grain solids that would be carried out of the fermenters by air entrainment could quickly render systems, such as carbon adsorption, inoperable. Add-on air pollution control devices for whisky aging warehouses are not used because of potential adverse impact on product quality. Distillers ensure that barrel construction is of high quality to minimize leakage, thus reducing ethanol emissions. Ethanol recovery would require the use of a collection system to capture gaseous emissions in the warehouse and to process the gases through a recovery system prior to venting them to the atmosphere.

9.12.3.3.3 Emission Factors -

Table 9.12.3-1 provides uncontrolled emission factors for emissions of VOCs from fermentation vats and for emissions of ethanol from aging due to evaporation. Because ethanol is the principal VOC emission from aging, the ethanol emissions factors are reasonable estimates of VOC emissions for these processes. Emission factors for grain receiving, handling, and cleaning may be found in AP-42 Section 9.9.1, Grain Elevators and Processes. Emission factors are unavailable for grain mashing, distillation, blending/bottling, and spent grain drying. An emission factor for carbon dioxide from fermentation vats is also unavailable, although carbon dioxide and ethanol are theoretically generated in equal molecular quantities during the fermentation process.

Table 9.12.3-1. EMISSION FACTORS FOR DISTILLED SPIRITS[a]

EMISSION FACTOR RATING: E

Source[b]	Ethanol	Ethyl acetate	Isoamyl Alcohol	Isobutyl Alcohol
Grain mashing (SCC 3-02-010-13)	NA	NA	NA	NA
Fermentation vats (SCC 3-02-010-14)	14.2[c]	0.046[c]	0.013[c]	0.004[c]
Distillation (SCC 3-02-010-15)	ND	ND	ND	ND
Aging (SCC 3-02-010-17)				
- Evaporation loss[d]	6.9[e]	ND	ND	ND
Blending/bottling (SCC 3-02-010-18)	ND	ND	ND	ND
Dryer house operations (SCC 3-02-010-02)	ND	ND	ND	ND

[a] Factors represent uncontrolled emissions. SCC = Source Classification Code. ND = no data available. To convert from lb to kg, divide by 2.2. NA = not applicable.
[b] Emission factors for grain receiving, handling, and cleaning processes are available in AP-42 Section 9.9.1, Grain Elevators and Processes.
[c] Reference 5 (paper). In units of pounds per 1,000 bushels of grain input.
[d] Evaporation losses during whisky aging do not include losses due to soakage.
[e] References 6-7. In units of lb/bbl/yr; barrels have a capacity of approximately 53 gallons.

Recognizing that aging practices may differ from distiller to distiller, and even for different products of the same distiller, a method may be used to estimate total ethanol emissions from barrels during aging. An ethanol emission factor for aging (total loss emission factor) can be calculated based on annual emissions per barrel in proof gallons (PG). The term “proof gallon” refers to a U.S. gallon of proof spirits, or the alcoholic equivalent thereof, containing 50 percent of ethyl alcohol (ethanol) by volume. This calculation method is derived from the gauging of product and measures the difference in the amount of product when the barrel was filled and when the barrel was emptied. Fugitive evaporative emissions, however, are not the sole difference between these two amounts. During the aging period, product soaks into the barrel, test samples are drawn, and other losses (e. g., spillage, leakage) may occur. Estimates of ethanol loss due to evaporation during aging based only on the gauging of product will produce an overestimate unless soakage and sampling losses (very small losses) are subtracted. The emission factor for evaporation loss in Table 9.12.3-1 represents an overestimate because only data for soakage losses could be calculated; data for other losses were not available.

References for Section 9.12.3

1. Bureau Of Alcohol, Tobacco, And Firearms (BATF), “Monthly Statistical Release--Distilled Spirits”, Department Of The Treasury, Washington, DC, January 1995 through December 1995.

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3. Bujake, J. E., "Beverage Spirits, Distilled", *Kirk-Othmer Encyclopedia Of Chemical Technology*, 4th. Ed., Volume No. 4, John Wiley & Sons, Inc., 1992.

4. *Cost And Engineering Study Control Of Volatile Organic Emissions From Whiskey Warehousing*, EPA-450/2-78-013, Emissions Standards Division, Chemical and Petroleum Branch, Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, April 1978.

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6. Written communication from R. J. Garcia, Seagrams Americas, Louisville, KY, to T. Lapp, Midwest Research Institute, Cary, NC, March 3, 1997. RTGs versus age for 1993 standards.

7. Written communication from L. J. Omlie, Distilled Spirits Council Of The United States, Washington, D.C., to T. Lapp, Midwest Research Institute, Cary, NC, February 6, 1997. Ethanol emissions data from Jim Beam Brands Co.

9.13.4 Yeast Production

9.13.4.1 General[1]

Baker's yeast is currently manufactured in the United States at 13 plants owned by 6 major companies. Two main types of baker's yeast are produced, compressed (cream) yeast and dry yeast. The total U. S. production of baker's yeast in 1989 was 223,500 megagrams (Mg) (245,000 tons). Of the total production, approximately 85 percent of the yeast is compressed (cream) yeast, and the remaining 15 percent is dry yeast. Compressed yeast is sold mainly to wholesale bakeries, and dry yeast is sold mainly to consumers for home baking needs. Compressed and dry yeasts are produced in a similar manner, but dry yeasts are developed from a different yeast strain and are dried after processing. Two types of dry yeast are produced, active dry yeast (ADY) and instant dry yeast (IDY). Instant dry yeast is produced from a faster-reacting yeast strain than that used for ADY. The main difference between ADY and IDY is that ADY has to be dissolved in warm water before usage, but IDY does not.

9.13.4.2 Process Description[1]

Figure 9.13.4-1 is a process flow diagram for the production of baker's yeast. The first stage of yeast production consists of growing the yeast from the pure yeast culture in a series of fermentation vessels. The yeast is recovered from the final fermentor by using centrifugal action to concentrate the yeast solids. The yeast solids are subsequently filtered by a filter press or a rotary vacuum filter to concentrate the yeast further. Next, the yeast filter cake is blended in mixers with small amounts of water, emulsifiers, and cutting oils. After this, the mixed press cake is extruded and cut. The yeast cakes are then either wrapped for shipment or dried to form dry yeast.

Raw Materials[1-3] -

The principal raw materials used in producing baker's yeast are the pure yeast culture and molasses. The yeast strain used in producing compressed yeast is *Saccharomyces cerevisiae*. Other yeast strains are required to produce each of the 2 dry yeast products, ADY and IDY. Cane molasses and beet molasses are the principal carbon sources to promote yeast growth. Molasses contains 45 to 55 weight percent fermentable sugars, in the forms of sucrose, glucose, and fructose.

The amount and type of cane and beet molasses used depend on the availability of the molasses types, costs, and the presence of inhibitors and toxins. Usually, a blend consisting of both cane and beet molasses is used in the fermentations. Once the molasses mixture is blended, the pH is adjusted to between 4.5 and 5.0 because an alkaline mixture promotes bacteria growth. Bacteria growth occurs under the same conditions as yeast growth, making pH monitoring very important. The molasses mixture is clarified to remove any sludge and is then sterilized with high-pressure steam. After sterilization, it is diluted with water and held in holding tanks until it is needed for the fermentation process.

A variety of essential nutrients and vitamins is also required in yeast production. The nutrient and mineral requirements include nitrogen, potassium, phosphate, magnesium, and calcium, with traces of iron, zinc, copper, manganese, and molybdenum. Normally, nitrogen is supplied by adding ammonium salts, aqueous ammonia, or anhydrous ammonia to the feedstock. Phosphates and magnesium are added, in the form of phosphoric acid or phosphate salts and magnesium salts. Vitamins are also required for yeast growth (biotin, inositol, pantothenic acid, and thiamine).

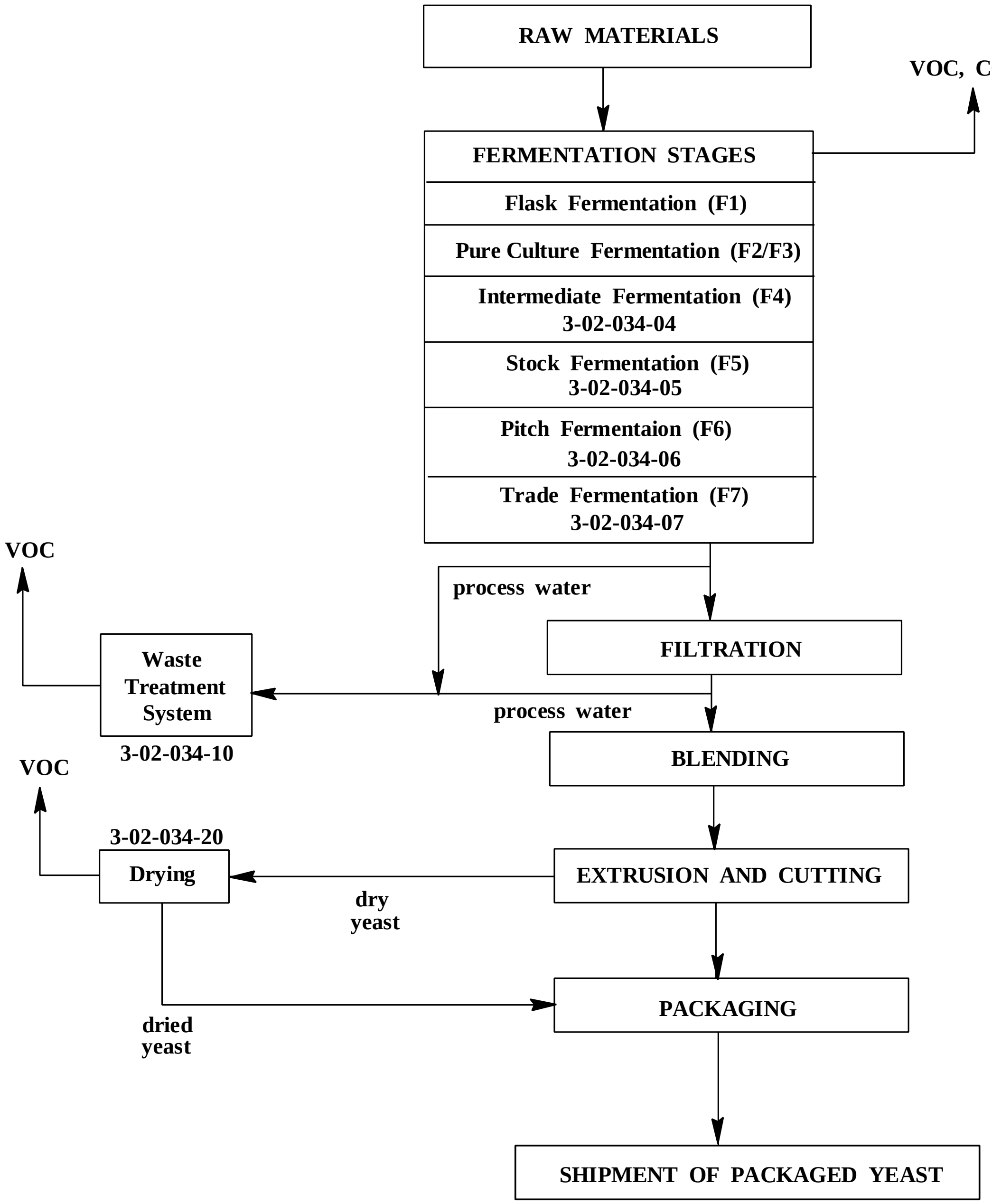

Figure 9.13.4-1. Typical process flow diagram for the seven-stage production of baker's yeast, with Source Classification Codes shown for compressed yeast. Use 3-02-035-XX for compressed yeast.

Thiamine is added to the feedstock. Most other vitamins and nutrients are already present in sufficient amounts in the molasses malt.

Fermentation[1-3] -

Yeast cells are grown in a series of fermentation vessels. Yeast fermentation vessels are operated under aerobic conditions (free oxygen or excess air present) because under anaerobic conditions (limited or no oxygen) the fermentable sugars are consumed in the formation of ethanol and carbon dioxide, which results in low yeast yields.

The initial stage of yeast growth takes place in the laboratory. A portion of the pure yeast culture is mixed with molasses malt in a sterilized flask, and the yeast is allowed to grow for 2 to 4 days. The entire contents of this flask are used to inoculate the first fermentor in the pure culture stage. Pure culture fermentations are batch fermentations, where the yeast is allowed to grow for 13 to 24 hours. Typically, 1 to 2 fermentors are used in this stage of the process. The pure culture fermentations are basically a continuation of the flask fermentation, except that they have provisions for sterile aeration and aseptic transfer to the next stage.

Following the pure culture fermentations, the yeast mixture is transferred to an intermediate fermentor that is either batch or fed-batch. The next fermentation stage is a stock fermentation. The contents from the intermediate fermentor are pumped into the stock fermentor, which is equipped for incremental feeding with good aeration. This stage is called stock fermentation, because after fermentation is complete, the yeast is separated from the bulk of the fermentor liquid by centrifuging, which produces a stock, or pitch, of yeast for the next stage. The next stage, pitch fermentation, also produces a stock, or pitch, of yeast. Aeration is vigorous, and molasses and other nutrients are fed incrementally. The liquor from this fermentor is usually divided into several parts for pitching the final trade fermentations (adding the yeast to start fermentation). Alternately, the yeast may be separated by centrifuging and stored for several days before its use in the final trade fermentations.

The final trade fermentation has the highest degree of aeration, and molasses and other nutrients are fed incrementally. Large air supplies are required during the final trade fermentations, so these vessels are often started in a staggered fashion to reduce the size of the air compressors. The duration of the final fermentation stages ranges from 11 to 15 hours. After all of the required molasses has been fed into the fermentor, the liquid is aerated for an additional 0.5 to 1.5 hours to permit further maturing of the yeast, making it more stable for refrigerated storage.

The amount of yeast growth in the main fermentation stages described above increases with each stage. Yeast growth is typically 120 kilograms (270 pounds) in the intermediate fermentor, 420 kilograms (930 pounds) in the stock fermentor, 2,500 kilograms (5,500 pounds) in the pitch fermentor, and 15,000 to 100,000 kilograms (33,000 to 220,000 pounds) in the trade fermentor.

The sequence of the main fermentation stages varies among manufacturers. About half of existing yeast operations are 2-stage processes, and the remaining are 4-stage processes. When the 2-stage final fermentation series is used, the only fermentations following the pure culture stage are the stock and trade fermentations. When the 4-stage fermentation series is used, the pure culture stage is followed by intermediate, stock, pitch, and trade fermentations.

Harvesting And Packaging[1-2] -

Once an optimum quantity of yeast has been grown, the yeast cells are recovered from the final trade fermentor by centrifugal yeast separators. The centrifuged yeast solids are further concentrated by a filter press or rotary vacuum filter. A filter press forms a filter cake containing 27 to 32 percent solids. A rotary vacuum filter forms cakes containing approximately 33 percent solids. This filter cake is then blended in mixers with small amounts of water, emulsifiers, and cutting oils to form the end product. The final packaging steps, as described below, vary depending on the type of yeast product.

In compressed yeast production (SCC 3-02-035-XX), emulsifiers are added to give the yeast a white, creamy appearance and to inhibit water spotting of the yeast cakes. A small amount of oil, usually soybean or cottonseed oil, is added to help extrude the yeast through nozzles to form continuous ribbons of yeast cake. The ribbons are cut, and the yeast cakes are wrapped and cooled to below 8°C (46°F), at which time they are ready for shipment in refrigerated trucks.

In dry yeast production (SCC 3-02-034-XX), the product is sent to an extruder after filtration, where emulsifiers and oils (different from those used for compressed yeast) are added to texturize the yeast and to aid in extruding it. After the yeast is extruded in thin ribbons, it is cut and dried in either a batch or a continuous drying system. Following drying, the yeast is vacuum packed or packed under nitrogen gas before heat sealing. The shelf life of ADY and IDY at ambient temperature is 1 to 2 years.

9.13.4.3 Emissions[1,4-5]

Volatile organic compound (VOC) emissions are generated as byproducts of the fermentation process. The 2 major VOCs emitted are ethanol and acetaldehyde. Other byproducts consist of other alcohols, such as butanol, isopropyl alcohol, 2,3-butanediol, organic acids, and acetates. Based on emission test data, approximately 80 to 90 percent of total VOC emissions is ethanol, and the remaining 10 to 20 percent consists of other alcohols and acetaldehyde. Acetaldehyde is a hazardous air pollutant as defined under Section 112 of the *Clean Air Act*.

Volatile byproducts form as a result of either excess sugar (molasses) present in the fermentor or an insufficient oxygen supply to it. Under these conditions, anaerobic fermentation occurs, breaking down the excess sugar into alcohols and carbon dioxide. When anaerobic fermentation occurs, 2 moles of ethanol and 2 moles of carbon dioxide are formed from 1 mole of glucose. Under anaerobic conditions, the ethanol yield is increased, and yeast yields are decreased. Therefore, in producing baker's yeast, it is essential to suppress ethanol formation in the final fermentation stages by incremental feeding of the molasses mixture with sufficient oxygen to the fermentor.

The rate of ethanol formation is higher in the earlier stages (pure culture stages) than in the final stages of the fermentation process. The earlier fermentation stages are batch fermentors, where excess sugars are present and less aeration is used during the fermentation process. These fermentations are not controlled to the degree that the final fermentations are controlled because the majority of yeast growth occurs in the final fermentation stages. Therefore, there is no economical reason for manufacturers to equip the earlier fermentation stages with process control equipment.

Another potential emission source at yeast manufacturing facilities is the system used to treat process waste waters. If the facility does not use an anaerobic biological treatment system, significant quantities of VOCs could be emitted from this stage of the process. For more information on waste water treatment systems as an emission source of VOCs, please refer to EPA's Control Technology Center document on industrial waste water treatment systems, *Industrial Wastewater Volatile Organic Compound Emissions - Background Information For BACT/LAER*, or see Section 4.3 of AP-42. At facilities manufacturing dry yeast, VOCs may also be emitted from the yeast dryers, but no information is available on the relative quantity of VOC emissions from this source.

9.13.4.4 Controls[6]

Only 1 yeast manufacturing facility uses an add-on pollution control system to reduce VOC emissions from the fermentation process. However, all yeast manufacturers suppress ethanol formation through varying degrees of process control, such as incrementally feeding the molasses mixture to the fermentors so that excess sugars are not present, or supplying sufficient oxygen to the fermentors to optimize the dissolved oxygen content of the liquid in the fermentor. The adequacy of oxygen distribution depends upon the proper design and operation of the aeration and mechanical agitation systems of the fermentor. The distribution of oxygen by the air sparger system to the malt mixture is critical. If oxygen is not being transferred uniformly throughout the malt, then ethanol will be produced in the oxygen-deficient areas of the fermentor. The type and position of baffles and/or a highly effective mechanical agitation system can ensure proper distribution of oxygen.

A more sophisticated form of process control involves using a continuous monitoring system and feedback control. In such a system, process parameters are monitored, and the information is sent to a computer. The computer is then used to calculate sugar consumption rates through material balance techniques. Based on the calculated data, the computer continuously controls the addition of molasses. This type of system is feasible, but it is difficult to design and implement. Such enhanced process control measures can suppress ethanol formation from 75 to 95 percent.

The 1 facility with add-on control uses a wet scrubber followed by a biological filter. Performance data from this unit suggest an emission control efficiency of better than 90 percent.

9.13.4.5 Emission Factors[1,6-9]

Table 9.13.4-1 provides emission factors for a typical yeast fermentation process with a moderate degree of process control. The process emission factors in Table 9.13.4-1 were developed from 4 test reports from 3 yeast manufacturing facilities. Separate emission factors are given for intermediate, stock/pitch, and trade fermentations. The emission factors in Table 9.13.4-1 are expressed in units of VOC emitted per fermentor per unit of yeast produced in that fermentor.

In order to use the emission factors for each fermentor, the amount of yeast produced in each fermentor must be known. The following is an example calculation for a typical facility:

Fermentation Stage	Yeast Yield Per Batch, lb (A)	No. Of Batches Processed Per Year, #/yr (B)	Total Yeast Production Per Stage, tons/yr (C = A x B/2,000)	Emission Factor, lb/ton (D)	Emissions, lb (E = C x D)	Percent of Total Emissions
Intermediate	265	156	21	36	756	0.84
Stock	930	208	97	5	485	0.54
Pitch	5,510	208	573	5	2,865	3.18
Trade	33,070	1,040	17,196	5	85,980	95.44
TOTAL	—	—	—	—	90,086	100

In most cases, the annual yeast production per stage will not be available. However, a reasonable estimate can be determined based on the emission factor for the trade fermentor and the total yeast production for the facility. Trade fermentors produce the majority of all VOCs emitted from the facility because of the number of batches processed per year and of the amount of yeast grown in these fermentors. Based on emission test data and process data regarding the number of batches processed per year, 80 to 90 percent of VOCs emitted from fermentation operations are a result of the trade fermentors.

Using either a 2-stage or 4-stage fermentation process has no significant effect on the overall emissions for the facility. Facilities that use the 2-stage process may have larger fermentors or may produce more batches per year than facilities that use a 4-stage process. The main factors affecting emissions are the total yeast production for a facility and the degree of process control used.

Table 9.13.4-1 (Metric And English Units). VOLATILE ORGANIC COMPOUND (VOC) EMISSION FACTORS FOR YEAST MANUFACTURING[a]

EMISSION FACTOR RATING: E

Emission Point[b]	VOC[c]	
	VOC Emitted Per Stage Per Amount Of Yeast Produced In A Stage, kg VOC/Mg Yeast	VOC Emitted Per Stage Per Amount Of Yeast Produced In A Stage, lb VOC/ton Yeast
Fermentation stages[d]		
Flask (F1)	ND	ND
Pure culture (F2/F3)	ND	ND
Intermediate (F4) (SCC 3-02-034-04)	18	36
Stock (F5) (SCC 3-02-034-05)	2.5	5.0
Pitch (F6) (SCC 3-02-034-06)	2.5	5.0
Trade (F7) (SCC 3-02-034-07)	2.5	5.0
Waste treatment (SCC 3-02-034-10)	See Section 4.3 of AP-42	
Drying (SCC 3-02-034-20)	ND	ND

[a] References 1,6-10. Total VOC as ethanol. SCC = Source Classification Code. ND = no data. F numbers refer to fermentation stages (see Figure 9.13.4-1).

[b] Factors are for both dry yeast (SCC 3-02-034-XX) and compressed yeast (SCC 3-02-035-XX).

[c] Factors should be used only when plant-specific emission data are not available because of the high degree of emissions variability among facilities and among batches within a facility.

[d] Some yeast manufacturing facilities use a 2-stage final fermentation process, and others use a 4-stage final fermentation process. Factors for each stage cannot be summed to determine an overall emission factor for a facility, since they are based on yeast yields in each fermentor rather than total yeast production. Total yeast production for a facility equals only the yeast yield from the trade fermentations. Note that CO_2 is also a byproduct of fermentation, but no data are available on the amount emitted.

References For Section 9.13.4

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PART 409—SUGAR PROCESSING POINT SOURCE CATEGORY

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Authority: Secs. 301, 304 (b) and (c), 306 (b) and (c), 307 (c) and (d), and 316(b) of the Federal Water Pollution Control Act, as amended; 33 U.S.C. 1251, 1311, 1314 (b) and (c), 1316 (b) and (c), 1317(c), and 1326(c); 86 Stat. 816 *et seq.,* Pub. L. 92–500; 91 Stat. 1567, Pub. L. 95–217.

Subpart A—Beet Sugar Processing Subcategory

top

Source: 39 FR 4037, Jan. 31, 1974, unless otherwise noted.

§ 409.10   Applicability; description of the beet sugar processing subcategory.

top

The provisions of this subpart are applicable to discharges resulting from any operation attendant to the processing of sugar beets for the production of sugar.

§ 409.11   Specialized definitions.

top

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in part 401 of this chapter shall apply to this subpart.

(b) The term *barometric condensing operations* shall mean those operations or processes directly associated with or related to the concentration and crystallization of sugar solutions.

(c) The term *product* shall mean crystallized refined sugar.

§ 409.12 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

top

The following limitations establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a point source subject to the provisions of this subpart after application of the best practicable control technology currently available; provided however, that a discharge by a point source may be made in accordance with the limitations set forth in either paragraph (a) of this section exclusively, or paragraph (b) of this section exclusively, below:

(a) The following limitations establish the maximum permissible discharge of process waste water pollutants when the process waste water discharge results from barometric condensing operations only.

Effluent characteristic	Effluent limitations	
	Maximum for any 1 day	Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kg/kkg of product)	
BOD *5*	3.3	2.2
pH	(1)	(1)
Temperature	(2)	(2)
	English units (lb/1,000 lb of product)	
BOD *5*	3.3	2.2
pH	(1)	(1)
Temperature	(3)	(3)

[1] Within the range 6.0 to 9.0.

[2] Temperature not to exceed the temperature of cooled water acceptable for return to the heat producing process and in no event greater than 32 °C.

[3] Temperature not to exceed the temperature of cooled water acceptable for return to the heat producing process and in no event greater than 90 °F.

(b) The following limitations establish the maximum permissible discharge of process waste water pollutants when the process waste water discharge results, in whole or in part, from barometric condensing operations and any other beet sugar processing operation.

Effluent	Effluent limitations

characteristic	Maximum for any 1 day	Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kg/kkg of product)	
BOD *5*	3.3	2.2
TSS	3.3	2.2
pH	([1])	([1])
Fecal coliform	([2])	([2])
Temperature	([3])	([3])
	English units (lb/1,000 lb of product)	
BOD *5*	3.3	2.2
TSS	3.3	2.2
pH	([1])	([1])
Fecal coliform	([4])	([4])
Temperature	([5])	([5])

[1] Within the range 6.0 to 9.0.

[2] Not to exceed MPN of 400/100 ml at any time.

[3] Not to exceed 32 °F.

[4] Not to exceed MPN of 400/100 ml at any time (not typically expressed in English units).

[5] Not to exceed 90 °F.

§ 409.13 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable.

top

(a) The following limitations establish the quantity or quality of pollutants or pollutant properties which may be discharged by a point source where the sugar beet processing capacity of the point source does not exceed 1090 kkg (2300 tons) per day of beets sliced or where the soil filtration rate, whether natural or by deliberate design, within the boundaries of all waste water treatment or retention facilities associated with the point source is less than or equal to 0.159 cm (1/16in.) per day; provided however, that a discharge by a point source may be made in accordance with the limitations set forth in either paragraph (a)(1) exclusively, or paragraph (a)(2) of this section exclusively.

(1) The following limitations establish the maximum permissible discharge of process waste water pollutants when the process waste water discharge results from barometric condensing operations only.

Effluent	Effluent limitations

characteristic	
Temperature	Temperature not to exceed the temperature of cooled water acceptable for return to the heat producing process and in no event greater than 32 °C (90 °F).

(2) The following limitations establish the maximum permissible discharge of process waste water pollutants when the process waste water discharge results, in whole or in part, from barometric condensing operations and any other beet sugar processing operation.

Effluent characteristics	Effluent limitations
Temperature	Not to exceed 32 °C (90 °F).

(b) [Reserved]

[39 FR 4037, Jan. 31, 1974, as amended at 40 FR 36337, Aug. 20, 1975; 44 FR 50740, Aug. 29, 1979]

§ 409.14   Pretreatment standards for existing sources.

top

Any existing source subject to this subpart that introduces process wastewater pollutants into a publicly owned treatment works must comply with 40 CFR part 403. In addition, the following pretreatment standard establishes the quantity or quality of pollutants or pollutant properties controlled by this section which may be discharged to a publicly owned treatment works by a point source subject to the provisions of this subpart.

Pollutant or pollutant property	Pretreatment standard
pH	No limitation.
BOD *5*	Do.
TSS	Do.
Fecal coliform	Do.
Temperature (heat)	Do.

[40 FR 6439, Feb. 11, 1975, as amended at 60 FR 33949, June 29, 1995]

§ 409.15   Standards of performance for new sources.

top

The following standards of performance establish the quantity or quality of pollutants or pollutant properties which may be discharged by a point source subject to the provisions of this subpart: There shall be no discharge of process waste water pollutants to navigable waters.

§ 409.16   Pretreatment standards for new sources.

top

Any new source subject to this subpart that introduces process wastewater pollutants into a publicly owned treatment works must comply with 40 CFR part 403.

[60 FR 33949, June 29, 1995]

§ 409.17   Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT).

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT): The limitations shall be the same as those specified for conventional pollutants (which are defined in §401.16) in §409.12 of this subpart for the best practicable control technology currently available (BPT).

[51 FR 24999, July 9, 1986]

Subpart B—Crystalline Cane Sugar Refining Subcategory

top

Source: 39 FR 10524, Mar. 20, 1974, unless otherwise noted.

§ 409.20   Applicability; description of the crystalline cane sugar refining subcategory.

top

The provisions of this subpart are applicable to discharges resulting from the processing of raw cane sugar into crystalline refined sugar.

§ 409.21   Specialized definitions.

top

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in part 401 of this chapter shall apply to this subpart.

(b) Net shall mean the addition of pollutants.

(c) Melt shall mean that amount of raw material (raw sugar) contained within aqueous solution at the beginning of the process for production of refined cane sugar.

§ 409.22   Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available (BPT):

(a) Any crystalline cane sugar refinery discharging both barometric condenser cooling water and other process waters shall meet the following limitations. The BOD *5* limitation is determined by the addition of the net BOD *5* attributed to the barometric condenser cooling water to that amount of BOD *5* attributed to the treated process water. The TSS limitation is that amount of TSS attributed to the treated process water. Where the barometric condenser cooling water and process water streams are mixed and impossible to measure separately prior to discharge, the values should be considered net.

Effluent characteristic	Effluent limitations	
	Maximum for any 1 day	Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD *5*	1.19	0.43
TSS	.27	0.09
pH	([1])	([1])
	English units (pounds per ton of melt)	
BOD *5*	2.38	0.86
TSS	.54	.18
pH	([1])	([1])

[1] Within the range 6.0 to 9.0.

(b) Any crystalline cane sugar refinery discharging barometric condenser cooling water only should be required to achieve the following net limitations:

Effluent characteristic	Effluent limitations	
	Maximum for any 1 day	Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD *5*	1.02	0.34
	English units (pounds per ton of melt)	
BOD *5*	2.04	0.68

[39 FR 10524, Mar. 20, 1974, as amended at 60 FR 33949, June 29, 1995]

§ 409.23   [Reserved]

top

§ 409.24   Pretreatment standards for existing sources.

top

Any existing source subject to this subpart that introduces process wastewater pollutants into a publicly owned treatment works must comply with 40 CFR part 403. In addition, the following pretreatment standard establishes the quantity or quality of pollutants or pollutant properties controlled by this section which may be discharged to a publicly owned treatment works by a point source subject to the provisions of this subpart.

Pollutant or pollutant property	Pretreatment standard
pH	No limitation.
BOD *5*	Do.
TSS	Do.

[40 FR 6440, Feb. 11, 1975, as amended at 60 FR 33949, June 29, 1995]

§ 409.25   Standards of performance for new sources.

top

The following standards of performance establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a new source subject to the provisions of this subpart:

Effluent characteristic	Effluent limitations	
	Maximum for any 1 day	Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD *5*	0.18	0.09
TSS	.11	.035
pH	([1])	([1])
	English units (pounds per ton of melt)	
BOD *5*	0.36	0.18
TSS	.21	.07
pH	([1])	([1])

[1] Within the range 6.0 to 9.0.

§ 409.26   Pretreatment standards for new sources.

top

Any new source subject to this subpart that introduces process wastewater pollutants into a publicly owned treatment works must comply with 40 CFR part 403.

[60 FR 33950, June 29, 1995]

§ 409.27 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT).

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT): The limitations shall be the same as those specified for conventional pollutants (which are defined in §401.16) in §409.22 of this subpart for the best practicable control technology currently available (BPT).

[51 FR 24999, July 9, 1986]

Subpart C—Liquid Cane Sugar Refining Subcategory

top

Source: 39 FR 10526, Mar. 20, 1974, unless otherwise noted.

§ 409.30 Applicability; description of the liquid cane sugar refining subcategory.

top

The provisions of this subpart are applicable to discharges resulting from the processing of raw cane sugar into liquid refined sugar.

§ 409.31 Specialized definitions.

top

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in part 401 of this chapter shall apply to this subpart.

(b) Net shall mean the addition of pollutants.

(c) Melt shall mean that amount of raw material (raw sugar) contained within aqueous solution at the beginning of the process for production of refined cane sugar.

§ 409.32 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available (BPT):

(a) Any liquid cane sugar refinery discharging both barometric condenser cooling water and other process waters shall meet the following limitations. The BOD *5* limitation is determined by the addition of the net BOD *5* attributed to the barometric condenser cooling water to that amount of BOD *5* attributed to the treated process water. The TSS limitation is that amount of TSS attributed to the treated process water. Where the barometric condenser cooling water and process water streams are mixed and impossible to measure separately prior to discharge, the values should be considered net.

Effluent characteristic	Effluent limitations	
	Maximum for any 1 day	**Average of daily values for 30 consecutive days shall not exceed—**
	Metric units (kilograms per 1,000 kg of melt)	
BOD *5*	0.78	0.32
TSS	.50	.17
pH	([1])	([1])
	English units (pounds per ton of melt)	
BOD *5*	1.56	0.63
TSS	.99	.33
pH	([1])	([1])

[1] Within the range 6.0 to 9.0.

(b) Any liquid cane sugar refinery discharging barometric condenser cooling water only shall meet the following net limitations:

Effluent characteristic	Effluent limitations	
	Maximum for any 1 day	**Average of daily values for 30 consecutive days shall not exceed—**
	Metric units (kilograms per 1,000 kg of melt)	
BOD *5*	0.45	0.15
	English units (pounds per ton of melt)	
BOD *5*	0.90	0.30

[39 FR 10526, Mar. 20, 1974, as amended at 60 FR 33950, June 29, 1995]

§ 409.33 [Reserved]

top

§ 409.34 Pretreatment standards for existing sources.

top

Any existing source subject to this subpart that introduces process wastewater pollutants into a publicly owned treatment works must comply with 40 CFR part 403. In addition, the following pretreatment standard establishes the quantity or quality of pollutants or pollutant properties controlled by this section which may be discharged to a publicly owned treatment works by a point source subject to the provisions of this subpart.

Pollutant or pollutant property	Pretreatment standard
pH	No limitation.
BOD *5*	Do.
TSS	Do.

[40 FR 6440, Feb. 11, 1975, as amended at 60 FR 33950, June 29, 1995]

§ 409.35 Standards of performance for new sources.

top

The following standards of performance establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a new source subject to the provisions of this subpart:

Effluent characteristic	Effluent limitations	
	Maximum for any 1 day	Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD *5*	0.30	0.15
TSS	0.09	.03
pH	(1)	(1)
	English units (pounds per ton of melt)	
BOD *5*	0.60	0.30
TSS	0.18	.06
pH	(1)	(1)

[1] Within the range 6.0 to 9.0.

§ 409.36 Pretreatment standards for new sources.

top

Any new source subject to this subpart that introduces process wastewater pollutants into a publicly owned treatment works must comply with 40 CFR part 403.

[60 FR 33950, June 29, 1995]

§ 409.37   Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT).

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT): The limitations shall be the same as those specified for conventional pollutants (which are defined in §401.16) in §409.32 of this subpart for the best practicable control technology currently available (BPT).

[51 FR 24999, July 9, 1986]

Subpart D—Louisiana Raw Cane Sugar Processing Subcategory

top

Source: 40 FR 8503, Feb. 27, 1975, unless otherwise noted.

§ 409.40   Applicability; description of the Louisiana raw cane sugar processing subcategory.

top

The provisions of this subpart are applicable to discharges resulting from the processing of sugar cane into a raw sugar product for those cane sugar factories operating in the State of Louisiana.

§ 409.41   Specialized definitions.

top

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in 40 CFR part 401 shall apply to this subpart.

(b) The term *gross cane* shall mean that amount of crop material as harvested, including field trash and other extraneous material.

§ 409.42   Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available (BPT):

(a) Any cane sugar factory continuously discharging both barometric condenser cooling water and other process waste waters shall meet the following limitations. The BOD *5* limitation is determined by the addition of the net BOD *5* attributable to the barometric condenser cooling water to that amount of BOD *5* attributable to the treated process waste water. The TSS limitation is that amount of TSS attributable to the treated process waste water, excluding barometric condenser cooling water.

Effluent characteristic	**Effluent limitations**	
	Maximum for any 1 day	**Average of daily values for 30 consecutive days shall not exceed—**
	Metric units (kg/kkg of gross cane)	
BOD *5*	1.14	0.63
TSS	1.41	0.47
pH	([1])	([1])
	English units (lb/1,000 lb of gross cane)	
BOD *5*	1.14	0.63
TSS	1.41	0.47
pH	([1])	([1])

[1] Within the range 6.0 to 9.0.

(b) Any cane sugar factory employing waste stabilization where all or a portion of the waste water discharge is stored for the entire grinding season shall meet the following limitations. The BOD *5* limitation is determined by the addition of the net BOD *5* attributable to the barometric condenser cooling water to that amount of BOD *5* attributable to the treated process waste water. The TSS limitation is that amount of TSS attributable to the treated process waste water, excluding barometric condenser cooling water.

Effluent characteristic	**Effluent limitations, the total of the daily values for the entire discharge period shall not exceed—**
	Metric units (kg/kkg of gross cane)
BOD *5*	0.63.
TSS	0.47.
pH	Within the range 6.0 to 9.0.
	English units (lb/1,000 lb of gross cane)
BOD *5*	0.63.
TSS	0.47.

pH	Within the range 6.0 to 9.0.

[40 FR 8503, Feb. 27, 1975, as amended at 60 FR 33950, June 29, 1995]

§ 409.47   Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT).

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT): The limitations shall be the same as those specified for conventional pollutants (which are defined in §401.16) in §409.42 of this subpart for the best practicable control technology currently available (BPT).

[51 FR 24999, July 9, 1986]

Subpart E—Florida and Texas Raw Cane Sugar Processing Subcategory

top

Source: 40 FR 8503, Feb. 27, 1975, unless otherwise noted.

§ 409.50   Applicability; description of the Florida and Texas raw cane sugar processing subcategory.

top

The provisions of this subpart are applicable to discharges resulting from the processing of sugar cane into a raw sugar product for those cane sugar factories located in the states of Florida and Texas.

§ 409.51   Specialized definitions.

top

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in 40 CFR part 401 shall apply to this subpart.

(b) [Reserved]

§ 409.52   Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

top

Except as provided in §§125.30 through 125.32, and subject to the provisions of paragraph (a) of this section, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available (BPT): There shall be no discharge of process wastewater pollutants to navigable waters.

(a) Process waste water pollutants in the overflow may be discharged to navigable waters whenever rainfall events cause an overflow of process waste water from a facility designed, constructed, and operated to contain all process generated waste waters.

(b) [Reserved]

[60 FR 33950, June 29, 1995]

§ 409.57   Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT).

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT): The limitations shall be the same as those specified for conventional pollutants (which are defined in §401.16) in §409.52 of this subpart for the best practicable control technology currently available (BPT).

[51 FR 24999, July 9, 1986]

Subpart F—Hilo-Hamakua Coast of the Island of Hawaii Raw Cane Sugar Processing Subcategory

top

§ 409.60   Applicability; description of the Hilo-Hamakua Coast of the Island of Hawaii raw cane sugar processing subcategory.

top

The provisions of this subpart are applicable to discharges resulting from the processing of sugar cane into a raw sugar product for those cane sugar factories located on the Hilo-Hamakua Coast of the Island of Hawaii in the State of Hawaii.

[40 FR 8504, Feb. 27, 1975]

§ 409.61   Specialized definitions.

top

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in 40 CFR part 401 shall apply to this subpart.

(b) The term *gross cane* shall mean that amount of crop material as harvested, including field trash and other extraneous material.

(c) The term *net cane* shall mean that amount of “gross cane” less the weight of extraneous material.

(d) The term *x* shall mean that fraction of the “net cane” harvested by the advanced harvesting systems.

[40 FR 8504, Feb. 27, 1975]

§ 409.62 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available (BPT):

Effluent characteristics	Maximum for any 1 day		Average of daily values for 30 consecutive days shall not exceed	
	kg/kkg gross cane	lb/1,000 lb gross cane	kg/kkg gross cane	lb/1,000 lb gross cane
BOD *5*	(1)	(1)	(1)	(1).
TSS	9.9	9.9	3.6	3.6.
pH	(1)	(1)	(1)	(1).

[1] No limitations.

[40 FR 8504, Feb 27, 1975, as amended at 44 FR 64080, Nov. 6, 1979; 45 FR 59152, Sept. 8, 1980; 60 FR 33950, June 29, 1995]

§ 409.67 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT).

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT): The limitations shall be the same as those specified for conventional pollutants (which are defined in §401.16) in §409.62 of this subpart for the best practicable control technology currently available (BPT).

[51 FR 24999, July 9, 1986]

Subpart G—Hawaiian Raw Cane Sugar Processing Subcategory

top

Source: 40 FR 8504, Feb. 27, 1975, unless otherwise noted.

§ 409.70 Applicability; description of the Hawaiian raw cane sugar processing subcategory.

top

The provisions of this subpart are applicable to discharges resulting from the processing of sugar cane into a raw sugar product for those cane sugar factories, other than those described by subpart F, located in the State of Hawaii.

§ 409.71 Specialized definitions.

top

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in 40 CFR part 401 shall apply to this subpart.

§ 409.72 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

top

Except as provided in §§125.30 through 125.32, and subject to the provisions of paragraph (a) of this section, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available (BPT): There shall be no discharge of process waste water pollutants to navigable waters.

(a) Process waste water pollutants in the overflow may be discharged to navigable waters whenever rainfall events cause an overflow of process waste water from a facility designed, constructed, and operated to contain all process generated waste waters.

(b) [Reserved]

[40 FR 8504, Feb. 27, 1975, as amended at 60 FR 33950, June 29, 1995]

§ 409.77 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT).

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT): The limitations shall be the same as those specified for conventional pollutants (which are defined in §401.16) in §409.72 of this subpart for the best practicable control technology currently available (BPT).

[51 FR 24999, July 9, 1986]

Subpart H—Puerto Rican Raw Cane Sugar Processing Subcategory

top

Source: 40 FR 8505, Feb. 27, 1975, unless otherwise noted.

§ 409.80 Applicability; description of the Puerto Rican raw cane sugar processing subcategory.

top

The provisions of this subpart are applicable to discharges resulting from the processing of sugar cane into a raw sugar product for those cane sugar factories located on the island of Puerto Rico.

§ 409.81   Specialized definitions.

top

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in 40 CFR part 401 shall apply to this subpart.

(b) The term *gross cane* shall mean that amount of crop material as harvested, including field trash and other extraneous material.

§ 409.82   Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available (BPT):

(a) Any cane sugar factory continuously discharging both barometric condenser cooling water and other process waste waters shall meet the following limitations. The BOD *5* limitation is determined by the addition of the net BOD *5* attributable to the barometric condenser cooling water to that amount of BOD *5* attributable to the treated process waste water. The TSS limitation is that amount of TSS attributable to the treated process waste water, excluding barometric condenser cooling water.

Effluent characteristic	Effluent limitations	
	Maximum for any 1 day	**Average of daily values for 30 consecutive days shall not exceed—**
	Metric units (kg/kkg of gross cane)	
BOD *5*	1.14	0.63
TSS	1.41	0.47
pH	(1)	(1)
	English units (lb/1,000 lb of gross cane)	
BOD *5*	1.14	0.63
TSS	1.41	0.47
pH	(1)	(1)

[1] Within the range 6.0 to 9.0.

(b) Any cane sugar factory employing waste stabilization where all or a portion of the waste water discharge is stored for the entire grinding season shall meet the following limitations. The BOD *5* limitation is determined by the addition of the net BOD *5* attributable to the barometric condenser cooling water to that amount of BOD *5* attributable to the treated process waste water. The TSS limitation is that amount of TSS attributable to the treated process waste water, excluding barometric condenser cooling water.

Effluent characteristic	Effluent limitations, the total of the daily values for the entire discharge period shall not exceed—
	Metric units (kg/kkg of gross cane)
BOD *5*	0.63.
TSS	0.47.
pH	Within the range 6.0 to 9.0.
	English units (lb/1,000 lb of gross cane)
BOD *5*	0.63.
TSS	0.47.
pH	Within the range 6.0 to 9.0.

(Secs. 301, 304 (b) and (c), 306 (b) and (c), 307 (c) and (d) of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251, 1311, 1314 (b) and (c), 1316 (b) and (c), 1317(c) and 1326(c)), 86 Stat. 816 *et seq.,* Pub. L. 92–500)

[40 FR 8504, Feb. 27, 1975, as amended at 60 FR 33950, June 29, 1995]

§ 409.87   Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT).

top

Except as provided in §§125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best conventional pollutant control technology (BCT): The limitations shall be the same as those specified for conventional pollutants (which are defined in §401.16) in §409.82 of this subpart for the best practicable control technology currently available (BPT).

[51 FR 24999, July 9, 1986]

STUDY OF RUM DISTILLERY WASTE TREATMENT AND BY-PRODUCT RECOVERY TECHNOLOGIES

by

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I. CONCLUSIONS

GENERAL

- Initial investigations showed the following four technologies are not applicable for the treatment of mostos:
  - Coagulation and sedimentation
  - Foam separation
  - High gradient magnetic separation
  - Reverse osmosis
- In-depth investigation showed that the following technologies are also not applicable:
  - Discharge of mostos to a POTW (on Puerto Rico and St. Croix)
  - Aquaculture
- Land farming, the Anamet process, evaporation, incineration and organic fertilizer production, appear to be feasible technologies. Their direct application to the treatment of mostos, however, has not been fully demonstrated.
- Agricultural utilization of mostos on sugar cane as currently practiced by Serralles Destileria in Mercedita, Puerto Rico, and Bacardi in Tultitlan, Mexico, appears to be a viable disposal alternative.

- Aerobic biological processes such as activated sludge and trickling filters are not applicable when considered solely by themselves.
- Anaerobic digestion is partially effective in reducing BOD and suspended solids.
- Pilot plant tests of the Anamet and evaporation processes at Puerto Rico Distillers and Bacardi, respectively, had not been finished prior to the completion of this study. Consequently, conclusions could not be developed with respect to their individual performance.
- The economics of mostos treatment and disposal technology are far from being clearly defined. The present practice of discharging untreated mostos into the ocean through short outfall pipes is inexpensive. All other treatment or disposal alternatives investigated are by contrast very costly. For example, estimates for land farming ranged from approximately 8 to 16 cents per proof gallon produced. The cost of treatment and disposal by the evaporation (CMS) production process, the Anamet treatment process, and incineration were not determined. It is hoped that the pilot plant research presently under way will provide accurate cost ranges.

TECHNOLOGY SPECIFIC

- Land Disposal
  - Land reclamation does not appear to be a viable disposal option

- Agricultural utilization appears to be a practical disposal option for Puerto Rico Distillers.
- The combination of potentially available land and dry climate suggests that VIRIL is suitably located to utilize land farming as a disposal option
- Bacardi is less favorably situated and may not be able to locate sufficient land near their Catano facility to make transport of mostos to the disposal site economically feasible.

- Evaporation

A review of available literature indicates that evaporation of mostos to condensed molasses solubles (CMS) is a technologically feasible treatment alternative. The utilization or ultimate disposal of CMS, however, may not be economically practical.

Estimates of local (Puerto Rican) CMS consumption suggest that approximately 18 percent of the total theoretical CMS production could be utilized as an animal feed supplement if incorporated in the feed at the five percent, by weight, level.

- Incineration

The recovery of potassium salts from incinerator ash is estimated to result in an annual supply of 5,550 T of K_2O, which is approximately five times greater than the current (1965-1975) average annual consumption of direct application materials. The total potassium market is uncertain.

- Organic fertilizer production

  Utilizing CMS as a raw material, an annual estimated 53,500 metric tons of an organic N-P-K fertilizer could be produced by the three distillers. The annual local consumption of this type of fertilizer was not available from the literature reviewed.

- Biological treatment processes

  Available data suggests that, while neither aerobic or anaerobic processes are, in themselves, satisfactory treatment alternatives, the combination of the two present technologically feasible treatment options. One such process known as Anamet, has been successfully utilized on waste streams similar but not identical to mostos. This suggests that other similar combined biological systems, while not specifically investigated during this study, may have applications to the treatment of mostos.

II. RECOMMENDATIONS

- Results of the Anamet and CMS pilot plant tests should be incorporated into any future evaluation of rum wastes.
- A program should be initiated to evaluate the potential for land farming of mostos. Pilot studies should be conducted in Puerto Rico and St. Croix to determine:
  - Degree of mostos pH adjustment required
  - Compatibility of land farming techniques with site specific topographical and hydrological conditions
  - Disposal application rates as a function of climate, methods of application, solids loading, etc...
  - Degree of mostos degradation as a function of time
  - Accumulation of mostos constituents within the soil matrix and the extent of cationic and anionic migration through the soil column
  - Potential aesthetic problems.
- The feasibility of mostos discharge by Puerto Rico Distillers to nearby government-owned sugar cane fields should be investigated.
- The Bacardi Corporation should consider a fusel oil and "heads" recovery program, thus eliminating this component from the mostos stream.

- Recent innovative aerobic biological treatment processes should be investigated for potential use following anaerobic digestion. Included among these are:
  - UNOX, a proprietary pure oxygen activated sludge process developed by Union Carbide
  - Deep Shaft, developed by Eco-Research
  - Carrousel, developed by Envirotech.
- The potential for local (Puerto Rican) and export consumption of CMS should be fully investigated.
- A study investigating the short and long-term markets for local organic fertilizers consumption should be initiated.
- A study should be initiated to determine the total potassium market for Puerto Rico and St. Croix.

III. INTRODUCTION

On December 6, 1977, the United States House of Representatives presented a mandate to the United States Environmental Protection Agency (EPA) to study the compatibility of pollutants discharged from Puerto Rico and Virgin Islands rum distillers with the marine environment. Specifically, the EPA was to determine:

- The environmental acceptability of rum distillation wastes
- The potential benefits or adverse effects of marine disposal
- The geographical, hydrological, and biological characteristics of the marine receiving waters around Puerto Rico and the Virgin Islands
- Waste processing technologies which facilitate the recovery of nutrients and/or other beneficial materials in the wastes
- Treatment technologies which reduce the discharge of rum distillation waste pollutants.

In 1978, the EPA initiated a study program aimed at fully assessing the options for disposal of rum distillery wastes and associated environmental consequences. The primary objectives of this study are (1) to identify and assess various treatment technologies and by-product recovery options available to the rum distillers, and (2) to indicate the existence of information voids so that research and development efforts can be directed toward the filling of these gaps.

IV. GENERAL APPROACH

Selection of treatment and by-product technologies for initial investigation was the first project objective. An initial list of treatment and by-product recovery technologies was prepared from a variety of sources, including:

- In-house EPA information on previous and related work
- Interviews with personnel from The Bacardi Corporation, Puerto Rico Distillers, and The Virgin Islands Rum Industries, Limited (VIRIL)
- Intensive literature review of available foreign and United States research projects dealing with the treatment of cane molasses distillation residues and related wastes and processes
- Unpublished and in-press data made available by the rum distillers
- Current university research projects
- Interviews and correspondence with knowledgeable consultants, and industrial equipment manufacturing representatives.

This assemblage of information and data resulted in the following list of potential treatment and by-product recovery technologies for preliminary evaluation.

- Treatment of wastes by a public owned treatment works (POTW)
- Biological treatment processes
  - Aerobic
    - Trickling filter
    - Activated sludge
  - Anaerobic
    - Anaerobic digestion
  - Anaerobic/aerobic systems
    - Cosculleuela
    - Anamet
  - Other
    - Cultivation of fodder yeasts, bacteria, and fungi
- Evaporation
  - Production of condensed molasses solubles (CMS) for animal feed
  - Utilization of CMS as an intermediate product
    - Incineration with conventional ash disposal
    - Incineration with potassium recovery
    - Organic fertilizer production
- Land disposal
  - Agricultural utilization
  - Land reclamation
  - Land farming
- Process modifications
  - Molasses pretreatment

  - Removal of fermenter beer
  - Recovery of fusel oils and heads
  - Removal and recovery of yeast from fermenter beer
- Ocean disposal
- Aquaculture
- Physical/chemical treatment processes
  - Coagulation and sedimentation
  - Foam
  - High gradient magnetic separation
  - Reverse osmosis.

SELECTION PROCESS

While each of the above treatment and by-product recovery technologies may be considered as a potentially viable alternative to the current waste discharge problems of the rum distillers, some of the alternatives have greater application potential than others. Most of the technologies have never been applied to rum wastes, although they have been successfully employed for the treatment of similar high strength fermentation wastes. Furthermore, the time constraints of this investigative effort dictated that the major research efforts be directed toward only those promising technologies. With these factors in mind, the following criteria were adopted to evaluate each alternative:

- Extent and substance of available literature
- Direct application experience of the technology to the treatment of rum distillery wastes

- Direct application experience of the technology to the treatment of similar wastes - (e.g. beet molasses fermentation residuals)
- Performance and operating characteristics of the treatment process on high strength waste streams
- Estimated investment and annual O&M costs
- Energy consumption
- Potential for retrofitting technology to existing plant facilities
- Ultimate disposal of primary and secondary wastes - (e.g. final effluent, sludge, ash).

Other considerations also entered into the evaluation process. For example, the fact that the distillers are located on islands considerably removed from the contiguous states and the limited availability of land and other resources were important factors.

Each technology was qualitatively reviewed in terms of the above criteria and either accepted or rejected for more intensive investigation.

TREATMENT TECHNOLOGIES AND BY-PRODUCT RECOVERY OPTIONS CONSIDERED UNFEASIBLE

The technologies considered unfeasible are:

- Sedimentation and coagulation
- Foam separation
- High gradient magnetic separation
- Reverse osmosis.

In the following section, an explanation is given for the rejection of each of these technologies.

Sedimentation and Coagulation

Sedimentation for treating rum distillery waste was found to be unsatisfactory by Biaggi (11) due to the fact that almost all of the waste solids were in solution. Biaggi (11) and Sen et al. (92) reported no success with the chemical coagulation process as a means of treating rum waste. Even with extremely high dosages of ferric chloride, aluminum sulfate, lime, bentonite, and various other coagulants, no floc formation was observed.

Foam Separation

Foams may be used to remove substances dispersed in a liquid by several processes known collectively as foam separation (89). The common feature of all these processes is that separation is brought about by virtue of differences in the surface activity of the dispersed substances. In contrast to most other treatment processes, foam separations work most efficiently with dilute solutions.

Air or other gases bubbling through the liquid generate gas-liquid interfaces and result in foaming, which allows the interfaces to be collected. Surface-active substances are adsorbed onto the rising bubbles and concentrate in the foam. The substances then can be removed from the liquid.

Foam technologies applicable to the treatment of mostos include froth flotation for the removal of suspended solids, and foam fractionation for the removal of certain ionic species (metals, etc).

Certain problems and shortcomings are inherent to the use of foam separation for the treatment of mostos. These are:

- Foam separation technologies do not remove the soluble BOD from the waste stream. Since the principal components of mostos are soluble solids, further treatment of the waste stream would be required.
- Aerating mostos in a laboratory scale activated sludge study has resulted in excessive foaming (11). The addition of gas for foam separation would probably increase the foaming problem.
- No treatment studies have been completed on the application of foam separation technologies to mostos. No transfer technology exists for the foam treatment of similar wastes.

High Gradient Magnetic Separation (HGMS)

Magnetic separation techniques have been used since the nineteenth century to remove tramp iron and to concentrate iron ores. A variety of conventional magnetic separation devices are in wide use today. These devices generally separate relatively coarse particles of highly magnetic material containing large amounts of iron from non-magnetic media.

In recent years, magnetic devices have been developed which are capable of separating even weakly magnetic materials on the order of one micron in size at high waste stream flow rates. These so-called "high gradient magnetic separators" have been designed to maximize the magnetic forces on fine, paramagnetic materials. The separations may be economically operated at process rates of up to several hundred gpm/ft^2 (1).

High gradient magnetic separators typically consist of a canister type device packed with fibrous ferro-magnetic material. They are magnetized by a strong external magnetic field surrounding the canister. Magnetic particles contained in fluids flushed through the canister are trapped on the edges of the magnetized fibers; non-magnetic particles pass through unaffected. This type of system has been demonstrated to work effectively in treatment of wastewaters containing low levels of impurities (1).

Magnetic components can be separated directly from waste streams, whereas non-magnetic contaminants (organics, colloids, etc.) must be given a "magnetic handle" by seeding the stream with finely divided magnetic seed material. Binding to the seed is accomplished by adsorption or coagulation.

Adsorption mechanisms are not fully understood, but are postulated to include chelation or surface bonding. The more practical technique is chemical coagulation of the contaminants into aggregates.

The potential for HGMS as an option for treating mostos appears to be unfavorable (116). The system relies heavily on the ability of alum or other flocculants to produce aggregate particulates. It has been demonstrated by Biaggi (11) and Sen et al. (92), however, the sedimentation was ineffective in treating mostos due to the high percentage of soluble constituents in the waste stream. Further, the HGMS system seems favorable as a secondary or tertiary treatment module, handling waste streams whose soluble and particulate constituents are in relatively low concentrations. Mostos, on the other hand, has a soluble solids content of approximately 10 percent.

Reverse Osmosis

Reverse osmosis (RO) is a process for removal of dissolved solids in water and wastewater. The name is derived from the fact that, in the process, water is made to flow from a solution of higher concentration through a semi-permeable membrane to a solution of lower concentration, the opposite of natural osmosis. To cause this flow, a pressure greater than the osmotic pressure of the water or wastewater being treated must be applied. In practice, pressure considerably in excess of the osmotic pressure (400 psi is a common feed pressure in desalination plants) is required to obtain a water flux through the membrane, which is sufficiently large to make the process effective and practical (25, 26, 70).

The majority of research and development on RO to date has been concentrated on applications involving the treatment of brackish waters. However, some investigation of the applicability of RO to the treatment of municipal wastewater has also occurred. In addition, the cost of power and membrane replacement is high.

Pilot programs of RO treatment of wastewater have been conducted under EPA sponsorship.

In these studies it was found that substantial pretreatment was required prior to operation of the RO unit to remove dissolved organics, which otherwise fouled membranes. Pretreatment included chemical flocculation, coagulation, and filtration plus activated carbon adsorption. These constitute a very expensive pretreatment chain (25, 26, 98). Additionally, RO technology has been generally applied to waste streams in which total dissolved solids (TDS) were not in excess of 7,000 ppm. Mostos, on the other hand, has a TDS concentration of 77,400 to 85,600 ppm (93). Therefore, RO could not be implemented without some form of dilution, an option which is not realistic, especially so on St. Croix, an island which has suffered under drought conditions over the last several years. Therefore, reverse osmosis is not considered to be a feasible treatment technology for rum distillery wastes.

FEASIBLE TECHNOLOGIES

The following chapters present an analysis of each treatment technology and by-product recovery option. Throughout the text, rum distillery wastes have been identified by one or more of several synonyms. These are: rum distiller's wastes, rum slops, slops, and mostos. They are all defined as the combined liquid discharge resulting from fermentation of sugar cane molasses.

V. DISPOSAL TO A PUBLIC OWNED TREATMENT WORKS (POTW)

INTRODUCTION

Manufacturing facilities located within any of the 48 contiguous states and faced with one of several wastewater treatment options generally have a POTW in reasonably close proximity. If all options prove technologically or economically unfeasible, the POTW can be selected as a final choice. Decision parameters such as present and future surcharges, peak flows, BOD equivalents, increased or decreased plant production must necessarily be factored into the final selection of treatment alternatives. The rum industry on both Puerto Rico and St. Croix, the U.S. Virgin Islands, should, therefore, be examined with discharge to a POTW as a viable disposal option.

The following discussion presents such an examination on a site-specific basis.

Bacardi

The Bacardi Corporation is located approximately 1 1/2 mi northwest of Catano. It is bounded on the north by Ensenada de Boca Vieja and by the small village of Palo Seco, and to the east by San Juan Bay. The overall region lacks an adequate sewage system. This inadequacy presently causes gross pollution to the waters of the region from domestic and industrial wastewater sources (1). The Puerto Rico Aqueduct and Sewer Authority (PRASA) has approved the Bayamon Wastewater System to provide sewage services to areas of Aguas Buenas, Catano, Toa Baja, Toa Alta, and San Juan. The wastewater system to be constructed will consist of trunk and branch sewers to collect wastewater from local sewer systems in existing and projected population centers through the year 2020. Included in this system is a treatment plant (POTW) designed to accomodate the regions expected wastewater. The POTW will be located in Barrio Palmas east of the Bayamon river channel in the municipality of Catano about 1 km from the sea coast of Ensenada de Boca Vieja. The plant will be constructed in 10 MGD modules and in treatment phases.

The initial phase will be designed for primary treatment with average capacity of 40 MGD; effluent will flow directly to the ocean through an ocean outfall to be constructed simultaneously with the trunk and POTW systems (5). Construction has not been implemented on either the POTW, or the ocean outfall. The future date for upgrading the POTW to secondary treatment is now known.

Previous analytical investigations of mostos reported an average total dissolved solids content of 7.77 percent, representing approximately 93 percent of the total solids present (93). Further, mostos is extremely high in soluble BOD and COD, with respective average ranges of 26,500 - 47,400 ppm and 72,000 - 92,000 ppm. The technological considerations of primary treatment are such that they would not be expected to remove any significant quantity of either. If discharged to the POTW, the Bacardi effluent would be diluted and discharged essentially untreated to the ocean. Therefore, the alternative of discharging to a POTW for the purposes of pollutant reduction is effectively not available to Bacardi.

Puerto Rico Distillers

Puerto Rico Distillers is located on the western edge of Arecibo, a city which currently discharges its domestic and industrial streams directly to the ocean. Construction has reportedly begun on a trunk line system to route domestic and industrial wastes to a primary POTW (also under construction) located on the eastern side of Arecibo (47). There are reportedly no present plans to install a trunk line to the western extremities of the city - the location of the distillery. Design capacity, estimated completion data, future timetable for upgrading to secondary treatment, etc., were not available in the literature reviewed and from personal correspondence. Further, since the mostos discharged from Puerto Rico Distillers is virtually identical to that of Bacardi, removal of any significant quantities of pollutants would not be expected. Therefore, discharge to a POTW for Puerto Rico Distillers is not a viable option.

Virgin Islands Rum Industries, Limited (VIRIL)

The VIRIL plant is located in a rural area about 5 mi east of Frederiksted, St. Croix. A small POTW with primary treatment is located several miles east of the distillery, on the eastern edge of the airport property. Recently, a secondary module was constructed several hundred yards from the primary facility and is currently in operation. The POTW serves several newly developed housing areas and the airport facilities. Current average flow is about 0.5 MGD; design capacity is 4 MGD (113). Secondary effluent is discharged to the ocean through a 48 in diameter, 9,000 ft outfall (71).

VIRIL and POTW personnel have conducted preliminary discussions concerning the possibility of pumping via pipeline, the mostos and otherplant wastestreams to the POTW. The POTW personnel suggested that considering the high strength and waste volume (population equivalent is approximately 90,000), the only acceptable method of receiving mostos would be in a diluted state so that the BOD would not exceed that of domestic sewage (200 - 300 ppm BOD) (71). Fresh water, sufficient for the necessary dilution, however, is not available on this water-starved island.

Dilution with seawater is not possible due to the toxic effects of sodium chloride on POTW microorganisms. Therefore, discharge to the POTW is not a viable alternative to VIRIL.

SUMMARY

Discharge of mostos to a POTW is not a viable or practical alternative for any of the rum distillers in Puerto Rico and St. Croix, U.S. Virgin Islands

VI. OCEAN DISPOSAL

Outfall pipes into the ocean are intended to return contaminated fluids to the environment in a way that promotes adequate transport and dispersion of the waste fluids. Urban and industrial communities who discharge their complex mix of wastes to the ocean are typically located along the shallow edge of the ocean, with often tens or even hundreds of kilometers of contaminated shelf between the shoreline and the deep ocean. The bottom slope on the shelf is typically less than one percent. Thus, outfalls extending several kilometers offshore discharge into a body of water of large lateral extent compared to the depth.

The decay times of the wastes are important in the choice of effective discharge strategies. For example, the problems of very persistent contaminants such as DDT cannot be alleviated by dispersion from an outfall. Such wastes must be contained at the source and prevented from entering the environment. On the other hand, degradable organic wastes may be effectively disposed of through a well-designed ocean outfall. Since the typical decay time is only a few days, potential problems are only local and not regional or global.

Coastal waters are biologically productive because of the infusion of nutrients from nearby land masses and upwelling of nutrient-rich bottom water. Man's additions of organic nutrient material cause perturbations in the coastal ecosystems. Most past problems have resulted from excessive waste loadings very close to shore or in estuaries with poor circulation patterns, that is, in cases where man's effects have been overwhelming. The current practice of outfall design for large systems is to build long pipelines (>3 km) on the open coast to depths up to 70 m, and to install large multiple-port diffusers. They can achieve large initial dilutions of the order of 100 to 1 and produce submergence of the entire wastewater cloud below the surface when there is sufficient ambient density stratification. This practice has greatly improved local water quality at relatively low costs (55).

A typical outfall consists of a submarine pipeline roughly perpendicular to the shoreline. In shallower water, it is buried under rip-rap for wave protection and, at greater depths, it is laid on the ocean floor with ballast rock on either side. At the far end, there is usually a diffuser section, a manifold with many small holes to distribute the flow throughout a large ocean area.

Effective utilization of the ocean for assimilation of wastewater depends on both engineering and environmental considerations. Engineering feasibility for ocean diffusion depends upon good jet mixing and oceanic convection and diffusion. Important factors are ocean currents, density stratification, waste decay constants, and the use of multiple-jet diffusers.

SUMMARY OF CONSIDERATIONS FOR AN OCEAN OUTFALL

Initial planning for an ocean outfall should include an oceanographic survey in the vicinity of possible discharge sites to determine (16):

1. Currents (direction, magnitude, frequency, variation with depth, relation to tides, water displacements)
2. Densities (variation with depth determined from salinity and temperature data and standard tables)
3. Submarine topography, geology, and bottom materials
4. Marine biology
5. Turbidity
6. Dissolved oxygen, etc.

The final site selection for an ocean outfall is usually based on general characteristics of the coastal waters and on topography of the drainage area. Details of diffuser design are developed after the general site is chosen.

DESIGN FOR DIFFUSION

Since the objective of an ocean outfall is to disperse waste effluent in the ocean, first consideration is given to the analysis of diffusion. From such an analysis one establishes a satisfactory length for the outfall from the shore, a desirable diffusor pipe arrangement and the approximate number and spacing of ports.

There are essentially three stages of diffusion or turbulent mixing of wastes discharged into the ocean (16):

1. Initial jet mixing (considering jet strength, currents, and density differences)
2. Development of a homogeneous diffusion field

3. Turbulent diffusion of waste field as a whole due to natural oceanic turbulence.

An excellent treatment on the above mentioned stages of diffusion is presented in papers by N. H. Brooks (16, 17, and 18). Some of the highlights of these papers are discussed here.

Port Design

The outlet ports may quite satisfactorily be circular holes in the side of the pipe without nozzles or tubes or other projecting fittings. For optimum dilution, the jets should discharge horizontally, with no initial upward velocity. The inside of the port should be bell-mouthed to minimize clogging and to provide a discharge coefficient which will remain constant over a period of years.

Number of Ports

Research has shown that a multiple-outlet diffuser greatly enhances the possibility of generating a submerged waste field (16). If the waste is discharged at a single port or "en masse," its dispersion and dilution will be slower than if it is discharged over a large area through a number of ports. In fact, without the use of multiple-outlet diffusers, other conditions being equal, much longer outfalls into deeper water are necessary to provide the same degree of dispersion. In general, the greater the depth (volume), the greater the dispersion.

Velocity in Diffuser

The flow velocity in all parts of the diffuser should be high enough to prevent deposition of any residual particles. For settled sewage, velocities of 2 to 3 feet per second at peak flow are adequate (but borderline). If deposition takes place in any part of the diffuser over an extended period of time, the cross section of the pipe may become so constricted that locally the velocity will be reduced, a cycle that will accelerate the in-pipe deposition and clogging process.

Flow Distribution

The outflow between the various diffuser ports should be fairly uniform. If the diffuser is laid on a sloping sea bottom, it will be impossible to achieve uniform distribution between ports for all flow rates. In such cases, it is desirable to make the distribution fairly uniform at low or medium flow, and let the deeper ports discharge more than the average port discharge during high rates of flow.

If waste pumping is necessary or the available gravity head is limited, the total head loss in any diffuser should be kept reasonably small. Additional head losses of a few feet are usually adequate.

Prevention of Seawater Intrusion

All ports should flow full in order to prevent the intrusion of seawater into the pipe. Seawater entering the pipe will be stagnant and will tend to trap grit and other settleable matter, reducing the hydraulic capacity of the diffuser.

SITE SPECIFIC CONSIDERATION

The following section presents ocean disposal options available to each rum distiller predicated on the following assumptions:

1. The chemical and physical characteristics of mostos are such that ocean disposal results in minimal environmental

harm to local ocean flora and fauna.

2. Practice of removing "heads" and "fusel oils" is continued by Puerto Rico Distillers and VIRIL and is adopted by Bacardi.

Bacardi Corporation

The Bacardi Corporation manufacturing facility (Figure VI-1). is located just south of the town of Palo Seco, on a peninsula of land bounded on the east by San Juan Bay and on the west by both the Palo Seco Thermoelectric Plant and the Bayamon River. Approximately one mile southeast of the plant is the town of Catano. The Bayamon River currently receives its water from the Thermoelectric Plant (approximately 100 MGD - cooling water) and from Bacardi (approximately 0.2 MGD - condensate, boiler blow down, cooling water, fermenter washings, etc.)

Design has been submitted and approved for the construction of the Bayamon Wastewater Treatment Plant (initial average flow of 27 MGD – primary treatment only), and an ocean outfall accepting the combined flow of the proposed Bayamon and existing Puerto Nuevo Treatment Plants. The combined effluent will be discharged through a 120-in-diameter concrete pipe extending 4,000 ft into the Atlantic Ocean to a depth of about 160 ft below mean ocean sea level. The wastewater will be diffused to the ocean through ports located along two 1,000-ft diffusers. Initial dilution is estimated to be about 150-175:1. The outfall pipe (Figure VI-1) will be located on the far eastern edge of the Bacardi property.

If Bacardi were to utilize this newly designed system, two options would be available:

Option 1: Discharge to the Bayamon Wastewater Treatment Plant. Bacardi would discharge its combined effluent (approximately 0.5 MGD) to the proposed primary treatment facility. The Bacardi effluent would be combined with other domestic and industrial wastes, thus affecting dilution, and would be discharged to the ocean. However, the nature of mostos is such that the high BOD and COD loads are a function of the high percentage of solubilized organics (nonfermentable sugars, acids, etc.) and would not be appreciably reduced by primary treatment. Hence, the mostos would essentially pass through the primary system unchanged.

Option 2: Discharge directly to the outfall. Initial flow through the outfall pipe is anticipated to be 40 MGD. By running pipe across the plant grounds and connecting directly to the outfall pipe, the 0.3 MGD Bacardi mostos stream would receive an instantaneous dilution of 130:1. Assuming that the diffuser operates within its design limits, the Bacardi effluent will be further diluted upon discharge to the ocean. The overall mostos dilution is estimated to be 20,000:1.

The difference between each of the above alternatives is basically one of semantics. Both dilute the waste to the same degree with final discharge to the ocean. However, in the first case, discharge is technically to a POTW; in the latter, discharge is directly to the ocean without benefit of "treatment".

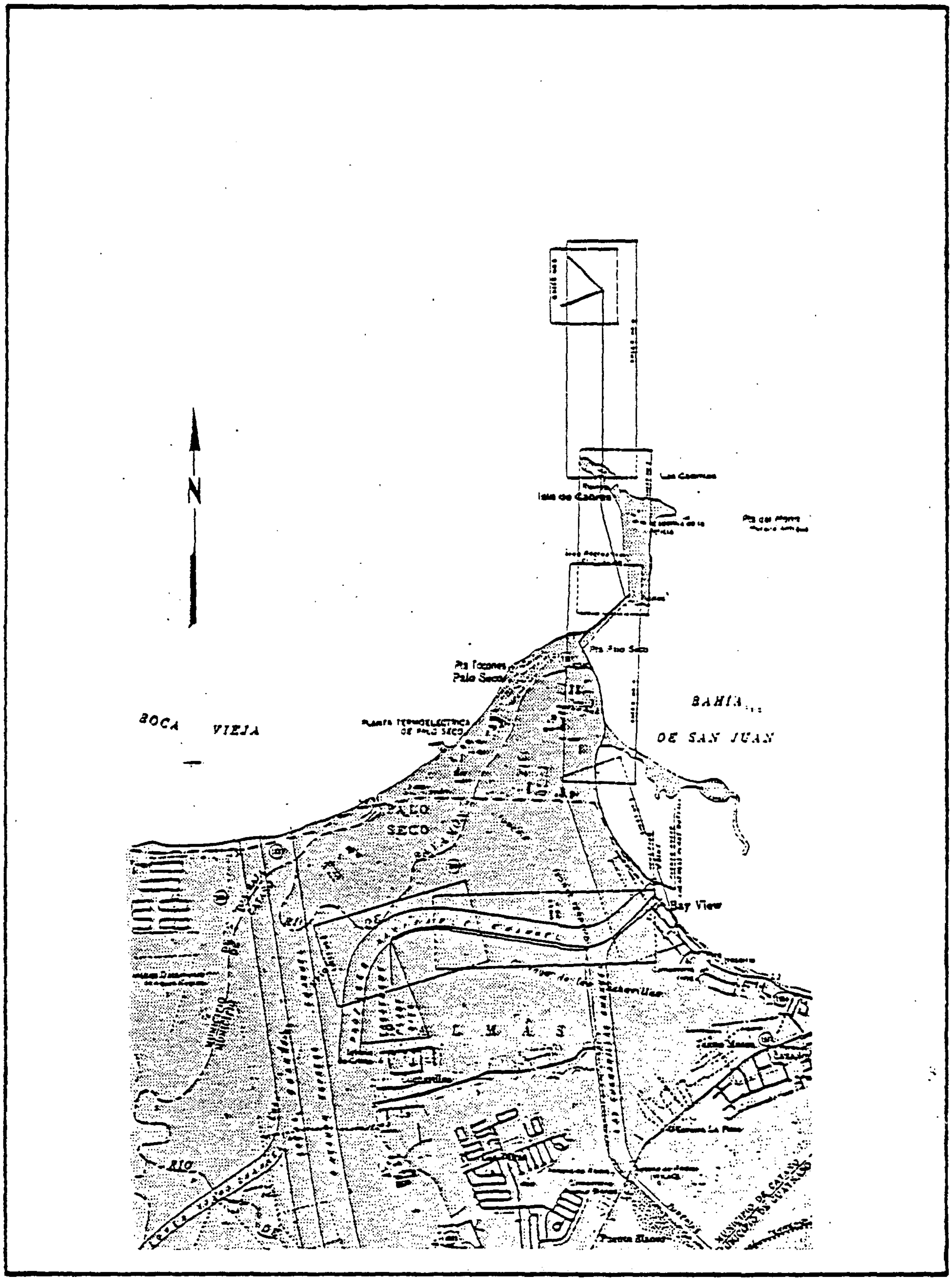

Figure VI-1. Proposed ocean outfall. San Juan, Puerto Rico (Bacardi).

Puerto Rico Distillers

Puerto Rico Distillers is located in the western section of Arecibo, bounded on its eastern, western, and southern borders by encroaching city development and to the north, by the Atlantic Ocean (Figure VI-2). Two options are presented.

Option 1: 1,600-ft outfall.

A 6-in-diameter concrete (C = 130) pipe will extend 1,600 ft into the Atlantic Ocean to a depth of approximately 100 ft. Based on a volume of 0.4 MGD (280 gal/min), effluent would flow at a velocity of about 3.2 ft/sec. Head loss was calculated to be 7.4 ft/1,000 ft or 11.8 ft for the entire 1,600-ft outfall. Pumping requirements are estimated at 1.1 brake horsepower (BHP).

Option 2: 2,000-ft outfall.

A 6-in-diameter concrete (C = 130) pipe will extent 2,000 ft into the Atlantic Ocean to a depth of approximately 150 ft. Based on a volume of 0.4 MGD (280 gal/min), effluent would flow at a velocity of 3.2 ft/sec. Total head loss would be 14.8 ft. Pumping requirement is estimated at 1.4 BHP.

Initial dilution for either option is estimated at 50:1. If the density of mostos could be lowered to less than that of seawater (for example, by diluting mostos with other lower

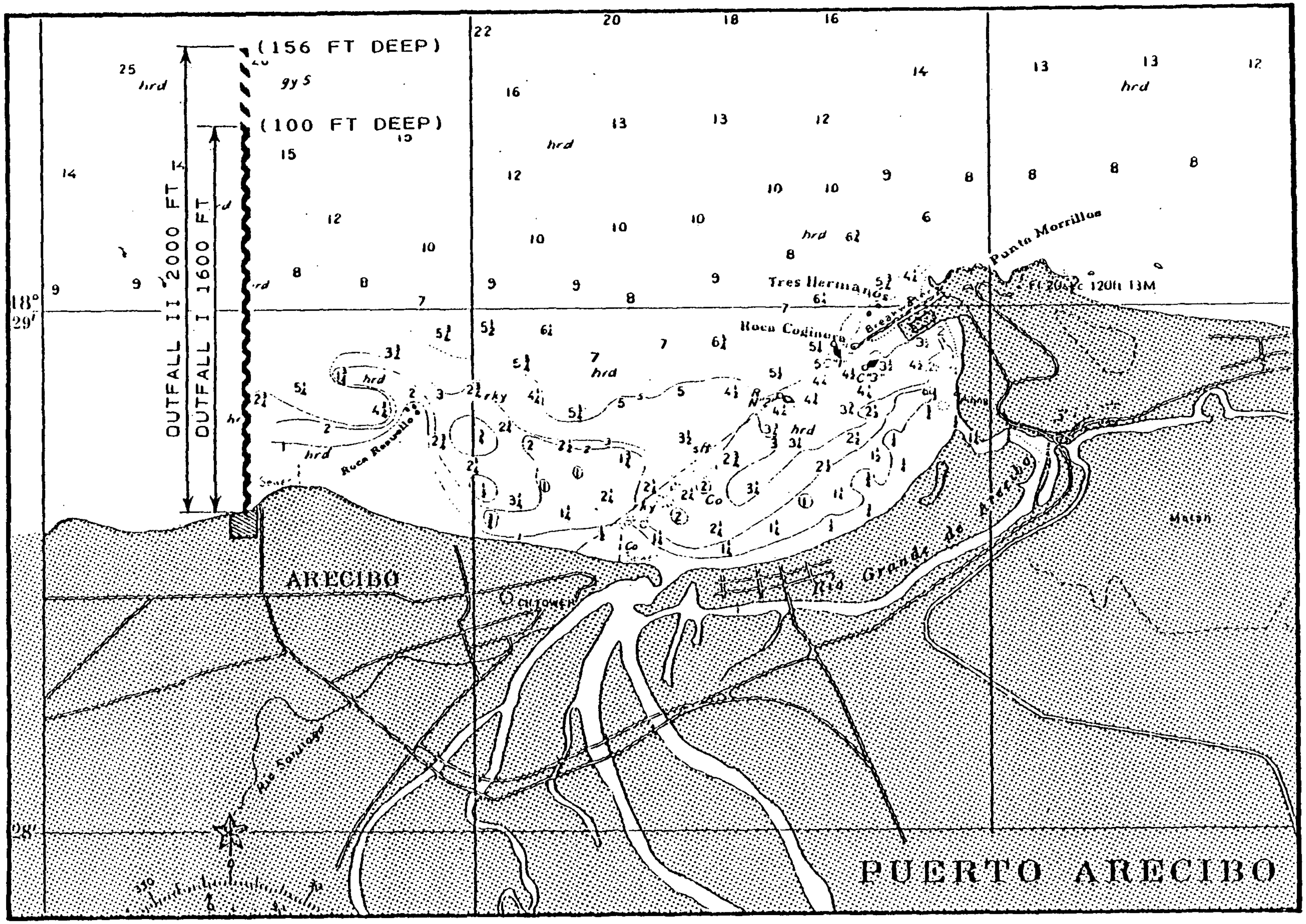

Figure VI-2. Proposed outfalls for Puerto Rico Distillers, Arecibo.

specific gravity waste streams), mixing would be expected to increase. If the outfall is extended to 3,000 ft, the waste stream would be discharged at a depth of approximately 400 ft.

Virgin Islands Rum Industries, Limited (VIRIL)

The VIRIL plant is located in the southwestern area of St. Croix, approximately 1-1/2 mi east of Long Point. Specifically, the plant is on the Diamond Estate of Princess Quarters approximately 1-1/2 mi north of the ocean. The mostos discharge pipe, originally a sewer outfall, runs from the plant, across the estate known as Betty's Hope, and terminates approximately 1,000 ft in the ocean at a depth of about 15 ft (see Figure VI-3). It is worthy of note that the ocean slopes very gradually throughout this area so that any outfall pipe designed for depths of 100 ft is reached, the degree of slope increases rapidly. For this reason, only one option has been examined.

Option 1: 150-ft outfall.

An outfall to a depth of approximately 150 ft. Approximately 22,000 ft of 4-in-diameter concrete pipe would be required. VIRIL's estimated 140-gal/min effluent would flow at 3.5 ft/sec. Head loss is estimated at 13.6 ft/1,000 ft or 300 ft for the entire net fall. Pumping requirements would be equivalent to 14.2 BHP.

Due to the rapid slope of the ocean bottom at the outfall termination point and the density limitations of the waste stream, diffusion ports would probably not be required. Rather, the waste stream could be permitted to exit directly from the end of the

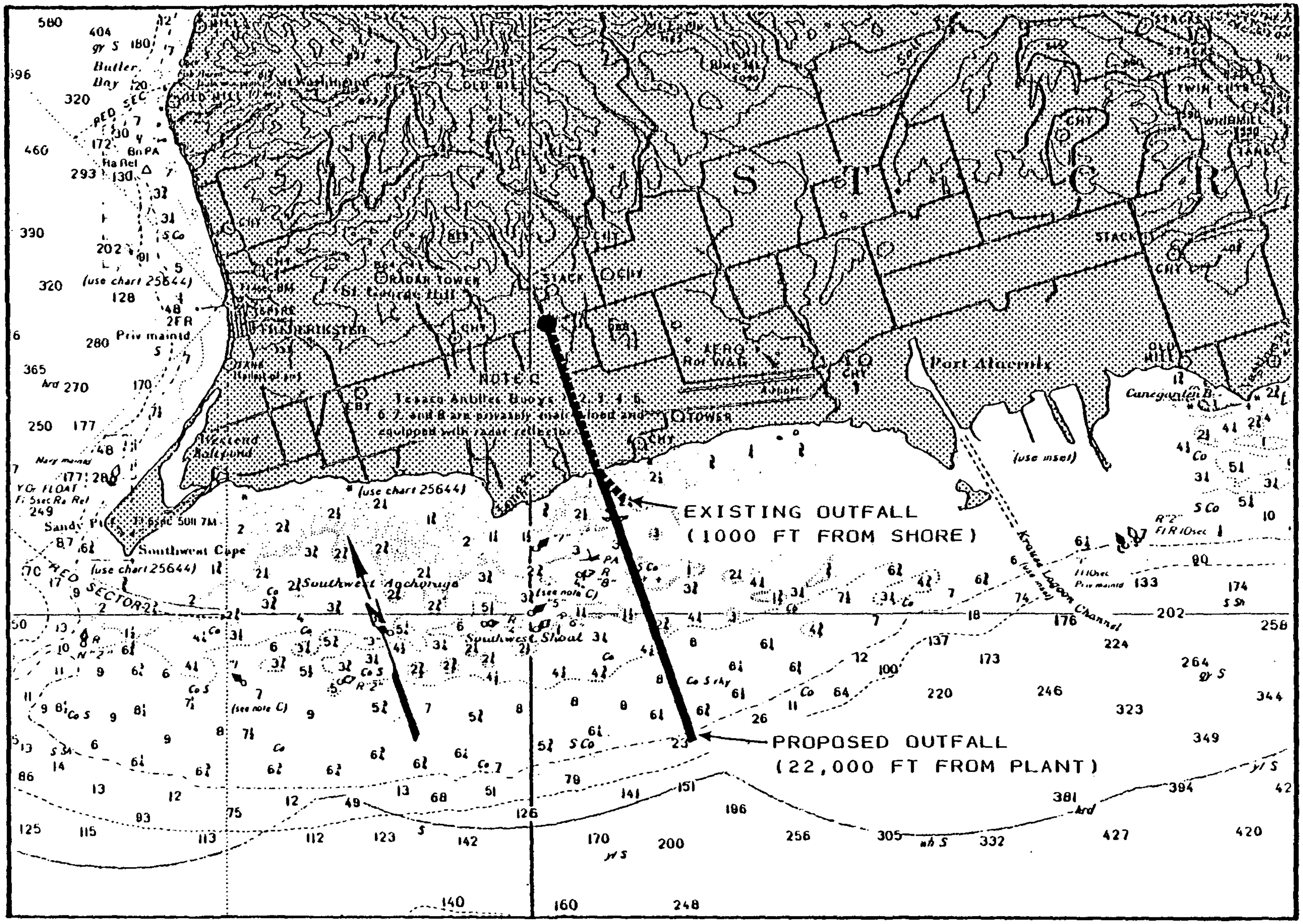

Figure VI-3. Proposed outfall for VIRIL.

outfall. Dye studies would have to be performed to investigate the velocity and direction of the ocean currents to ensure that the stream would not be diffused into the shallower areas.

The continuation of mostos disposal to the ocean will be largely dependent upon the results of marine biological studies currently in progress. Consequently, a complete economic analysis, including capital and O&M costs for a pipeline, is premature. However, to place the economics of disposal in proper perspective to other disposal technologies, pipeline estimates are presented for Puerto Rico Distillers and VIRIL. It is assumed that costs include pipe, connectors, ballast and/or cement (for anchoring pipeline to ocean floor), and labor for installation. Further, it is assumed that the above-mentioned costs for a 6-in-diameter pipe will be approximately $125/ft and for a 4-in-diameter pipe, $100/ft (46). Extending these unit costs to the pipeline lengths shown in the preceeding section gives the following:

- Puerto Rico Distillers

    Option 1 (1,600-ft outfall - 6-in-diameter pipeline)

    1,600 x $125 = $200,000

    Option 2 (2,000-ft outfall - 6-in-diameter pipe)

    2,000 x $125 = $250,000

- VIRIL

    Option 1 (22,000-ft outfall - 4-in-diameter pipe)

    22,000 x $100/ft = $2,200,000

Costs for Bacardi were not estimated because they would be utilizing the proposed POTW outfall.

VII. LAND DISPOSAL

INTRODUCTION

Soil, with its tremendous surface area and varied microbial population, has been viewed as a physical, chemical, and biological filter for waste materials (98). The waste is retained by the soil matrix, and the organic fraction of the waste is eventually decomposed by the soil microorganisms (79,98).

Land application is a practice whereby wastes are applied to the soil surface and incorporated into the top 6 to 12 in of soil. As in farming practices, only the surface soil is utilized, and the process of waste assimilation is aerobic. Optimal degradation of the added wastes requires environmental conditions that are similar to those needed for raising a crop: adequate amounts of sunlight, water, nutrients, and oxygen. In addition, land application and farming employ similar types of equipment.

Wastes may be applied to soils for a variety of reasons. Principal among these are the following:

1. Agricultural Utilization - as a soil amendment, utilizing the available organic and inorganic nutrients to enhance the growth of certain crops.
2. Land Reclamation - as a soil amendment to add organic and inorganic nutrients to distressed or submarginal lands.

3. Land Farming - as a means to dispose of wastes on a dedicated piece of land, whereby, the organic constituents are degraded by natural processes (oxidation and reduction via sunlight) and the inorganics are trapped within the surface soil matrix.

The objective of this investigation is to explore the concept of land disposal of mostos and to discuss in detail, that particular method of land application which is technologically and economically most feasible. As will become apparent in the following pages, land farming for all three distillers studied and agricultural utilization for Puerto Rico Distillers, were selected to offer the most feasible land disposal options. Agricultural utilization for Bacardi and VIRIL and land reclamation for all three were excluded from more serious considerations for the following reasons:

- Agricultural utilization - from the literature reviewed, research relating the effects of mostos on crop growth could not be found. However, two other rum distilling facilities, Serralles in Mercedita, Puerto Rico and Bacardi in Tultitlan, Mexico have successfully disposed of mostos by distribution (after dilution with fresh irrigation water) through canals irrigating nearby sugarcane fields. In this instance the feasibility of distillery discharge depends upon the availability of nearby sugar cane fields. Puerto Rico Distillers is the only distillery in a similar situation in such a favorable locale.

Agricultural utilization of mostos to other crops cultivated in the islands is dependent on significant crop land availability and the adequate research expressing the effects of mostos on such crops (affinity to absorb heavy metals, organics (toxic or otherwise), pesticides, etc....). Currently, neither of these are available. The reader is referred to the section, Estimation of Mosto Application Rates, for a more detailed explanation of the Serralles and Bacardi, Mexico land disposal operations.

Land Reclamation - land reclamation programs are typically employed in a situation where a waste generator is in close proximity to sub-marginal or distressed land, e.g., areas that have been heavily mined. These circumstances are not known to exist within any practical distance of three distilleries.

LITERATURE REVIEW

From the literature reviewed, the only research that could be found presenting relationships between mostos and soils was that of Raul Perez Escolar (75-78). A series of four articles resulting from his studies was published in the Journal of Agriculture of the University of Puerto Rico in 1966 and 1967. Summarized, they are as follows:

- "Reclamation of a Saline-Sodic Soil by Use of Molasses and Distillery Slops," (July 1966) - An application of 2.3 ac-in of mostos to a saline-sodic Faith clay of southwestern Puerto Rico was shown to lower both the soil conductivity and exchangeable sodium. Further, he demonstrated that the soil was reclaimed, resulting in an excellent stable soil structure (75).

- "Use of Molasses and Distillery Slops with Sulfur for the Reclamation of a Saline-Sodic and a Sodic Soil from Puerto Rico," (January 1967) - Tests and results similar to the above cited references with sulfur included to enhance reclamation. Testing was expanded to include both a Guanic clay and a Faith clay (78).
- "Stability of Soil Aggregates Treated with Distillery Slops or Blackstrap Molasses," (July 1966) - Mostos, applied at a minimum of 1/4 ac-in, was shown to produce a long lasting and favorable effect on soil aggregate stabilization which persisted after the growth of four consecutive crops (77).
- "Separation and Characterization of the Active Soil-Aggregating Agent Present in Distillery Slops," (October 1967) - The soil aggregating and stabilizing agents were found to be present in the 80 percent alcohol insoluble fraction of mostos with a composition of a mannose-bearing polysaccharide (6 percent), protein (7 percent), and a caramel (87 percent) (76).

References to mostos decomposition mechanisms and kinetics were not available from the materials reviewed. Further, references to land disposal systems could not be found in this literature. However, several personal communications(33, 103, 104) revealed the following land application programs:

- Serralles - Mercedita, Puerto Rico

  The Serralle's rum distillery is located in southwestern Puerto Rico in Mercedita, several miles east of Ponce. It is situated on approximately 4,000 acres, all of which is owned by the Serralles family, except for some acreage on which a sugar mill is located. Annual production of rum is approximately 4 million proof gallons. Estimated mostos flow is approximately 100,000-150,000 gal/day. Since 1935, mostos has been discharged through a system of canals which supply irrigation water to about 400 acres of sugarcane. The mostos is combined with other plant wastes, achieving final dilutions ranging from 1/2 (other plant wastes/mostos) to 5/1 (104). This combined stream is pumped to a central irrigation station which further dilutes the wastes prior to final field discharge. The combined plant wastes at this point are diluted approximately twofold. Irrigation water is supplied by an adjacent river originating in the mountains north of the plant. In 1975, a system of peripheral ditches was constructed to prevent mostos runoff during periods of heavy rain. Soil and groundwater monitoring programs have not been established at those sites although, no deleterious effects have been reported for either the soil or sugarcane (103, 104).

- Bacardi, Tultitlan, Mexico - Bacardi operates a rum distillery in Tultitlan, Mexico (near Mexico City). Five hundred acres of sugarcane are located approximately one mile from the plant. There is no sugar mill present on the site, which would provide processing water for further mostos dilution. The mosto stream is combined with other plant wastes achieving a dilution of 5/1 (other plant wastes/mostos). The combined solution is mixed with fresh irrigation water further diluting the mostos resulting in a final concentration ranging from 11/1 - 19/1. The mixture, in turn, is distributed throughout the fields (via canals and ditches) simultaneously supplying water to the sugarcane crop and disposing of the mostos. This process has reportedly been in operation for 17 yr, the only apparent problems being occasional ponding, resulting in some foul odors. The native soil is alkaline and the acidic nature of mostos is reported to aid in maintaining near neutral soil conditions (33).

- Other Mexican Operations - Other distilleries in Mexico reportedly discharge their rum wastes in a similar manner but are able to achieve much greater dilutions as a result of added sugar mill processing water. Mostos dilutions at these operations are reported to range from 100-500 to 1.

COMPONENTS OF A LAND DISPOSAL SYSTEM

The implementation of a successful land disposal program is dependent upon the interrelationships of many variables including the selection of a disposal site, the nature of the wastes being disposed, method of waste application, and economics. More specifically, these considerations involve the following parameters:

- Selection of Disposal Site
    - Land area required
    - Land availability and cost
    - Proximity to distilleries
    - Proximity to homes and commercial establishments
    - Ready access from all-weather roads
    - Climate (rainfall, freedom from flooding, prevailing wind direction)
    - Field slopes and general topography
    - Hydrogeology (location of groundwater)
    - Soil characteristics
    - Types of crops historically planted
    - Ultimate land use of disposal site.
- Waste Characteristics
    - Quantities of waste available
    - Final waste disposal form (liquid, concentrate)
    - Physical, chemical, biological properties
    - Variability of constituents.
- Application of Wastes
    - Methods of transportation (irrigation pipe, tanker, rail car, barge..)
    - Methods of application (spreading, spraying, ridge and furrow irrigation, subsurface injection, etc...)
    - Hydraulic loading limitations

  - Metals loading, pH, nutrient constraints
  - Existing local and federal regulations
  - Monitoring requirements.
- Economics
  - Capital costs (land, equipment, installation...)
  - Operation and maintenance costs
  - Overall disposal costs (total and factored).

SITE DESCRIPTIONS

Puerto Rico

Puerto Rico has an area of approximately 3,435 sq mi. The island has three principal physiographic divisions. The most extensive consists of the complex mountain ranges, which include nearly all of the interior of the island. The less extensive are the playa plains and the coastal plains, which circle the outer edge of the island in a ribbonlike band. The elevation ranges from sea level to 4,398 ft above, and the relief ranges from level to precipitous. Ecologically, the complex mountain ranges are of volcanic origin, and the coastal plains and playa plains are sedimentary. The principal rocks include several types of Tertiary and Cretaceous limestones shales, volcanic ash, lava, granite, andesite, sandstone, serpentine, tuff, and conglomerate (86). There are 358 soil types, phases, and miscellaneous land types recognized on the island, representing a total of 115 soil series (86).

The population densities, which vary greatly from place to place, create the most serious social and economic problems confronting the government. A high proporation of the island area consists of shallow, stony, steep, or submarginal land (86).

The present population is estimated to be approximately 3.4 million (1976-3.2 million). Projections to the year 2000, suggest a population as high as 5 million (46). Available land, therefore, is anticipated to be of premium value and reserved for the growth of crops critical to the welfare of the people and the government.

The climate is nearly ideal for a 12-month growing season. It is tropical, uniform, and oceanic, and nearly ideal conditions exist for a heavy precipitation over all but the southwestern and the extreme northwestern parts of the island. The average annual precipitation ranges from less than 30 in in the southwestern part to nearly 200 in on the high peaks in the Sierra de Luquillo. Most of the cultivated crops are irrigated in districts receiving less than 45 in of mean annual rainfall, and sugarcane and grapefruit are irrigated in districts receiving less than 60 in. The climate is nearly ideal for the production of such crops as coffee, sugarcane, pineapples, bananas, mangoes, coconuts, yautias, and yuca, but it is poor for alfalfa and berries. Such crops as wheat, oats, barley, apples, pears, and peaches are not grown. Rice is well adapted to the climate and to many of the soils, and will probably be cultivated to a much greater extent in the future (86).

Rainfall in the San Juan and Arecibo areas has averaged about 60 in/yr, evaporation, about 82 in/yr.

Bacardi--

The Bacardi Corporation is located approximately 1 1/2 mi northwest of Cataño. It is bounded on the north by Ensenada de Boca Vieja and the village of Palo Seco; on the east by San

Juan Bay; and on the immediate west by the Palo Seco Thermoelectric Plant. Further west is the small village of Levitown. To the south are some marsh lands reserved for industrial park development and town expansions(5). Therefore, the only direction available for Bacardi to land dispose their wastes is west. Some acreage once used for sugarcane production is approximately 4-5 mi west of the plant, but information as to the amount of land, ownership, cost, future planned use, etc., was not available from the sources contacted.

Puerto Rico Distillers--

Puerto Rico Distillers is located on the western edge of Arecibo. The plant is bounded on the north by the Atlantic Ocean, and on the east and south by the encroaching fringes of the city. Sugarcane fields, owned by the government are located approximately 10 mi west of the plant. The planned use, ownership, etc., of land between the sugarcane fields and the plant was not available from the sources contacted.

St. Croix, U.S. Virgin Islands

The U.S. Virgin Islands include the islands of St. Thomas, St. John and St. Croix. The last is the largest of the three with an area of 84 sq mi.

The topography is somewhat different from the other two with a broad expanse of low, relatively flat land running along the south 2/3 of the island. A range of hills, ranging in elevation from about 500 ft to more than 1,000 ft, topped by Mount Eagle at 1,165 ft, runs along the northern coast. In the eastern end of St. Croix is found another group of slightly lower hills with a maximum elevation of about 860 ft. The relatively small area covered by hills on St. Croix results in rather steep slopes down to the Carribbean in the north and to the level areas to the south. St. Croix is the only U.S. Virgin Island with any sizable expanse of flatland suitable for farming. Here, sugarcane, which was the principal crop, has been abandoned (84). Subsistence crops are now a minor effort. Some cattle are raised for milk and meat (84).

In St. Croix, industrial growth has become a significant factor in the island's economy (84). With the downgrading of agriculture, industrial complexes have been expanded to include the petrochemical industry and refinement of aluminum.

One of the principal causes of concern in the U.S. Virgin Islands is the short supply of water. Rainfall, while averaging about 40 in annually (rainfall has been well below average over the past several years) over most of the area, is insufficient. This is due partially to a high evaporation rate (average about 73 in/yr) and rapid runoff.

In an effort to utilize available water efficiently, most homes and business establishments catch rainwater on the roofs and pipe it to cisterns. Generally, during the drier portion of the year, it is necessary to carry water by barge from Puerto Rico.

Virgin Island Rum Industries, Limited (VIRIL)--

The VIRIL plant is located about 5 mi east of Frederiksted, St. Croix. Unlike Bacardi and Puerto Rico Distillers, VIRIL is situated in an area which is just beginning to show signs of development. The 25-ac plant is in a rural area surrounded by 400 to 500 ac of uncultivated land (not owned by VIRIL). Some evidence of urban expansion, however, can be seen. To the south and east about 1/2 mi away, several small housing developments have recently been constructed, and to the north, approximately 1/2 mile, ground has been dedicated to the construction of a hospital. The area south of the plan extending to the Carribbean (approximately 1 mi) is not inhabited and is covered with brush, trees, and natural grasses.

WASTE CHARACTERISTICS

In the processing of rum, wastewater streams are generated from four or five sources. Mostos has been previously identified as the stream representing approximately 66 percent of the flow, and 98 percent of the pollutants(93). For the sake of the following presentation of data, it is assumed that only the mostos stream will be land disposed.

Table VII-1 presents the chemical characteristics of mostos but on a dry weight basis. It should be noted that approximately 69 percent of the dry solids are in the form of dissolved volatiles - namely organics. While the exact nature of these are uncertain, they are most likely a mixture of sugars, organic acids, amino acids, proteins, polysaccharides, and various organic salts. All are decomposable but the kinetics and degradation times are not known. Total Kjeldahl nitrogen is 1.36 percent (dry wt basis), indicating that sufficient nutrients are probably present to

TABLE VII-1. COMPOSITION OF SELECTED CONSTITUENTS IN MOSTOS ON A DRY-WEIGHT BASIS.

Parameter	Previously Reported*	Expressed on Dry-Weight Basis
	%	
Total solids	8.35	
Total dissolved volatile solids	5.79	69.3
Total Kjeldahl nitrogen	0.114	1.36
Calcium	0.209	2.50
Potassium	0.426	5.10
Chloride	0.211	2.53
Sulfate	0.412	4.93
	mg/ℓ	
Zinc	9.89	118
Cadmium	0.18	2.16
Lead	1.10	13.2
Copper	32.8	393
pH	4.36	

*(93)

sustain a reasonable level of bacteriological activity.

Heavy metals are in the ranges typically reported for municipal sewage sludge - another waste often disposed to land. On the other hand, calcium, potassium, chlorides and sulfates are extremely high and would probably have adverse effects on germination of seeds and subsequent growth of certain crops.

Table VII-2 presents estimated annual quantities of mostos generated by each distillery

ESTIMATION OF MOSTOS APPLICATION RATES

Agricultural Utilization

As previously mentioned, both Bacardi (Tultitlan, Mexico) and Serralles (Mercedita, Puerto Rico) have active and long-termed agricultural utilization programs which involve irrigation canal distribution of mosto through sugarcane fields. Both of these plants have one thing in common - they have sugarcane fields

TABLE VII-2. ANNUAL QUANTITIES OF MOSTOS GENERATED BY BACARDI, PUERTO RICO DISTILLERS, AND VIRIL

Distiller	Average Daily Discharge (gals)	Average Number of Operating Days	Annual Generation of Mostos (gals)	Total Annual Dry Solids Generated* (Tons)
Bacardi Corp.	300,000	300	90,000,000	33,066
Puerto Rico Distillers	200,000	200	40,000,000	14,696
VIRIL	100,000	200	20,000,000	7,346
Total			150,000,000	55,110

*Based on 8.35 percent solids

in close proximity to their distilleries. Of the three distilleries to which this study is addressed, only Puerto Rico Distillers is located in such an area. It is reported that approximately 4,000 or more acres of government-owned sugarcane fields are within a five-mi radius of Puerto Rico Distillers (66, 103, 104). If arrangements could be made with the owner-operators of these fields, it may be possible to transport (via pipeline) the entire plant waste stream to these fields where, upon further dilution with fresh water, the combined streams could be used for irrigation of the sugarcane.

From existing data on both the Bacardi (Tultitlan) and Serralles disposal operations, estimates of mosto application rates (dry weight basis) and irrigation rates were made (33, 103, 104). These are presented in Table VII-3. Assuming that mostos is equally distributed over the available acreage, the mosto application rate is equivalent to 20.2 and 28.7 dry T/ac/yr at Bacardi and Serralle's respectively. Similarly, from the information available, annual irrigation application rates of the diluted mosto streams were calculated to be 30.7 ac-in for Bacardi and 10.2 ac-in for Serralles. The amount of irrigation water supplied by natural rainfall is approximately 30 inches at Serralles, but was not available for Bacardi.

It would seem, therefore, that Puerto Rico Distillers, with approximately 4,000 acres of sugarcane in reasonably close proximity may have a favorable disposal alternative not available to the others. Further, Puerto Rico Distillers' annual mostos discharge is estimated to be approximately 40,000,000 gals - about

TABLE VII-3. ESTIMATED ANNUAL MOSTOS AND IRRIGATION WATER APPLICATION RATES FOR BACARDI (TULTITLAN, MEXICO) AND SERRALLES (MERCEDITA, PUERTO RICO)

Plant	Estimated Annual Mostos Production[*] (million gal)	Estimated Fresh Water: Mostos Ratio	Sugar Cane Acres	Estimated Annual Mostos Loading Rate[†] (T/ac) (dry weight basis)	Estimated Annual Irrigation Water Supplied to Dispose of Mostos (ac-in/yr)
Bacardi	27.5	15:1	500	20.2	30.7
Serralles	31.3	3.5:1	400	28.7	10.2

[*] Based on 250 operating days/yr.
[†] Assuming mostos with specific gravity of 1.06 (8.8 lb/gal).

20 to 30 percent higher than Serralles or Bacardi, Tultitlan. The greater amount of sugarcane acreage available to Puerto Rico Distillers suggests that mostos could be discharged to the fields on an even lower dry weight basis than is currently estimated for Serralles and Bacardi, Tultitlan.

LAND FARMING

There are two principal considerations which will determine the maximum waste application rate for a land farming operation:

- Quantity of heavy metals in the mostos applied
- Hydraulic capacity of the site (the ability of the soils to absorb moisture in addition to the annual precipitation).

A third consideration, land requirements, will determine the practicality and feasibility of a land farming program.

Heavy Metals--

While there are no criteria governing the application of mostos to soil, the presence of heavy metals suggests a similarity to municipal sewage sludge, for which there are recommended limitations. In most situations mostos will be applied to soils in a manner analagous to sludge. Therefore, regulations and practices which control the use of sludge will be applied throughout this analysis. Table VII-4 presents the U.S. Department of Agriculture (USDA) recommendations for the total amounts of four metals contained in sludge, which may be added to agricultural soils (54). The calculations in column four were derived from the following formula:

$$\text{mostos (dry T/ac)} = \frac{\text{Net. max allowable metal loading (lb/ac)}}{\text{ppm metal in mostos (dry wt)} \times 0.002}$$

TABLE VII-4. ESTIMATION OF MAXIMUM ALLOWABLE HEAVY METALS AND SLUDGE LOADINGS FOR AGRICULTURE CROPS AND MOSTOS LOADINGS FOR LAND FARMING

Metal	USDA Maximum Allowable Metal Loading*	Estimated Amount of Metal in Soil at the Site	Maximum Allowable Metal Loading for Agricultural Soils	Maximum Allowable Mostos Loading for Agricultural Soils	Maximum Allowable Mostos Loading for Land Farming†
		lbs/ac		Tons/ac	
Lead	2,000	25	1,975	74,811	374,055
Zinc	1,000	100	900	3,814	19,070
Copper	500	20	480	611	3,055
Cadmium	20	1	19	4,318	21,590

*Total amount of waste metals allowed on agricultural land for soils with CEC>15 meg/100g (54).

†Based on preliminary EPA estimate that approximately 5 times the agricultural soil metal accumulation would be the maximum acceptable loading for non-agricultural soils.

The calculation assumes that the concentrations of these metals (refer to Table VII-1) will remain constant over the life of the disposal site. As shown in Table VII-4, the maximum allowable mostos loadings vary considerably with respect to the individual metals, with copper being the limiting constitutent.

For land farming purposes, no recommended criteria are available. Conversations with EPA personnel indicate that loading rates as high as 5 times USDA criteria for agricultural soils may be acceptable for non-agricultural soils if the metals applied are demonstrated to be retained in the plow zone. If a landfarm site will not be utilized for agricultural purposes at any future time, the estimated maximum allowable waste loading in column 6 of Table VII-4 may be applicable. In this case, the heavy metal concentration of the waste is not a significant constraining factor in determining the annual application rate to the site if good soil management is practiced. Soil pH is of specific concern since mostos is particularly acidic (pH - 4.4). In order to minimize the potential for metal migration under acidic soil conditions, mostos may have to be neutralized to maintain a soil pH of 6.5 - 7.5. However, the accumulation of metals in the soil will limit the site life. The life span of the site with respect to each metal can be calculated as follows:

$$\text{Life (yr)} = \frac{\text{Maximum waste loading (T/ac)}}{\text{Annual application rate (T/ac/yr)}}$$

Table VII-5 presents these data. For mostos, the site life would be limited by copper accumulation, although a site life of

TABLE VII-5. ESTIMATED SITE LIFE BASED ON ANNUAL APPLICATION RATE OF 12 AC-IN/YR*

	Allowable Years of Disposal	
Element	Agricultural Site	Non-Agricultural Site
Lead	625	3,125
Zinc	32	160
Copper	5	25
Cadmium	36	180

*Mostos assumed to have a specific gravity of 1.06 with a total solids content of 8.35 percent. Annual application of mostos equivalent to 120 dry Tons/acre.

25 yr is not a significant constraint. Note that the calculation is based on the assumptions that the annual application rate remains the same (12 ac-in/yr at 8.35 percent total solids) and that there is no change in metal concentrations in the waste generated. An annual application rate of 12 ac-in/yr was selected because it represents an equivalent loading of 120 dry Tons/ac. For comparisons sake, a recently completed study of municipal sewage sludge agricultural utilization programs at 9 sites showed a range of annual sludge application rates of 15.3-146 dry Tons/ac. The median value was 50 dry Tons/ac (63).

The sodium adsorption ratio (SAR) is also an important consideration in the application of a liquid waste to soils. Calculation of SAR can be made by the following equation:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

Wastewaters with SAR values greater than 15 should be avoided because of their detrimental effect on soil structure and ultimate reduction in the infiltration rate of the soils. Sodium adsorption ratio values from 5 to 15 can, over a period of years, lead to loss of structure in soil horizons containing more than 10 or 20 percent clay (loam or finer texture). Lower values are generally satisfactory, although long term declines in infiltration and percolation capacities have been observed in moderately fine-textured soils when irrigated with water having SAR ratios as low as 3 (54).

The SAR value calculated for mostos is 1.74, suggesting that long range application to soils will not result in degradation of its structure. Further, and of more practical significance, is that both Bacardi in Tultitlan, Mexico and Serralles in Mercedita, Puerto Rico, have practiced a "combined" form of agricultural utilization/land farming over a time frame considerably longer than calculations show to be feasible, yet neither has reported any deleterious effects to soils or crops.

Hydraulic Loading--

The ability of a soil to assimilate a specific quantity of waste is a function of many variables, including:

- Application rates
- Waste characteristics
- Soil type
- Location of water table
- Rainfall
- Evaporation.

Twelve (12) ac-in is a suggested annual application rate. The exact mostos application rate suitable to each location would have to be determined in a pilot test program. Application rates on St. Croix, for example, may be several times greater than in Puerto Rico because of the lower precipitation and higher evaporation rates. Mostos could be applied on a regular basis (1 ac-in/mo) or an equivalent schedule to cope with weather patterns. Additionally, storage facilities would have to be constructed for retention during periods of inclement weather.

The soils of the coastal plains in and around San Juan and Arecibo range from poorly to well-drained. In some areas, perched ground waters may reach the surface during the wettest portions of the year. On slightly higher ground, improved drainage characteristics would be expected. Evaporation exceeds rainfall throughout these coastal areas by about 22 in.

St. Croix, on the other hand, is semi-arid and has suffered under drought conditions for the past few years. The soils surrounding the VIRIL plant are mainly composed of the Diamond series (soil which is nearly level to moderately sloping, well drained and shallow over semi-consolidated limestone). The subsoil is about 15 percent limestone fragments. Hard limestone is at a depth of about 14 in. Evaporation exceeds rainfall by about 40 to 45 in (84).

The last four factors are site specific and while detailed examination of each is not within the scope of this preliminary study, certain general comments are applicable.

Land Requirements--

Table VII-6 presents the relationship between minimum land requirements and application rates for each of the three distilleries.

Land requirements are also directly affected by the solids content of mostos, i.e., as the solids content increases, the land requirement decreases. No attempt was made to correlate these, however, since the only practical method of increasing solids is by concentration through evaporation, implying a twofold treatment scheme.

In reality, the estimates shown in Table VII-6 must be increased somewhat to cover contingencies such as extended periods of soil saturation, equipment storage, access roads, protective runoff ditches, etc.... These considerations will be elaborated in the Conceptual Design section of this report.

Bacardi--From the data presented in Table 6 and expanded to account for the above mentioned factors, Bacardi would require 220 to 317 ac to implement a land farming program. The lower figure would correspond to an annual application rate of 18 ac-in; the higher acreage, to 12 ac-in.

TABLE VII-6. MINIMUM ESTIMATED LAND REQUIREMENTS FOR BACARDI, PUERTO RICO DISTILLERS AND VIRIL AS A FUNCTION OF APPLICATION RATES

	Land Required for Annual Application Rates of*:		
Plant	9 ac-in	12 ac-in	18 ac-in
	(acres)		
Bacardi	370	275	185
Puerto Rico Distillers	165	125	83
VIRIL	80	60	40

*Based on assumption that heavy metal content and volume produced remain constant.

Puerto Rico Distillers--Similarly, Puerto Rico Distillers would require 121 to 155 ac for the same application rate (12 ac-in/yr).

VIRIL--Land requirements for VIRIL are 62-80 ac.

CONCEPTUAL DESIGN OF A LAND FARMING PROGRAM

General

Land farming is a viable and economically feasible option for the disposal of many and varied waste forms. The following analysis presents a conceptual design of a landfarming program for each of the three distillers. Specific site information, operating data, economics, etc., are unknown. Therefore, certain engineering assumptions have been made and are documented throughout.

State agencies generally prefer land farming sites to have a maximum slope of five percent. The minimum desirable depth to groundwater is typically considered to be 15 ft, although this criterion may be modified depending on the quality and uses of groundwater and the types of overlying soils. It is also preferred that the soils be deep - greater than 4 ft - and moderately permeable. Waste and site characteristics assumed for the conceptual design are summarized in Table VII-7. The developmental design is based on land farming of mostos.

To provide cost comparisons for differing quantities of mostos disposal, the conceptual design considers three annual disposal rates: 33,100 dry Tons (Bacardi); 14,700 dry Tons (Puerto Rico Distillers); and 7,350 dry Tons (VIRIL). While these figures are only estimates, the conceptual design and resultant costs clearly show the economies of scale for the three rates considered.

A sketch of the hypothetical land farming site is shown in Figure VII-1. The topography of the site is such that slopes range from one to three percent, with an average slope of approximately two percent. The site is part of an open drainage system, which is typical of most humid regions. As a result, the movement of sediments and soluble materials from the site to neighboring water courses is possible. However, the site can be modified to control runoff.

Soils at the hypothetical site are medium textured, such as silt loam, with a clay content ranging from 10 to 25 percent and varying with depth. The soils are moderately well drained and have an available moisture holding capacity of approximately 15

TABLE VII-7. BASIS FOR CONCEPTUAL DESIGN

Waste characteristics:

- Chemical and physical characteristics as shown in Table 1
- Annual generation rates as shown in Table 2.

Site characteristics:

- Slope from 1 to 3 percent, averaging 2 percent
- Silty loam soil at least 4 ft deep
- Soils are moderately well drained, with a moisture holding capacity of approximately 15 percent
- Average precipitation of approximately 60 in/yr in Puerto Rico, and 40 in/yr in St. Croix
- At least 15 ft to groundwater.

Application rate:

- 12 ac-in (120 dry tons/ac) per year.

Site monitoring:

- Six water samples taken quarterly
  - Two surface water samples
  - Four groundwater samples
- Two soil samples taken quarterly
  - One surface 0- to 12-in depth or within plow layer
  - One subsurface 12- to 24-in depth
- Ten water quality parameters measured in each sample.

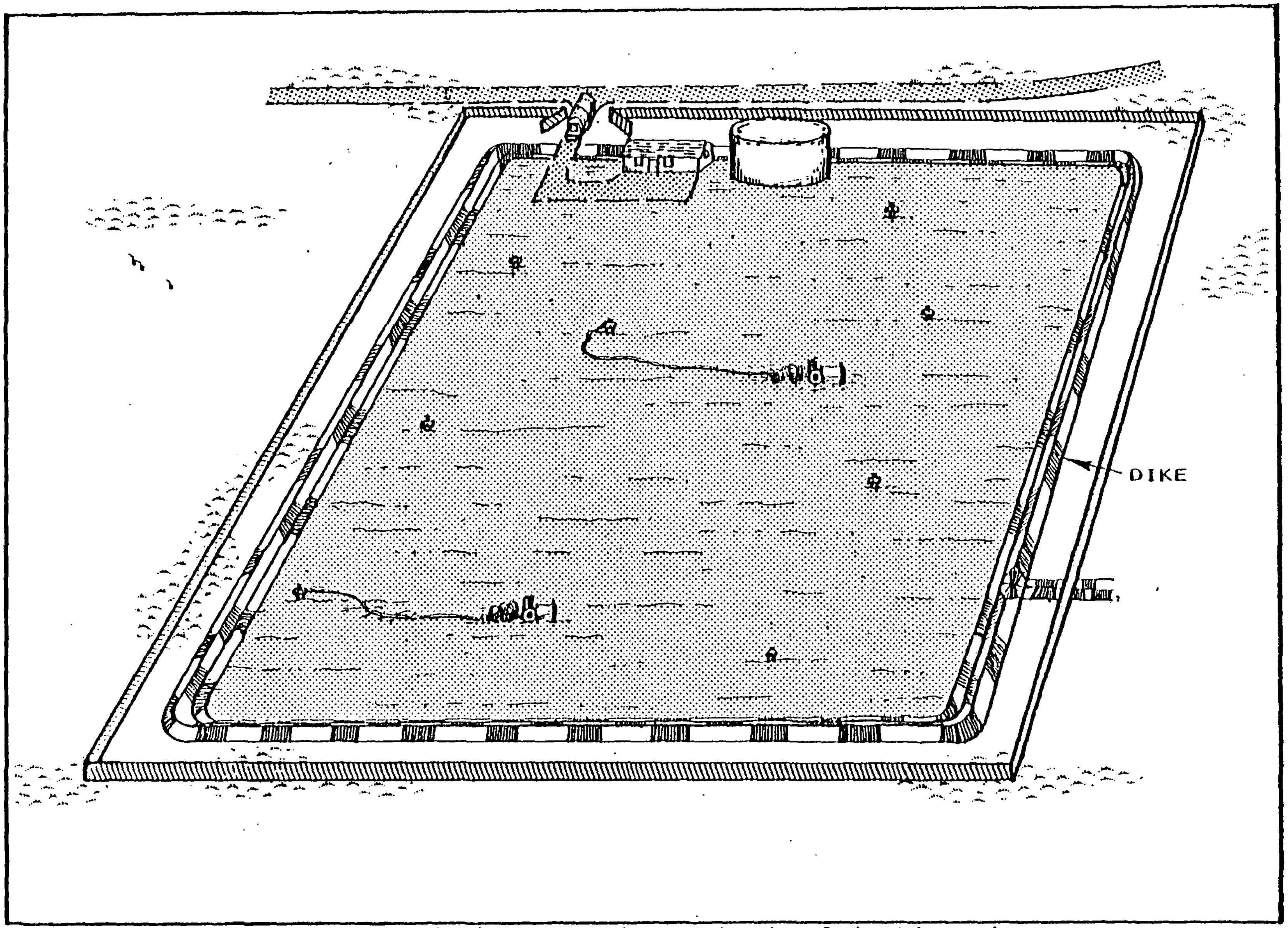

Figure VII-1. Artist's conception of land cultivation site.

percent. The site is assumed to have been cleared and used for pasture or low level agriculture for several years.

Land area required depends on the mostos application rate which normally must be determined on a case-by-case basis. The assumed mostos characteristics are such that an annual application rate of 120 dry Tons/ac is appropriate for a useful site life of 25 years. At this application rate, the productivity of the site for agricultural crops after 25 years of land farming may not be irreversibly impaired. It is preferable, however, that the site be used solely for disposal purposes; no crop is grown during or after completion of disposal operations to prevent introduction of toxic substances into the food chain. Further, from what has been presented earlier, the actual site life may be considerably larger than that calculated as evidenced by the Serrales and Bacardi, Mexico land disposal operations.

A surface and groundwater monitoring program is a necessary part of any land farming design. To adequately monitor surface water near or adjacent to a site, two samples should be taken at quarterly intervals. One sample point should be located upstream from the site and the other downstream.

The number of wells required to adequately monitor groundwater at each site depends on the complexity of the subsurface hydrology. For each hypothetical site, four wells are specified. Two wells are located at the upstream boundary of the site to establish background water quality. Two wells are located downstream from each site to establish the distribution and impact of localized contamination (if any) on water quality in the aquifer. More wells would be desirable, but cost considerations will usually indicate that a plan be developed to ensure most effective coverage with the least number of wells.

The suggested soil monitoring program entails taking 10 soil samples each at the 0 to 12 in and 12 to 24 in depths prior to the first mostos application and at quarterly intervals thereafter. The samples at each depth are composited, processed, and anlyzed. Data obtained for the soils which have received mosto can be compared with the results for the controls (samples obtained prior to first mosto application). This comparison will indicate any accumulation and the extent of vertical migration of most constituents (e.g., heavy metals) beyond the plow layer. It is recommended that the following parameters be monitored:

- Total dissolved solids (TDS) or soluble salts (EC)
- TOC
- pH
- Sulfates
- Chlorides
- Nitrate-nitrogen
- Iron
- Copper
- Potassium
- Cadmium

Other parameters of concern such as selenium, boron, and toxic organics should be included in the water and soil monitoring programs if these constituents are present in significant concentrations in the incoming mostos.

All analytical determinations can be performed by a contract laboratory.

Quarterly water sampling should be adequate for monitoring site performance. Such a sampling frequency has been typically employed by numerous land farming site operators and state regulatory agencies.

Site Design

For the purposes of the following discussion, it is assumed that the site selection process has been completed. Since each site's topography is gently sloping and relatively flat, substantial grading is not required to facilitate land farming operations. The site has been used previously for pasture or low level agriculture, so substantial clearing is unnecessary. Uncontrolled sheet runoff from the site's surface during periods of intensive rainfall could result in contamination of adjacent surface waters. For this reason, construction of a system of berms and runoff collection ditches around the site perimeter prior to initiating land farming activities is specified. This surface drainage system will eliminate standing water in the cultivated area, thereby ensuring that aerobic processes necessary for mosto decomposition are maintained.

Appropriate liming of the soil or neutralization of mosto may be necessary to maintain a soil pH between 6.5 and 7.5. Additionally, application of nitrogen fertilizer may be needed if the waste is highly carbonaceous (carbon to nitrogen ratio <30) to enhance decomposition. These parameters will have to be investigated further in a pilot plant program.

An access control fence is placed outside the disposal area's ditch/berm and within 100 ft of the site perimeter. A 30 ft gate is located where the access road enters the site.

The site includes a paved access road to an office/equipment storage building. The building is prefabricated aluminum on a cement slab, with plumbing and utility connections. A 10 x 20 ft office extension area is furnished for the attendant and includes restroom facilities. The remainder of this structure houses the cultivation equipment and is closed to the weather on three sides.

Mostos Application Procedures

Selection of an application system depends upon several factors including facilities at the distillery, transportation costs, required flexibility, capacity and regulatory agency requirements. In most instances, regulatory agencies require that wastes be covered or mixed with soil soon after application to prevent aesthetic problems and contamination of runoff waters.

Subsurface injection has proven successful in many situations. These systems are normally used with liquids in the range of 1 to 10 percent solids. Although subsurface injectors particularly the continuously operating types, can apply liquid wastes at relatively high rates, factors such as transportation methods, costs and storage facilities for inclement weather require serious consideration.

Selection of a truck- or tractor-mounted injector unit depends, to a large extent, upon the goals established for the land farming program, continuity of and access to the application site, and the quantity of waste that must be applied in a given time period. A truck-mounted unit offers the primary advantage of increased flexibility. That is, since waste is supplied from a mobile tank, the unit is essentially self-contained. It can be used both to transport and apply waste and can easily be used to service several sites. Typical productivity of truck-mounted units ranges from 30,000 to 80,000 gal/day and approximately 1,000 gal/acre per pass.

Primary advantages of the tractor-mounted unit are high productivity (200,000 to 300,00 gal/day) and high application rates (25,000 to 50,000 gal/acre per pass). Track-type tractors can operate in more adverse weather and/or soil conditions than wheel tractors or truck-mounted units. Tractor-mounted units, however, require more sophisticated controls and waste handling facilities to achieve maximum operating efficiency. Waste is supplied to the tractor-mounted injector through a long flexible hose, and a fixed liquid distribution system may also be required on the site.

Subsurface injectors normally use agricultural tillage tools (chisels or sweeps) to open cavities in the soil, allow liquid waste to flow into the cavities, and then cause the soil to bridge or cover the openings. Sweeps generally provide better covering at shallower injection depths and provide better mixing of the waste and soil. Good mixing of the waste and soil at shallow depths enhances evaporative drying, accelerates assimilation of the waste into the soil environment and practically eliminates odors, insects, and runoff problems. Further, in visual appearance, the operation seems to be a normal agricultural practice. Careful landscaping or screening of storage and other handling facilities aids in eliminating the appearance of anything aesthetically offensive.

The following detailed analysis presents two scenarios: the first utilizes a tractor-type application vehicle fed from on site (land farm) holding tanks. Mosto is transported to the site via tanker trucks. The second utilizes the same application vehicle but on site mostos is supplied via a buried pipeline.

Via Tanker Truck--

Mostos is transported between the distillery and land farming site via 6,000 gal tanker trucks. A 10-day storage tank is provided at each distillery to provide a buffer during periods of inclement weather. A further 2-day capacity storage tank is provided at each land disposal site to supply the application vehicles. Application of mostos (assumed total solids of 8.35 percent) is accomplished using a subsurface injector mounted on a crawler tractor, the discharge from which is rated at 800 gpm. Application units are fed from the storage tank through a distribution system consisting of 10-in buried cast iron pipe terminating in a hose connect. The hose is heavy-duty flex type, typically 600-700 ft in length and 4-in diameter

Table VII-8 shows the cultivation areas, quantities of mosto, and storage capabilities required for each of the three sites at the suggested 12 ac-in application rate. It is assumed that the increase in the areas shown (total) will be required for the access road, perimeter berm, buildings, runoff control facilities, and a 100-ft buffer on all sides. Figure VII-2 presents a representative profile of the site, indicating several of the key features previously discussed.

Mostos is applied on a daily basis except in extended periods of heavy precipitation during which the soil will not support the weight of the crawler tractor. It is assumed that soil applications can be made an average of 210 days/year and that application will be restricted to a one shift/day operation.

TABLE VII-8. CONCEPTUAL DESIGN WASTE AND SITE PARAMETERS

Parameters	Bacardi	Puerto Rico Distillers	VIRIL
Estimated annual volume (gal)	90,000,000	40,000,000	20,000,000
Gallons per operating field day (assume 210 working days/yr)	428,000	190,000	95,000
Estimated annual total solids disposed (@ 8.35% solids) (Tons)	33,066	14,696	7,348
Land area required (acres) (12 ac-in/yr):			
• For mostos disposal	275	125	60
• Total (including area for access road, building, ditches, buffer zone, etc.)	317	155	80
Storage tank volume at distillery with 10-day storage capacity (million gal)	4.3	1.9	1.0
Storage tank volume at land farm site with two-day storage capacity (million gal)	0.86	0.38	0.19

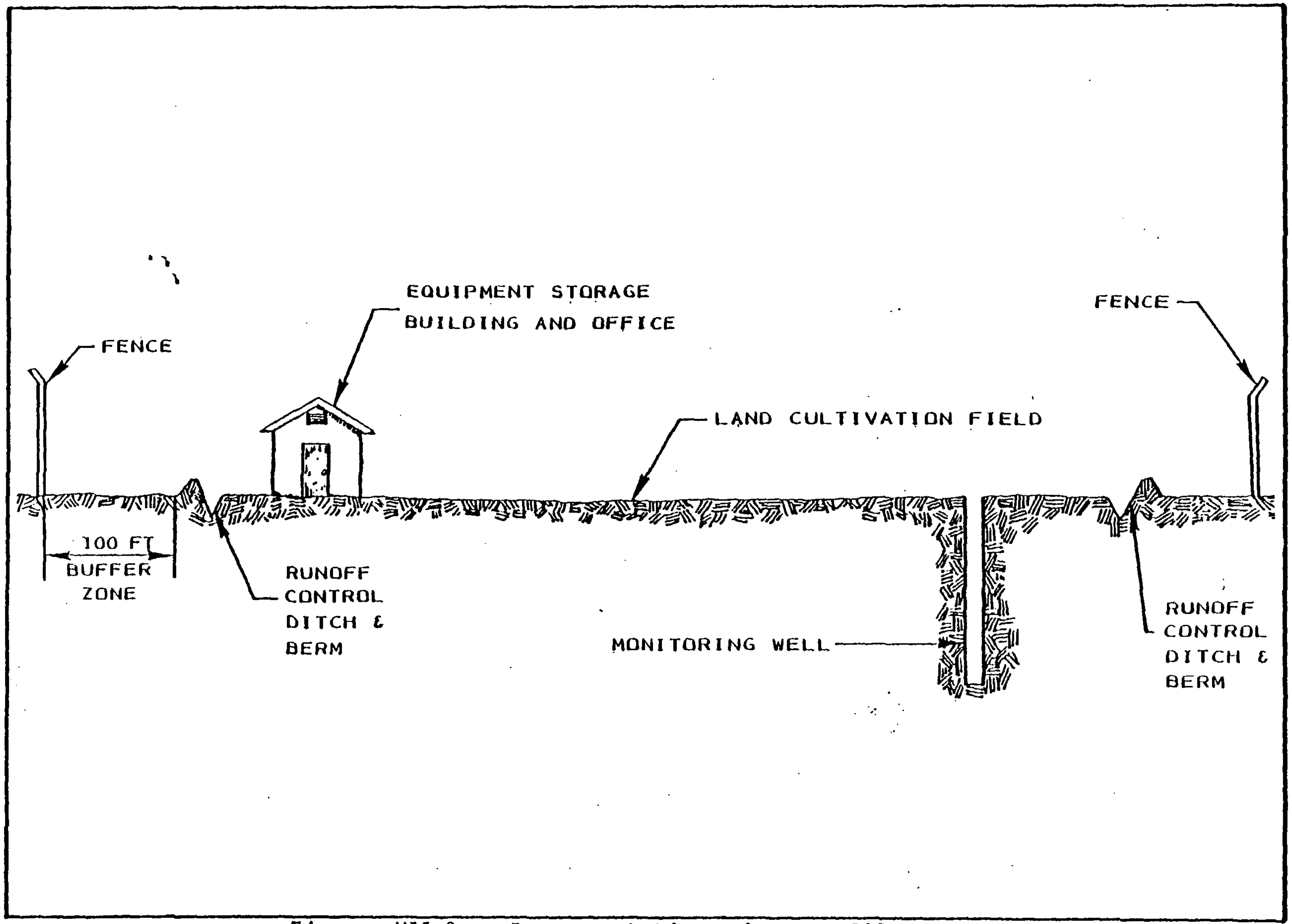

Figure VII-2. Representative site profile.

Truck transport of mostos in 6,000 gal tractors will operate on an extended (8 or more hours/day) schedule, approximately 210 days/year, (more for Bacardi) to maintain feedstock to the field. Times to load at the distillery, travel to the site, unload, and return are estimated to be (assuming site is five miles from distillery) 10, 15, 10, and 15 minutes, respectively. Further, it is estimated that this operation will be 70 percent efficient, therefore requiring a total cycle time per tanker of 71 minutes.

Based on the above (presented in Table VII-9). Bacardi will require nine tractor trucks, Puerto Rico Distillers four, and VIRIL, two. Each will require one additional cab for preventive maintenance and nonscheduled repairs. Similarly, at a rated capacity of 800 gpm, Bacardi will need two crawler-tractor application vehicles to handle their daily disposal volume; both Puerto Rico Distillers and VIRIL will require only one each. Labor requirements basically will follow the manning of equipment pieces as shown in Table VII-10.

TABLE VII-9. CONCEPTUAL DESIGN VEHICLE REQUIREMENTS FOR LAND FARMING UTILIZING TANKER TRUCKS FOR MOSTOS TRANSPORTATION

Factors	Bacardi	Puerto Rico Distillers	VIRIL
Gal/land farm operating day (gal)	428,000	190,000	95,000
Tanker loads/day land farm @ 6,000 gal per tank	72	32	16
Total cycle time for one tanker load @ 70% efficiency (min)	71	71	71
Number of tank trucks required per day assuming one shift - 10 hr/day	8.4	3.7	1.9
Actual number of tanker vehicles required:			
• Tankers	9	4	2
• Cabs	10	5	3
Number of tractor-crawler field applicators required at a capacity of 800 gal/min	2	1	1

TABLE VII-10. LABOR REQUIREMENTS FOR LAND FARMING UTILIZING TANKER TRUCKS FOR MOSTOS TRANSPORTATION

	Bacardi	Puerto Rico Distillers	VIRIL
Tanker Truck Drivers	9	4	2
Crawler-tractor Drivers	2	1	1
Full Time Mechanics	2	1	*
Foreman	1	-	-
Relief Personnel	1	-	-
Total	15	6	3

*Assume that employee assigned to crawler-tractor can substitute as a part-time mechanic.

Via Pipeline--

This scenario is similar in all respects to that presented in the previous section with the following exception: mostos is supplied to the land farm site via an 8 to 10 in diameter buried pipeline.

Mostos storage is assumed to remain the same - i.e., a ten-day capacity tank at the distillery and a two day capacity tank at the land farm site. Labor requirements, revised from Table VII-10 accordingly, are presented in Table VII-11.

TABLE VII-11. LABOR REQUIREMENTS FOR LAND FARMING UTILIZING A PIPELINE FOR MOSTOS TRANSPORTATION

	Bacardi	Puerto Rico Distillers	VIRIL
Crawler-tractor Drivers	2	1	1
Full Time Mechanics	3	2	1
Total	5	3	2

Estimated Costs for Conceptual Land Farming Site

Both capital and operating and maintenance costs are estimated.

Capital costs associated with land farming for both scenarios are presented in Tables VII-12 and VII-13. The recovery period ("useful life" or "payback" period) varies according to the type of investment. All capital costs have been annualized based on an 11 per-cent interest rate (on internal rate of return) over their

TABLE VII-12. CAPITAL COSTS FOR THREE CONCEPTUAL LAND FARMING SITES UTILIZING TANKER TRUCKS FOR MOSTOS TRANSPORTATION*

Cost Element†	Recovery Period (yr)	Bacardi		Puerto Rico Distillers		VIRIL	
		Total	Annual	Total	Annual	Total	Annual
Debt service for purchase of land @ 11% yr; based on original price of $15,000/ac		---	523,000 (317 ac)	---	255,800 (155 ac)	---	132,000 (80 ac)
Site preparation: Leveling, some clearing, surveying, design @ $300/ac	20	95,100	11,900	46,500	5,840	24,000	3,010
Site work: Fencing, buildings, roads, runoff prevention ditch @ $1,100/ac	20	349,000	43,800	171,000	21,400	88,000	11,000
Monitoring wells: 4 to 7 in wells, 60 ft deep, including pumps and casing @ $1,000/well	20	4,000	500	4,000	500	4,000	500
Storage tanks @ $.30/gal.							
• At the distillery	20	1,290,000	162,000	570,000	71,600	300,000	37,700
• At land farm		258,000	32,400	114,000	14,300	57,000	7,160

TABLE VII-12 (continued)

Cost Element	Recovery Period (yr)	Bacardi		Puerto Rico Distillers		VIRIL	
		Total	Annual	Total	Annual	Total	Annual
Field distribution system: From farm storage to field stations; includes pumps, risers, underground pipe @ $1,000/ac	10	317,000	53,800	155,000	26,300	80,000	13,600
Electrical equipment: Includes installation of power at site, transformers, controls @ $600/ac	20	190,200	23,900	93,000	11,700	48,000	6,030
Property tax and insurance @ 1.5% of in-place capital investments			35,200		16,605		8,650
Injection equipment: Includes crawler-tractor, hoses, reels, freight	10	240,000	40,000	120,000	20,400	120,000	20,400
Communication equipment	5	5,000	1,350	5,000	1,350	5,000	1,350
Subtotal		2,748,300	928,650	1,278,500	445,795	726,000	241,400

TABLE VII-12 (continued)

Cost Element	Recovery Period (yr)	Bacardi Total	Bacardi Annual	Puerto Rico Distillers Total	Puerto Rico Distillers Annual	VIRIL Total	VIRIL Annual
Tanker trucks @ $60,000/unit ($40,000-cab; $20,000-tanker)	10	580,000	98,500	280,000	47,500	180,000	30,600
Total Capital Investment		3,328,300		1,558,500		906,000	
Annual Capital Costs			1,027,150		423,295		272,000
Annual Capital Costs/Dry T			31.06		33.57		37.03
Annual Capital Costs/1,000 gal Mostos			11.41		12.33		13.60

*"Total" amounts are initial costs, "annual" amounts are for first 12 months of operation. All costs are in 1978 dollars.

†Annualized capital recovery (equal annual payments) at 11% interest rate.

TABLE VII-13. CAPITAL COSTS FOR THREE CONCEPTUAL LAND FARMING SITES UTILIZING A PIPELINE FOR MOSTOS TRANSPORTATION*

Cost Element†	Recovery Period (yr)	Bacardi		Puerto Rico Distillers		VIRIL	
		Total	Annual	Total	Annual	Total	Annual
Subtotal from Table 12		$2,748,300	$ 928,650	$1,278,500	$445,795	$ 726,000	$241,400
Pipeline: 5 mi of 6" dia. pipe, including accessories @ $13/ft	20	343,200	43,100	343,200	43,100	343,200	43,100
Pump stations: 2/site @$150,000 ea	10	300,000	51,000	300,000	51,000	200,000	51,000
Debt service for right of way lease @ $15,000/ac (11% interest)	20		16,500		16,500		16,500
Property taxes and insurance @ 1.5% of in-place capital investments			9,650		9,650		9,650
Total capital investment		$3,391,500		$1,921,700		$1,369,200	
Annual capital costs			$1,048,900		$566,045		$361,650
Annual capital costs/ dry T			$ 31.72		$ 38.52		$ 49.23
Annual capital costs/ 1,000 gal mostos			$ 11.65		$ 14.15		$ 18.08

*"Total" amounts are initial costs, "annual" amounts are for first 12 mo of operation. All costs are in 1978 dollars.

†Annualized capital recovery (equal annual payments) at 11% interest rate.

recovery period. Major capital cost categories are land, site preparation and construction, and equipment.

The estimated unit cost for land is $15,000/ac. However, land is considered an appreciating asset and as such is not considered in the same light as other investments. Rather it is shown as an annual cost in the form of debt service.

Tables VII-14 and VII-15 respectively present annual capital and operating costs for both scenarios. From the data shown, lower total annual costs are shown for pipeline transport for Bacardi and Puerto Rico Distillers. From the scenarios presented, the less expensive option to VIRIL would appear to be tanker transport. This would change, however, if VIRIL would be able to utilize the adjacent land surrounding the plant (the scenario is for a disposal site five miles from the plant.

Table VII-16 presents a summary of Tables VII-12, VII-13, VII-14 and VII-15.

In considering the foregoing analysis, however, several qualitative factors should be included when comparing the scenarios. These are:

- Social and aesthetic cost are intangible but should be considered. For example, the logistics of Bacardi hauling 70 or more daily loads (6,000 gals each) of mostos on reasonably busy roads would suggest considerable traffic congestion, noise, and possible annoyance to roadside villagers.
- Further, no costs have been included for highway and road repairs. These are difficult, at best, to calculate, but

TABLE VII-14. ANNUAL OPERATION AND MAINTENANCE COSTS FOR THREE LAND FARMING SITES UTILIZING TANKER TRUCKS FOR MOSTOS TRANSPORTATION

Cost Element	Bacardi	Puerto Rico Distillers	VIRIL
Labor @ $10/hr, including fringe benefits	$ 312,000	$ 124,800	$ 62,400
Operation and maintenance of vehicles @ 20% of capital costs; includes fuel and replacement parts	164,000	80,000	60,000
Monitoring (32 samples x 10 parameters ea @ $20/parameter plus other testing)	10,000	10,000	10,000
Annual operating costs	486,000	214,800	132,400
Annual capital costs	1,027,150	493,295	272,000
Subtotal	1,513,150	708,095	404,400
Administrative costs @ 15%	226,970	106,214	60,660
Total annual costs	1,740,120	814,309	465,060
Annual costs/dry T	52.63	55.41	63.31
Annual costs/1,000 gal mostos	19.33	20.36	23.25

TABLE VII-15. ANNUAL OPERATION AND MAINTENANCE COSTS FOR THREE LAND FARMING SITES UTILIZING A PIPELINE FOR MOSTOS TRANSPORTATION

Cost Element	Bacardi	Puerto Rico Distillers	VIRIL
Labor @ $10/hr, including fringe benefits	$ 104,000	$ 62,400	$ 41,600
Maintenance:			
• of pipeline @ 2% of capital investment	6,860	6,860	6,860
• of pump stations @ 2½% each of capital investment	7,500	7,500	7,500
Operation and maintenance:			
• of crawler-tractor vehicles @ 20% of capital investment, including exchange parts and fuel	40,000	20,000	20,000
Power and supplies for operation of pump stations @ $15,000/yr	15,000	15,000	15,000
Monitoring (see Table 14)	10,000	10,000	10,000
Annual operating costs	183,360	121,760	100,960
Annual capital costs	1,048,900	566,045	361,650
Subtotal	1,232,260	687,805	462,610
Administrative costs @ 15%	184,839	103,170	69,392
Total annual costs	$1,417,099	$790,975	$532,002
Annual cost/dry T	$ 42.86	$ 53.82	$ 72.42
Annual cost/1,000 gal mostos	$ 15.75	$ 19.77	$ 26.60

TABLE VII-16. SUMMARY OF ANNUAL CAPITAL AND OPERATING TOTAL COSTS FOR TANKER TRUCK VS. PIPELINE MOSTOS TRANSPORTATION

Cost Element	Bacardi	Puerto Rico Distillers	VIRIL
Tanker truck transportation:			
Annual capital costs/dry T	$31.06	$33.57	$37.03
Annual capital costs/1,000 gal mostos	11.41	12.33	13.60
Annual operating costs/dry T	52.63	55.41	63.31
Annual operating costs/1,000 gal mostos	19.33	20.36	23.25
Pipeline transportation:			
Annual capital costs/dry T	31.72	38.52	49.23
Annual capital costs/1,000 gal mostos	11.65	14.15	18.08
Annual operating costs/dry T	42.86	53.82	72.42
Annual operating costs/1,000 gal mostos	15.75	19.77	26.60

could become significant, especially so for roads designed for normal passenger car traffic - not fully loaded tanker trucks.

- Annual capital costs for both scenarios can be significantly reduced if the cost of land is less than shown. Additionally, long-term leases may be negotiated at a fee much less than that used for debt service.
- No costs are presented for appreciation of land values. If purchased, this land would be expected to increase in value, thus increasing the net worth of the respective purchasing companies.
- All estimated costs for the conceptual designs are based on 1978 dollars. It is to be expected that those costs will rise in the future due to inflation, but no cost projections were made because of uncertainty in the inflation rate.

The annual operating costs of mostos pipeline transport (Table VII-15) are 14 percent of the total annual costs. The same values for tanker truck transport show the annual operating costs to be 47 percent (Table VII-14). The comparison is significant since those operating dollars needed for annual support of a tanker truck fleet would be expected to increase with inflation. Total operating costs for pipeline transport are similarly subject to inflation, but would be expected to increase less in overall total dollars since they represent a smaller overall percentage of the total annual costs. The relative cost of pipeline transport, therefore, would be expected to become more economically favorable in the ensuing years, assuming that the inflation rate continues to increase.

As expected, the total unit costs shown indicate that larger land farming sites are less costly to operate on a unit cost basis than are smaller sites. For comparisons the range of unit costs on a dry weight basis for either scenario are within the range of municipal sewage sludge disposal costs typically reported.

Finally, Table VII-17 presents the effect of each scenario in terms of annual proof gallon production (1977 figures). It was assumed that production figures were 17.4, 5.2, and 3.4 million proof gallons respectively for Bacardi, Puerto Rico Distillers, and VIRIL.

TABLE VII-17. ANNUAL LAND FARMING COSTS OF MOSTOS AS A FUNCTION OF RUM PRODUCTION

	Bacardi	Puerto Rico Distillers	VIRIL
		$/proof gallon	
Scenario A - Transport via Tanker Truck	0.1000	0.1566	0.1368
Scenario B - Transport via pipeline	0.0814	0.1522	0.1565

IDENTIFICATION OF RESEARCH NEEDS

The preceeding sections have outlined the basic fundamentals of a land disposal program and have carried these through in the form of a conceptual land farm design. Throughout the discussions, certain key parameters were identified, which, if quantified, would facilitate a more detailed and precise feasibility evaluation. A pilot study would, therefore, seem a logical first step to obtain the required data. The following program describes the equipment, site preparation, mostos applications, and monitoring recommended to determine the acceptability of the landfarming practices described in the Conceptual Design section.

A prerequisite, however, to this entire program is a thorough exploration with local regulatory agencies for necessary permitting and acceptance of the concept.

Equipment Required

For the conduct of this small pilot program, it is recommended that the necessary equipment be rented, either with or without an operator. For best results, the same type of equipment which will be used for the full-scale land farm should be used for the pilot test program. This, however, is not practical in all cases, expecially so with reference to subsurface injection equipment. In lieu of not having these specialized pieces, it is recommended that conventional surface applications followed by disking be substituted. The results are generally comparable. It is anticipated that the following equipment will be required:

- Farm tank trailer (1,500 - 2,000 gal capacity) equipped with exit valve and bar or fan spreader
- Tractor
- Roto-tiller or disk (3-tier, 10 ft wide, 18 in diameter).

The program should be implemented on a small plot of land (10 to 15 ac) and should be allowed to run for 6 to 9 mo, or an equivalent time frame to cover the seasonal variations. The location of the site is preferably near either the Bacardi or Puerto Rico Distillers facility. It may be assumed with a certain degree of confidence that application rates and other parameters determined in Puerto Rico will be applicable to a similar operation on St. Croix. The opposite, however, may not be the case considering the current drought conditions of St. Croix.

The test and control plots should be constructed so that they are of equal size and are located on identical soils. A berm should be constructed around the perimeter of the test area and between the test plots to contain runoff and mosto applied within the fields.

Mostos Application

In the pilot program, mostos should be applied at rates equivalent to 6, 9, 12, 15, and 18 ac-in/yr to each of 5-two ac plots. A sixth 2-ac plot would serve as a control (no mostos would be added to this plot for the duration of the testing period). Applications can be made by filling the tank (known volume) with mostos, driving to the particular plot designated for the specific application rate, and subsequently discharging the load at a previously calculated speed equivalent to the prescribed application rate. Depending on the weather, the mostos will be allowed to dry for a few days (or more if it rains), and then mixed with the surface soils to a depth of 6 to 8 in, with a roto-tiller or tractor-pulled disk. Disking should be accomplished after each application and may have to be increased if odor problems develop.

Mostos should not be applied when the soil is excessively wet, since the equipment may get stuck in the mud and odors may possibly develop from casual ponding.

To facilitate evaluation of the pilot test program, precise records need to be maintained on the time, quantity and percent solids at which each load of mostos is applied to the plots. In addition, cultivation records need to be kept.

Monitoring

Soil characteristics and hydrogeologic data for the site should be carefully investigated. Of particular concern are such factors as permeability, soil pH, and distance to groundwater. Major environmental concerns typically, however, are soil accumulations of heavy metals and the potential for surface water contamination.

In the test program, soil samples from 0 to 1 ft, 1 to 2 ft, and 2 to 3 ft depths should be collected prior to the first mostos application. Subsequent sampling should be conducted at three-month intervals. These samples are to be analyzed for heavy metals (e.g., Cd, Pb, Cd, Zn, etc.), organic matter, total Kjeldahl N, pH, nitrate-N, chlorides, and sulfates. If these constituents show significant increases in concentration with waste application, the extent to which they build up in soil and potential for surface water contamination can be assessed.

Likewise, runoff from the plots should be collected periodically and analyzed for the above-mentioned constituents.

Odor problems, if any, are to be noted during daily inspection of the plot, particularly after spreading of the mostos and on wet days.

Of special concern is the effect of mostos on soil pH. As mentioned earlier, mosto is very acidic (pH = 4.4) and may require neutralization prior to application. Alternately, liming of the soils may be required.

VIII. EVAPORATION

Evaporation of mostos, when viewed as a treatment technology, must be examined as a function of two considerations:

- Available technology
- Disposal options for secondary products (concentrates and side waste streams).

The technology for evaporation of cane molasses stillage has been successfully demonstrated (57, 58, 59, 60). Typically, the end result of such treatment is the production of a secondary product known as condensed molasses solubles (CMS) with a solids content in excess of 50 percent.

European and United States distillers have demonstrated that CMS can be successfully marketed. Puerto Rico and the Virgin Islands, however, are islands with limited potential for domestic CMS consumption (see "Potential for CMS Use in Puerto Rico and the U.S. Virgin Islands" for a detailed discussion). An in-depth analysis of evaporation as a disposal option, therefore, will be directed toward discussions of both the technologies available to produce secondary products and the alternatives available to dispose of these (final) products.

EVAPORATION TECHNOLOGY

Much of the knowledge about the experiences of existing facilities was presented in testimony for the EPA adjudicatory hearings in the matter of NPDES permits for Puerto Rico Distillers, Schenley, and VIRIL (15, 24, 34, 87 and 57-60). Similar experience has also been reported by Bacardi (4). This testimony is assumed to be accurate and reliable. Included in the testimony are some cost estimates which are typically subjective judgements of the party offering testimony. The reader should keep in mind that these estimates are provided for general information without substantiation. Additional technological input to the various processes employed has been supplied by equipment manufacturers.

Theory, Design, and Operation

Two basic evaporation principles have successfully been utilized by the distillery industry to treat liquid waste streams - multiple effect and mechanical recompression. Within each category, various evaporator types are available to handle evaporation duties with maximum efficiency and economy. The most common types currently in use by the distillers are either plate (falling or rising film) or tubular evaporators (falling film). The following section will briefly discuss each of the above and their interrelationships.

The principle of multi-effect (ME) operations allows several single evaporation units (known as effects) to be connected in series. This system involves the multiple reuse of the heat content of steam. By this method, the energy contained in a single pound of steam may be used to evaporate anywhere from two to eight pounds of water, depending on the number of effects and the auxiliary equipment employed. Steam from a boiler enters the heating jacket in the first of a series of interconnected evaporators. This steam boils the mostos in the first evaporator and condenses in the heating jacket after it has transferred its heat content to the mostos. This condensate is returned to the boiler. The water vapor from the boiling mostos is piped to the heating jacket in the second evaporator, where it boils the mostos in that evaporator. This process is continued as many times as the number of effects in the system (3).

Mechanical vapor recompression (MVR) entails increasing the heat content of the water vapor from the evaporation process. The recompression is generally applied to the vapor from the first effect in the system, causing an increase in the heat content of the vapor and enabling it to evaporate more water per initial unit of heat input (3). Some manufacturers produce MVR evaporators only as single effect units (3).

Generally, the evaporators which would be considered for application to mostos are designed on the basis of either thin film or forced circulation principles (3, 28). Five basic evaporator designs employ the thin film principle (3):

- The falling film tubular evaporator
- The rising film tubular evaporator
- The falling film plate evaporator
- The free flow falling film evaporator.

Thin film systems are offered as single-or multiple-effect units, with or without MVR.

Forced circulation evaporators are designed for processing liquids which are susceptible to scaling or crystallizing (74,75). Two basic types are offered (3):

- The forced circulation tubular evaporator
- The forced circulation plate evaporator.

Forced circulation systems are offered as single-or multiple-effect units, and may be combined with film evaporator pre-concentrating effects. MVR can be considered with forced circulation systems, but economic considerations usually do not favor such a design (28).

The energy efficiency of an evaporation system can be increased through the use of additional effects and MVR, but only at the cost of increased capital outlays from the addition of such equipment. MVR is theoretically the most energy-efficient evaporation method (34). MVR provides its greatest energy cost savings in applications where the cost of electricity is low and the operating hours per year are relatively high.

Applicability to Mostos

Evaporation of molasses stillage is a common occurrence in Europe, but, with few exceptions, it is applied to beet instead of cane molasses stillage. Two exceptions are the Bols Distillery in the Netherlands and the Bacardi rum facility in Malaga, Spain. Bols has a four-effect evaporator of the falling film type with a separate finishing unit. This unit has been in use for four years. The Bacardi, Malaga, evaporator, designed by Vogelbusch, is a multiple-effect evaporator with forced circulation for final concentration. Multiple-effect evaporators are currently in use at the Bols Distillery in Scheidam, the Netherlands; Florida Distillers, Lake Alfred, Florida; and Bacardi, Malaga, Spain. Prior to plant closure, Standard Brands in Peekskill, New York, also utilized multiple effect evaporation.

The Bols Distillery is not specifically a rum distillery, but it produces liqueurs from the distillation of cane molasses. The differences between liqueurs and rum result from processing and formulation stages after distillation. Therefore, the composition of the raw waste discharge from the Bols Distillery is similar to that from a rum distillation plant. The equipment at the distillery is made of type 316-L stainless steel to permit cleaning with both dilute hot nitric acid, as well as with dilute hot caustic soda. Normally, four to six hours of cleaning are required out of a 24-hour operating period to remove organic and inorganic scale deposits (59).

Although Bacardi's multiple-effect evaporator at Malaga, Spain, has been in actual operation for a limited period of time, it has successfully demonstrated the evaporation of rum slops (58). Many initial scaling and fouling problems, however, were encountered. During initial start-up, one of the stages was in a continuous down-phase for cleaning.

In the United States, evaporation has been applied to beet, citrus, and cane molasses wastes from yeast, pharmaceutical, and rum manufacturing facilities (58). Standard Brands Industries (SBI) successfully operated an evaporation system at its yeast producing facility in Peekskill, New York. The primary waste stream from the facility consisted of the spent molasses slops remaining after the fermentation process in the production of yeasts. The raw material for the yeast production consisted of varying amounts of cane and beet molasses. Restrictions in the supply of beet molasses were such that SBI on occasion used only cane molasses as their raw material. Although SBI initially experienced difficulties with the evaporator when only cane molasses was used, they could evaporate cane molasses wastes by implementing some specific improvements to their system designed to reduce the scaling (58).

The Red Star Yeast Plant in Belle Chase, Louisiana, produces yeast from Brazilian cane molasses. Red Star evaporates the waste to CMS and the evaporator needs to be cleaned only once every two to three weeks (58).

Pfizer, a pharmaceutical manufacturer in Groton, Connecticut, operates a large and technologically sophisticated evaporative system for a beet molasses waste stream and only has to clean the evaporators once every two weeks using caustic soda and nitric acid (58).

Process Performance

The overall evaluation of evaporation technology is a function of several parameters, the more important of which are:

- Effect of process in reducing pollutants
- Operating efficiency of equipment
- Energy consumption.

Effect of Process in Reducing Pollutants--

According to the testimony of Erik Krabbe, Region II EPA staff consultant to the Facilities Technology Division (60), the rum producers are required by EPA to remove approximately 94 percent of their wasteload BOD_5. The Malaga, Spain, Bacardi rum plant is capable of 98.7 percent BOD_5 reduction (58). Some data from Florida Distillers in Lake Alfred, Florida, consisting of seven samples taken between May 17 and 19, 1976, showed a mean BOD_5 reduction of 96.2 percent (58). Unfortunately, the Bols Distillery does not measure BOD_5 removal.

Puerto Rico Distillers (15) has noted that the evaporation process performance at Bols and other distilleries is greatly affected by whether or not the yeast and the fermenter bottoms are removed from the mostos stream. At Bols they must be removed to prevent rapid clogging of the evaporator. Puerto Rico Distillers has also noted that these high BOD sidestreams cannot be discharged untreated to the ocean without violating the BOD_5 limits of their NPDES permit. Therefore, these yeasts and fermenter bottoms must either be discharged to a POTW (an option not available to any of the distillers - see Chapter V , "Disposal to a Public Owned Treatment Works (POTW)") or may require further treatment.

The production of CMS results in large quantities of evaporator condensate reportedly having a BOD value of 100 to 2,000 ppm (32). Supplemental biological treatment of this wastestream may, therefore, be required prior to discharge. Erik Krabbe, however, has stated that biological treatment of the evaporator condensate is not needed to meet the effluent standards required by EPA (60).

Operational Efficiency of Equipment--

From a practical standpoint, the ability to successfully evaporate mostos depends upon the nature of the input waste, the desired output, and the operating conditions to achieve this output.

It is generally accepted that the evaporation of cane molasses stillage results in more severe scaling than either beet or citrus molasses. For example, the Standard Brands operation in Peekskill, New York, was basically designed to evaporate beet molasses. Their six-stage multiple plate evaporator, when pressed into duty on only cane molasses (a condition which occurred for a two-week period when beet molasses was not available), showed evidence of even more severe scaling and fouling than normal (88). Standard Brands, in more recent operations, has switched to falling-film tube type designs (88).

Similar experiences were reported by the Zuid Nederlandse Spiritusfabriek at Delfzil, Netherlands (ZNSF) (15). This plant normally uses beet molasses, but on several occasions - two months in 1974 and one week in 1977 - the plant had to exclusively use cane molasses. On the first occasion, six to eight hours of cleaning were required after running the evaporator for 24 hours. During 1977, they were able to operate 10 to 15 hours before cleaning, a sitation which more closely approximates the Bols cycle (15).

To alleviate the fouling problems, Standard Brands was forced to modify their equipment. Their original APV-designed evaporator was not able to concentrate beyond 40-percent solids without experiencing problems. To overcome the basic design limitations, they installed a two-stage falling-film tubular evaporator to achieve final concentration to 55 percent.

Regardless of evaporator type, however, certain cleaning procedures must be employed on a regular basis to alleviate the continual build-up or inorganic and organic deposits. Typically, both nitric acid and caustic soda are employed for removal of these deposits. In cases of more severe scaling, mechanical cleaning has to be employed.

Another factor affecting efficiency is the desired solids content of the final product. Whereas CMS derived from beet molasses may be taken to 65-70° Brix, CMS from cane stillage has been generally limited to 55-60° Brix. Above this level, fouling and scaling become more pronounced and viscosity increases to a point where the final product becomes difficult to handle.

Energy Consumption--

This was discussed in the section entitled "Theory, Design, and Operation."

Pilot Installation

Bacardi has built a pilot-scale evaporation system at its distillery in Cataño, Puerto Rico, with an operating capacity of approximately 30,000 gal/day (87). Bacardi has said that if the pilot tests are successful and a method can be found for disposal of CMS, they may build a full-scale system (34). The pilot tests involve experiments with:

- Construction materials
- Pretreatment alternatives
- Cleaning cycles
- Temperature and other parameter optimization
- Condensate treatment
- CMS marketing (34).

Bacardi's pilot-scale evaporator, a two-body, three-stage type, was designed by the Dedert Corporation. The first two stages are falling film; the final is forced recirculation. The system was designed to operate on the principle of mechanical vapor recompression (MVR). Bacardi believes that this will be the best-suited evaporator for treatment of its waste from the standpoints of cost and energy savings (34).

In Puerto Rico electrical power is six times more expensive than steam energy. Therefore, Bacardi has opted to use a steam turbine power generator to drive the MVR system rather than electricity (34).

It was calculated that the Bacardi pilot MVR unit would require about 2.2 KwH/1,000 lb water removed, while the Bacardi, Malaga, multiple-effect evaporator currently requires about 112 KwH/1,000 lb water removed (57).

Bacardi will be the first to evaluate its efficiency in a rum distillery for the treatment of cane molasses.

The construction of the pilot evaporation unit was completed in August 1977, but the contractors were unable at that time to furnish the turbine for the MVR. The unit was consequently run with steam until July 1978, at which time the MVR mode became operative.

During the break-in runs, there was some evidence that scale build-up was reduced, permitting longer operation periods between cleanings. In one of the early runs, for instance, the unit developed some encrustation after 120 hr of operation, and circulation with a caustic solution did a fair job of cleaning (87). It should be noted, however, that the long lengths of the initial runs were chosen to study the outer limits of operation and may not represent the most practical production-to-cleaning cycle. Furtheremore, the ash content of the molasses used was only 10 percent, whereas the average ash content of the molasses used by Bacardi is approximately 12 percent (87).

Certain mechanical problems were also experienced during several of the test runs, but these were corrected between the runs. It was suggested that molasses pretreatment might provide a waste that would be easier to evaporate, but as of October 1978 this step has yet to be implemented (87).

The evaluations of both the evaporator and the MVR unit are forthcoming from the Bacardi Corporation, but are not anticipated until sometime after December 1, 1978. Until such a report is issued, a detailed analysis of the units' performance is not possible.

CONDENSED MOLASSES SOLUBLES (CMS) UTILIZATION AS AN ANIMAL FEED SUPPLEMENT

The term "CMS" refers to a number of different products, all of which are made from the residue of a molasses fermentation process. Molasses fermentation is involved in the production of yeast, pharmaceuticals, citric acid, monosodium glutamate, alcohol (for both industrial and beverage use), and various other products. During the manufacture of these products, the fermentable sugars contained in the molasses are consumed by microorganisms, leaving a residue which could be described as sugarless molasses. This residue is converted into CMS by evaporation until a concentration of 55 to 60 percent solids is attained (35).

The composition of CMS varies greatly depending upon the type of molasses used and, to a lesser extent, the type of fermentation process and end product involved. The single most important determining factor in the composition of CMS is whether the input material is cane or beet molasses. In addition, there is considerable variation when cane molasses is used because cane molasses varies greatly in composition, depending upon the weather and soil conditions where the cane was cultivated, the method by which the cane is harvested, and the efficiency of the sugar-refining process, of which molasses is a by-product (35).

Beet-based CMS is much more desirable as a feed additive than cane-based CMS because the protein level is much higher than that of cane--approximately 18 percent for beet as opposed to 4 to 6 percent for cane (35).

Animal feed supplements are widely employed in the raising of cattle, sheep, poultry, and other domestic animals (40). These supplements extensively utilize by-product materials such as molasses, fat, and urea (40 ,100). CMS, derived from sugar cane, sugar beet or citrus, may be substituted for part of the molasses in some animal feed supplements (35). In this manner, not only the CMS is utilized, but limited supplies of more expensive molasses are extended (35).

CMS potentially could be employed in dry supplements and liquid supplements. There are technical difficulties however, in utilizing CMS in dry and block form supplements. Little CMS (as a molasses substitute) can be used in feed blocks because technical problems related to the consistency of molasses have severely limited its incorporation into solid blocks (40). Therefore, it appears that utilization in liquid and dry feed supplements offers the most favorable potential for marketing large quantities of CMS.

Liquid supplements are available which contain a large percentage of molasses for high energy content. The molasses content of a finished liquid supplement may be as high as 70 percent by weight (solids basis). The higher the molasses concentration, the greater the stability of the liquid supplement (40).

The trend in feed supplements has been away from dry supplements to liquid forms because the latter are based on low cost non-protein nitrogen sources such as urea instead of more costly natural proteins such as soybean. Fluid materials also have certain advantages in blending, handling, and transport operations (100).

Literature Review: Feed Acceptance and Nutritional Value

Feed Acceptance--

The results of some relatively recent animal feeding experiments are summarized below.

A progressively severe condition of black and watery excrement was noted in hens which consumed rations containing more than 10 percent mostos. The appetite, weight, and appearance of the birds remained healthy although, the watery excretions stained eggs, hens, and surroundings (29).

CMS levels of 0, 1, 2.5, 5, 7.5, and 10 percent were incorporated into broiler starter diets (27). The eight-week body weights of all birds receiving CMS were numerically superior to those of the controls, with those of the 7.5 percent treatment being the highest. Daily feed intake increased as the dietary level of CMS was increased. Feed conversion efficiency was significantly lower than the control for the 7.5 percent level of supplementation (27).

Diets containing increasingly higher levels of CMS were also fed to laying hens (27). Statistical evaluation revealed a significant egg production improvement associated with the feeding of 2.5 percent or more of CMS. Egg weights and Haugh unit scores (interior egg quality) were significantly reduced when 2.5 percent or more of CMS were fed. Specific gravity of eggs (shell quality) and mortality were not significantly related to diet. There was a trend toward increasing feed intake as CMS levels were increased. The investigator concluded, on the basis of these data, that CMS appeared to be an acceptable and nutritious product for use in diets of broilers and laying hens when proper attention was given, during the diet formulation, to its overall nutrient content (27).

Under wire cage management practices, levels of cane molasses as high as 20 percent can be incorporated in a practical diet for laying hens (96). But the average poultryman in Puerto Rico has his flocks under floor management, where molasses levels over 15 percent can cause a problem with caked litter. Another factor which would limit the use of locally-produced cane molasses in commercial laying diets is its cost, when compared to that of corn or other suitable more nutritive substitutes (96). Since there is a similarity between cane molasses and CMS, this suggests an upper limit of 15 percent CMS incorporation into poultry diets.

Dried mostos (10 percent moisture) was tested as a feed ingredient (corn substitute) for laying hens (97). Above a level of 20 percent, a serious detrimental effect on egg production appeared. Average egg weight, hen weight, broken-open egg height, and shell thickness were not affected by dry mostos levels as high as 35 percent. This tended to disprove the theory that high levels of potassium, magnesium, and sulfates in the mostos could have toxic effects such as the inhibition of calcium metabolism. Most of the eggs produced by hens consuming levels of dry mostos above 15 percent were stained, and the animals themselves were soiled. The overall data indicated that in practical diets for laying hens, the level of dry mostos should not exceed 15 percent (97).

The effects of feeding three percent dried molasses distillers solubles to steers in all-grain rations was examined in Australia (39).

Spray-dried mostos has been used in cattle nutrition as a supplement in block or liquid form under grazing conditions. Incorporation in the feed caused a decrease in animal live- and carcas-weight gain and an inferior feed conversion ratio (39).

Forty Angus and Angus X Hereford yearling steers were assigned to four treatment groups in a completely randomized design for an 84-day feeding trial (2). Condensed molasses solubles were substituted in a corn-soybean meal diet at 0, 5, 10, and 15 percent on a dry weight basis. The CMS were obtained from a cane-sugar molasses distillation operation. After 56 days, steers fed 15 percent CMS were changed to the control diet due to reduced weight gain and feed efficiency. CMS at 5 and 10 percent also decreased average daily gain and feed conversion efficiency; however, dry matter intake was not influenced by treatment. At 84 days, there were no differences in average daily gain or dry matter intake for steers fed 0, 5, and 10 percent solubles, but feed conversion efficiency was reduced.

CMS had no effect on carcass quality or yield. Chemical analysis of CMS samples revealed high levels of potassium (11.6 percent, dry matter basis). CMS were judged to be less valuable than corn as an ingredient for finishing cattle. They were judged as useful when maintenance of animal weight or less than maximum gains were desired (2).

Nutritional Value--

The mean chemical composition of several cane CMS samples is presented in Table VIII-1. The inorganic ash fraction comprises approximately 30 percent of the dry matter of the CMS. Protein comprises approximately 9 percent. The potassium level is very high. An amino acid analysis of cane CMS is also presented in Table VIII-2. This data is based on the mean of only two samples but it compares well with data presented elsewhere (68) for "molasses ethyl alcohol fermentation solubles." Several of the amino acids are present in relatively high concentrations.

The quality of molasses stillage as a feed supplement is improved by desalting and replacing potassium with ammonium ion. (94, 102). There are several variations in the desalting technique but generally sulfuric acid and gypsum are added to concentrated stillage at room temperature. The potassium content is reduced by 70 percent and the ash content in dry matter by 40 to 45 percent. The content of nitrogen-containing substances is increased by 30 percent (65, 172).

Potential for CMS Use in Puerto Rico and the U.S. Virgin Islands

The preceeding section has presented data indicating that CMS can be successfully utilized when incorporated into animal feed rations at certain low percentages. This may be performed by local feed manufacturers (on the islands) or, alternately, CMS can be exported in bulk to one of several destinations -

TABLE VIII-1. MEAN CHEMICAL COMPOSITION OF CANE CMS[*]

Component	Concentration
Dry Matter (%)	52.56
Ash (%)	32.63
Crude Protein (%)	8.69
Ca (%)	2.06
P (%)	0.16
K (%)	11.59
Na (%)	0.84
Mg (%)	1.07
Fe (ppm)	1865
Mn (ppm)	71.7
Cu (ppm)	115.5
Zn (ppm	56.9

[*] Dry weight basis (2).

TABLE VIII-2. AMINO ACID ANALYSIS OF CANE CMS[*]

Amino Acid	Concentration (%)
Aspartic Acid	.791
Threonine	.125
Serine	.144
Glutamic Acid	.403
Glycine	.118
Alanine	.200
Valine	.159
Cystine (Cysteine)	.026
Methionine	.024
Isoleucine	.101
Leucine	.146
Tyrosine	.072
Phenylalanine	.086
Lysine	.089
Histidine	.046
Arginine	.069

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[*] Dry weight basis (2).

United States, South America, etc. This discussion will only consider the potential for local consumption.

Approach--

The potential for local CMS consumption is a function of both the animal population and the amount of locally formulated feed supplements. According to Soldevila the only likely vehicle for incorporating CMS into the diets of local animals is in feed concentrate prepared and sold by local commercial feed mills (73). Therefore, estimates of the potential CMS market must be dependent upon the quantities of feeds manufactured. Since agriculture is virtually non-existent on any of the three U.S. Virgin Islands, this analysis will be confined only to Puerto Rico.

A degree of uncertainty exists relative to the maximum amount of CMS that can be tolerated by cattle, swine, and poultry. Many of the feeding studies cited in The Literature Review section of this chapter have been conducted with, in some cases, mostos (either dilute or spray dried) or with CMS. These tests are not readily translatable into acceptable maximum or minimum ration levels. For the purpose of estimating CMS consumption, therefore, several levels of incorporation were used - 5, 10, and 15 percent. Fifteen percent was chosen as the maximum allowable level for feed incorporation as suggested by Dr. Soldevila's testimony (73), in which he discussed homogeneity mixing problems with liquids used as supplements to dry feed. While Dr. Soldevila's remarks were directed toward molasses incorporation, it is assumed that CMS would offer similar mixing problems. Dr. Soldevila reports that the feed mills in Puerto Rico are only incorporating five percent molasses into feed concentrate (73). Therefore, to assume a percentage of more than five percent CMS presupposes that the feed mills could change their mixing operations.

In 1975, a reported 423,057 T of animal feed were produced locally in Puerto Rico (73). Using this figure as a starting point, Table VIII-3 presents the estimated maximum annual amount of CMS which could be used at three differing levels of feed incorporation. Estimates were based, in part, in the following assumptions:

- All feed mills in Puerto Rico would incorporate CMS into their respective production
- The constituents contained in CMS are not harmful to the consuming animals up to the 15 percent maximum
- CMS is 60 percent solids, a percentage at which bacterial activity is known to be negligible (32), and was concentrated from mostos at 8.35 percent total solids.

As can be seen from Table VIII-3, roughly 50 percent of the total CMS produced could be consumed locally if utilized at the 15 percent level. This is a hypothetical maximum. In reality, the total amount of CMS consumable through feed incorporation would probably be closer to the 21,000 T shown at the 5 percent level. This allows for both marketing and diet problems, surely to be encountered when initially utilizing a waste by-product as a food supplement.

TABLE VIII-3. ESTIMATED MAXIMUM ANNUAL QUANTITIES OF CMS WHICH COULD BE INCORPORATED INTO PUERTO RICAN MIXED ANIMAL FEED*

Parameter	Incremental Subtotal	Total
	-----Tons-----	
Quantity of feed mixed in Puerto Rico		423,057
Quantity of CMS used at 5% supplement	21,153	
Quantity of CMS used at 10% supplement	42,306	
Quantity of CMS used at 15% supplement	63,459	
Total annual quantity of CMS (60% solids) produced by Bacardi, Puerto Rico Distillers, and VIRIL		114,813

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* Based on 1975 feed figures (73)

USE OF CMS AS AN INTERMEDIATE PRODUCT

Introduction

The previous section discussed the use of CMS as an end products in itself - i.e., as a potential animal feed supplement. CMS, or a similar product with lower solids content, can also be utilized as an intermediate product, from which certain by products can be recovered. Utilization of CMS as a intermediate product in the following processes will be discussed.

- Incineration - Control Parameters
- Incineration - Equipment Options
- Costs of Evaporation/Incineration
- Potassium Recovery
- Organic Fertilizer Production

Control Parameters for Incineration

Incineration of mostos may be accomplished either directly in the waste stream or after some degree of concentration. The advantage of concentration is anticipated cost savings, on both total equipment investment and operating costs. Engineers and manufacturers of incinerating equipment have been quoted as saying that it would be several times more expensive to incinerate slops directly than to pre-concentrate and then incinerate (15). Therefore, any cost-effective incineration plan is likely to include an evaporation step.

Important control parameters which should be considered are the incinerator feed solids concentration, the temperature in the reactor, and the excess air supply. Calculations performed on an analysis for a typical mostos stream indicate that autogenous combustion (combustion without the need for a continuous supply of auxiliary fuel) can take place with a feed total solids (TS) concentration as low as 35 percent (61). An analysis was not performed to determine whether auxiliary fuel was needed to initially bring the incinerator up to its normal operating temperature, or whether the CMS could serve as start-up fuel.

A TS concentration significantly above 35 percent is desirable to increase heat recovery in a waste heat boiler (61) and to decrease the size of the incinerator. A CMS concentration of about 50 percent TS seems optimum since at higher concentrations technical problems with evaporation conditions and pumping characteristics of the CMS arise (61). A further disadvantage of having a higher concentration is due to the fact that the incinerator temperature must be maintained below 700°C in order to prevent ash fusion. Pilot plant work (10) showed that with a 75 percent TS feed, maintaining the incinerator temperature below 700°C resulted in the need for higher excess air conditions. In order to supply a large amount of excess air, a larger sized reactor is required than would otherwise be necessary.

The need for maintaining the incinerator temperature below 700°C is due to the low melting point of the inorganic salts contained in the waste. In general, the need to strictly control the temperature causes difficulty in attaining the correct balance of operating conditions for a suitable combustion temperature with a complete combustion of volatiles (61). The difficulty of stabilizing the operating conditions is accentuated by variations in the organic and inorganic composition of the waste.

The variability in the waste composition is related to the variations in the molasses raw material. Molasses is a by-product of the sugar industry and is affected by variations in the original sugar cane source, in the sugar processing, and in the sugar mill efficiency. Its characteristics, accordingly, vary widely and cannot be completely predetermined or controlled by the rum producers. Bacardi Corporation, especially, because of its large volume of product, must rely on many molasses sources.

Several variations in types of incineration systems are available, as each manufacturer tends to have their own innovations. Few of these have been applied specifically to rum wastes. However, wastes produced in the paper manufacturing industry which are somewhat similar to rum slops, but containing sodium rather than potassium salts, have been concentrated and fully oxidized in a conventionally operated fluidized bed incinerator (61). In 1915 rum slops were concentrated and incinerated in the Porion Furnace and a system was later developed by Whitaker (117) and U.S. Industrial Chemicals, Inc. (4a, 43). During the early 1940's Reich (83) carried out experiments in low temperature carbonization retorts at 343°C for the production of carbon and potash. Further work was carried out in the distillery of the Dyer Meaking Breweries Ltd., in Lucknow, India, in 1960 with a pilot-scale multiple hearth-type incinerator (10).

Kujala, et al. (61) have described an alternative to a conventional fluidized bed incinerator, consisting of using the fluidized bed reactor as a gasifier and performing the after burning in an after combustion chamber which is linked to a waste heat boiler. Apparently, the advantage of this type of system over a conventional single reactor system is that it alleviates the difficulty of maintaining the proper balance of operating conditions for a suitable combustion temperature while obtaining a complete combustion of volatiles. In the alternative fluidized system, the temperature in the gasifier is regulated below the melting point of the ash, but is sufficient for the volatilization of organic materials. Gases and volatilized organics are separated from ash and are fully oxidized in the after combustion chamber at a temperature which need not be below the ash fusion point. Several incineration systems are manufactured which utilize this same principle, having a primary and secondary combustion chamber. Most of these however, are not of the fluidized bed type, and therefore, do not require a cyclone separator for ash separation. By providing near-complete combustion of gases and organics in the secondary chamber, they have the ability to minimize air pollution. In fact, some of them reduce pollutant emissions to the extent that the systems can be installed without scrubbers. Combustion systems based on this design are called controlled air incinerators.

Costs of Evaporation and Incineration

The costs of evaporation alone have been discussed previously under "Evaporation Technology." The same cost considerations apply here. In addition, in a combined evaporation and incineration system there is an interrelationship between heat recovery during incineration and fuel costs for evaporation. An attempt to determine the costs of an evaporation and incineration system depends to a great extent on the accuracy of information with regard to fuel consumption for both processes and on the potential for the recovery and use of heat energy in place of fuel. Accurate information on the net energy requirements for evaporation and incineration of rum slops is lacking.

George H. Dorion of Bacardi Corporation has evaluated project designs for two types of incineration systems (34). The first, the Copeland system, is a modified type of fluidized bed system. It involves pre-concentration of mostos to 34° Brix. During pilot tests with this method, auxiliary fuel was necessary to sustain incineration. It was possible to incinerate 48 gal of slops/gal of fuel during the best test run. The investment cost for this system was estimated at $1,075,000 for a unit processing 73,000 gal mostos/day. The operating cost/1,000 gal slops was estimated at $20.00.

A second system, the Prenco incineration system, was evaluated and pilot tested. Being a liquid incineration system, it required auxiliary fuel because of the low BTU/gal available from mostos. The investment cost was estimated at $476,000 for a 33,600 gal mostos/day. The estimated operating cost/1,000 gal mostos was $24.40

Neither the Prenco nor the Copeland system designs were based on maximum waste heat recovery, and neither included costs for air pollution control or ash handling. Efficient waste heat recovery would be expected to lower the net costs of treatment, while air pollution control and ash handling requirements would raise them.

Puerto Rico Distillers has estimated costs for evaporation followed by a Brulé Incinerator (15) which include costs for ash handling and air pollution control, but again do not include the savings possible with efficient heat recovery. These costs are much higher on a per gallons basis than Bacardi's estimates for the Prenco and Copeland systems. This is suprising because the former system involved production of CMS (50° Brix), while the two latter systems did not. Puerto Rico Distillers has stated that manufacturers who quoted them incineration equipment costs agreed that it would be several times less expensive to incinerate CMS than the dilute slops (15). Yet the estimated capital expense of an evaporation and incineration system was $4,655,000 for a 223,200 gal mostos/day; and the operating cost was estimated at $47.00/1,000 gal slops. The corresponding breakdown of costs, allocated $400,760/yr for fuel oil for incineration (of a total direct cost for incineration of $579,440). This fuel oil cost is based on 1.268 mil gal/yr at $0.32/gal. This allocation is extremely high, amounting to 5,283 gal fuel oil/day. In addition, $284,400 was allocated for fuel oil for evaporation, or 3,750 gal/day. In total, 9,033 gal fuel/day were allocated for evaporation and incineration, equivalent to 25 gal slops treated/gal fuel. In contrast, the Copeland system described earlier indicated that it was possible to treat as much as 48 gal mostos/gal fuel. Puerto Rico Distiller's estimate should be at least as low as 48 gal slops/gal fuel; and in fact with the type of system proposed by Bacardi, fuel for incineration should be minimal except during start-up. While it is not possible to calculate the amount of fuel required, it is estimated that approximately 1,000 gal fuel would be a maximum requirement for incinerator start-up. Assuming that CMS is autogenous, auxiliary fuel consumption to sustain combustion should be minimal as compared to Puerto Rico Distillers' estimate of 5,283 gal/day.

Potassium Recovery from Incinerator Ash

Evaporation and subsequent incineration is expensive in terms of plant investment and operating costs. Therefore, it is essential to obtain a return on the capital expenditure if possible. The incinerator ash is itself a by-product which has a potential value as a fertilizer component; however, by means of further processing a more purified product may command a higher market price.

The incinerator ash is basically a crude potash containing potassium salts and impurities such as calcium and magnesium salts, silica, traces of iron and manganese, and unburned carbonaceous particles (61). Ash has been reported to contain 37 percent potassium (expressed as K_2O) (59, 16). According to Kujala, et al. (61) potassium salts generally should comprise 65 to 70 percent of the ash. Expressed as a percentage of the ash, the composition of salts is typically K_2SO_4, 56 percent; KCl, 7.0 percent; and K_2CO_3, 5.0 percent. Some investigators (37) have reported K_2CO_3 contents of as high as 50 to 60 percent, with only 15 percent K_2SO_4, and 10 percent KCl.

The use of incinerator ash as fertilizer component, in conjunction with nitrogen- and phosphorus-rich chemicals, is practiced at Izumi, Japan (24). A plant belonging to the Japanese Ministry of International Trade and Industry producing nonbeverage alcohol incinerates some of its CMS. The ash is a fine slate gray powder which is crushed in a mill and then sold to a dealer. The dealer resells it as such or, more often, mixes it with other materials to make a fertilizer. The plant reportedly sells the ash for about $21/t and the dealer resells it for about twice that price, or still higher if it is converted to a fertilizer.

Work on the recovery of potassium salts has taken place in India (10, 61). A 90 gal/hr pilot plant consisting of evaporation, incineration, and potassium salt recovery was constructed at one of the Indian rum distilleries. Fresh slops were neutralized with lime to pH 7.0, filtered in a filter press, and fed to an evaporator through a heat exchanger. CMS at 75 percent dry solids was produced and fed to an incinerator where it was ashed. The ash was removed and leached with water for the dissolution of all the potassium salts. The solution was filtered and neutralized with sulfuric acid to convert the carbonates to sulfates. The neutralized liquor was concentrated in an evaporator to 25 to 30 percent dry solids. Potassium salts were crystallized out from the concentrate in a screw trough crystallizer. A basket centrifuge followed for separating suspended crystals from magma. The crystals were then dried and bagged, while the magma was reused in the process. The finished product contained 83 percent potassium sulfate; 9 percent potassium chloride with traces of sodium salts; and 8 percent moisture. A flow diagram of the entire potassium salt recovery process is shown in Figure VIII-1.

Based on this research, it was estimated that a distillery producing 72,000 gal rum slops/day could recovery 3.85 ton/day of potassium salts (expressed as K_2O). At 1964 prices for potassic fertilizers, the cost of the treatment plant could be recovered in an estimated 5 to 6 yr from the sale of the by-product (10).

Kujala, et al. (61) state that the factory selling price for a refined potassium salt by-product could be on the order of $200/t within a few years. They report that there are indications that world resources of potassium salts, essential in N/P/K fertilizer formulations, are tending to reach a finite limit in availability, with anticipated future shortfalls in supply. Kujala, et al. (61) state that potassium for fertilizer needs is normally sold as KCl with a smaller market for

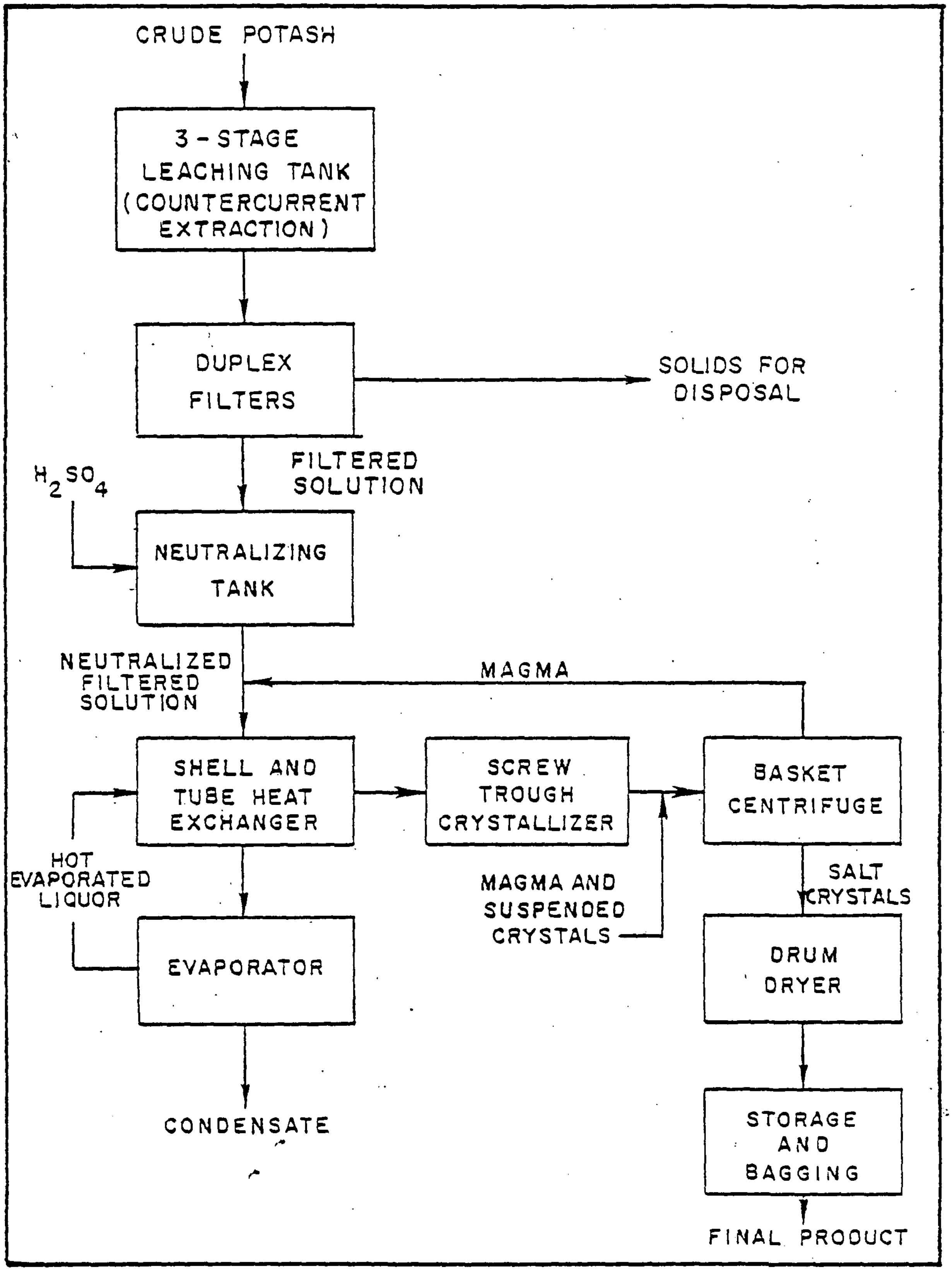

Figure VIII-1. Potassium Salt Recovery From Crude Potash.

K_2SO_4 (the major potassium salt recoverable from rum slops). With certain crops and in many tropical areas where soil salinity levels are high, the chloride ion is undesirable and sulfate of potash is preferred. Quite often, these areas are to be found where sugar cane is grown.

The market for potassium salts available to the Puerto Rican and Virgin Islands rum producers is uncertain. Table VIII-4 presents estimated potassium production figures based on the following assumptions:

- Incinerator ash is produced at the rate of 0.2 lb ash/gal of 8.35° Brix mostos
- Ash is 55 percent total potassium salts (37 percent expressed as K_2O).

Of the total estimated annual production of 15,000 T, 5,550 T (expressed as K_2O) would be available for potential use as a fertilizer source. To place this figure in proper prospective, the potential local market for potassium needs must be examined.

Table VIII-5 presents the annual average consumption of potassium chloride and other potassium salts by direct application (not mixed with other nutrients) in Puerto Rico over the period 1965 to 1975 (109).

TABLE VIII-4. ESTIMATED ANNUAL POTASSIUM PRODUCTION AS AN INCINERATION BY-PRODUCT

	Bacardi	Puerto Rico Distillers	VIRIL	Totals
Daily Generation of Mostos (gals/day)	300,000	200,000	100,000	600,000
Operating days/yr	300	200	200	--
Ash Production (T/yr)	9,000	4,000	2,000	15,000
Potassium Production (T/yr) (Expressed as K_2O)	3,330	1,480	740	5,550
Remaining Residue to be Disposed (T/yr)	5,670	2,520	1,260	9,450

TABLE VIII-5. PUERTO RICAN ANNUAL COMMERCIAL CONSUMPTION OF POTASH AND POTASSIUM COMPOUNDS IN DIRECT APPLICATION MATERIALS*

Potassium Product		Annual Average Consumption (Tons)†
Potassium Chloride, 50-62% Grade (expressed as KCl)		1,110
Other Forms		586
	Total	1,696

* (109)

† Based on 1965 to 1975 consumption figures.

Assuming that the bulk of KCl is in the normal 60 percent grade, the 1,110 T would be equivalent to 802 T (expressed as K_2O). Similarly, if the "Other Forms" are predominately K_2SO_4, the 586 T could be translatable into 318 T expressed as K_2O. The estimated K_2O total of 1,120 T (802 +318) can then be compared to the hypothetical production total of 5,550 T (Table VIII-1). As can be seen, production would exceed current use by roughly five times. Assuming that local consumption would not increase, the difference would have to be exported at a presumed price disadvantage.

Organic Fertilizer Production from CMS

Molasses alcohol stillage contains considerable amounts of organic materials including amino acids, proteins, saccharides, gum materials, etc. Kyowa Hakko Kogya Co., Ltd., of Tokyo and

Hofu, Japan, has developed a process for creating an organic complex N-P-K fertilizer from stillage by converting the organic components to humic acid (24). The humic acid forms an organic complexing agent to which inorganic nutrients are coupled. This coupling controls the release of the nutrients for plant growth. Consequently, the damages caused by high concentrations of nutrients often seen in inorganic chemical fertilizers are minimized.

Kyowa Hakko Kogyo Co. obtains sugarcane molasses in Japan and from Indochina, the Philippines, and Taiwan. The cane molasses is converted into alcohol and is used in the production of pharmaceuticals and other products at Hofu, Japan (24). The company has performed experiments (44) which revealed significant damage to germinating plants when untreated cane molasses stillage was applied to the soil. However, if the stillage was treated with mineral acids, the damage was essentially eliminated. The damage was apparently caused by organic acids contained in the untreated stillage or by the acids formed in the soil from the sugar component of the stillage. By treating with mineral acids, the low molecular weight organic compounds were dehydrated, condensated, and converted to humic acid.

A procedure for producing fertilizer from stillage involving evaporation to CMS prior to subsequent treatment steps was developed. A pilot program using a plate-type triple effect evaporator with a capacity of 15 t/hr was conducted. Later, actual operation was set up at Hofu with the installation of 6 triple effect evaporators, each with a capacity of 33 t/hr (44).

With five of these evaporators, the Hofu plant has produced approximately 140,000 t/yr fertilizer (24). The evaporators produce CMS with approximately 50 percent total solids. In the fertilizer plant, sulfuric acid is added to adjust pH. The mixture is then heated to about 110°C for 8 to 10 hr as it is passed through a series of six - 300 gal reactors. Ammonia is added to achieve a pH of 4 to 5. Finally, phosphoric acid and potassium sulfate are added to adjust the composition of the final fertilizer. The resulting mixture has a soupy consistency. An agglomeration process then follows, resulting in a granulated but moist product. The granules are dried in a direct-fired (with heavy oil) rotary kiln which is about 6 ft in diameter and 70 ft long. Treatment of the exhaust gasses from the rotary kiln is required. The dried granules are cooled and put through a vibrating sifter to obtain the final product. A flow diagram for this process, is shown in Figure VIII-2.

The final product has the desirable characteristics of being homogeneous, granulated, and available in several grades. It has been commercially sold for $212 to $220/t in Japan. A U.S. selling price of $160/t was proposed (24). Kyowa Hakko Kogyo Co. advised that this type of fertilizer production was not a break even proposition unless annual quantities were in excess of 10,000 t/yr (24). They estimated that if VIRIL were to employ this process, their annual production of fertilizer would be approximately 7,000 t. Assuming that this estimate was based on a yearly production figure of approximately 3.4 million proof

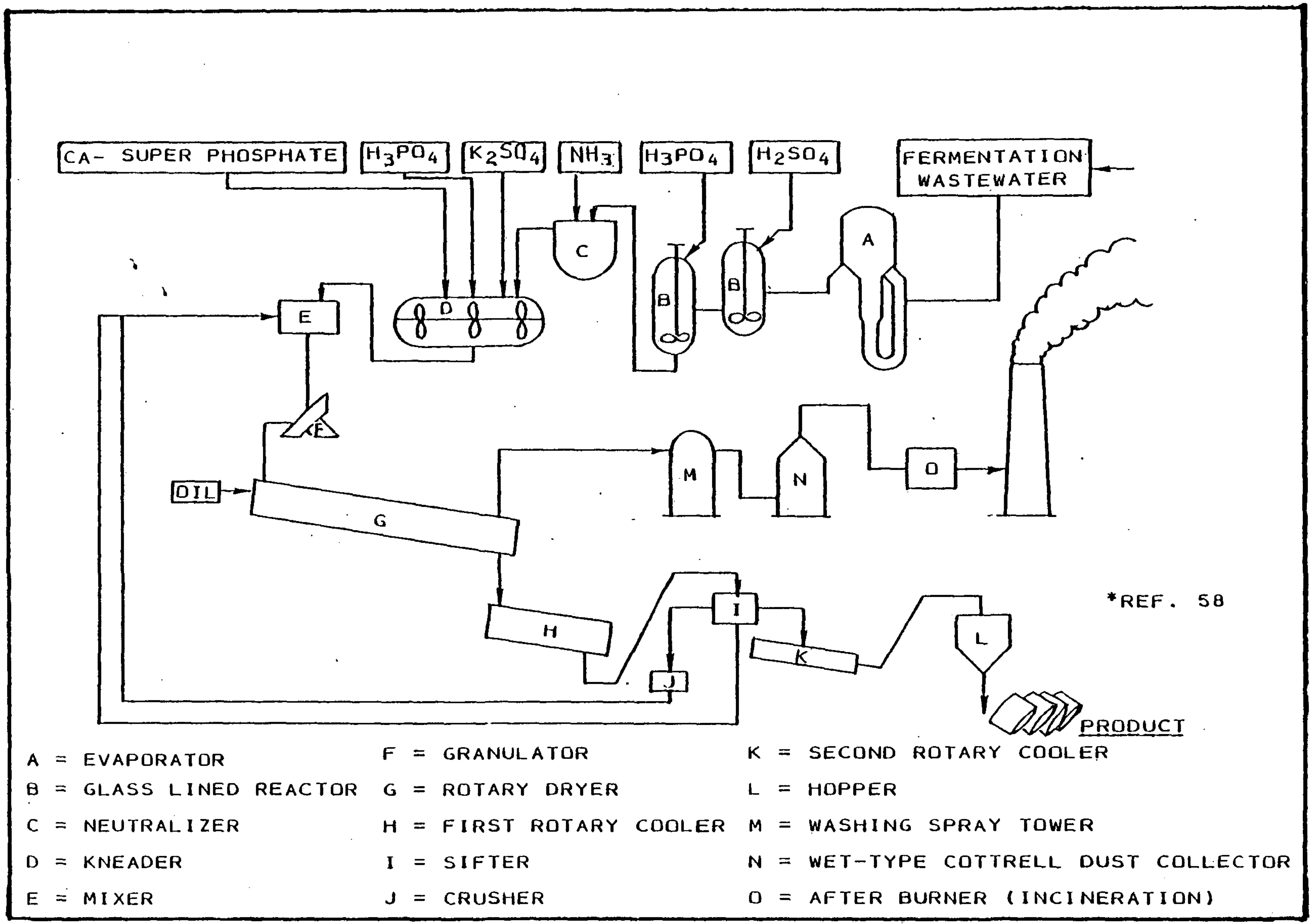

Figure VIII-2. Process Flow Diagram for the Production of An Organic Compound Fertilizer* gallons, organic fertilizer estimates for Bacardi (17.4 million proof gallons) and Puerto Rico Distillers (5.2 million proof gallons(would be 35,800 and 10,700 t, respectively.

IX. POLLUTANT REDUCTION THROUGH PROCESS MODIFICATIONS

There are several process modification options available to the rum distillers which, if implemented, would effect partial reductions of certain pollutants. Those of significant importance are:

- Pretreatment of molasses prior to fermentation
- Removal and recovery of yeast from fermenter beer
- Removal of fermenter bottoms
- Recovery of fusel oils and "heads" as a fuel supplement.

These are all options which the permittees have indicated that they could implement quickly, i.e., within 6 mo to 1 yr (80). Unfortunately, together, these methods are expected to give a maximum BOD_5 reduction of only 18 percent and TSS removals of slightly more than 65 percent (80). The BOD_5 reduction is so low because only the insoluble solids are affected by these methods, and approximately 80 percent of the waste BOD_5 is in soluble form (93). Nevertheless, these options may be considered as feasible because of the relative ease of implementation, the possibilities for recovery of valuable by-products, and the positive effects on subsequent mostos treatment options.

PRETREATMENT OF MOLASSES

Molasses pretreatment clarifies and pasteurizes the raw molasses, removing gums, sludges, salts, and unwanted microorganisms. These components tend to inhibit the yeast activity and, if not removed, will become unfermentable solids in the bottoms of the fermentation tanks (61).

Molasses pretreatment may be achieved by diluting molasses to approximately 40^0 Brix and raising the temperature close to the boiling point, when, due to the inverted solubility of the calcium salts, mainly calcium sulfate, maximum sedimentation occurs. Under these heated conditions, separation can be carried out in large settling tanks or by use of an ejecting-type molasses clarifier. After clarification, heat recovery is possible by exchange with the incoming, freshly-diluted 40^0 Brix molasses (61).

Molasses pretreatment has important side benefits. Clarification and pasteurization of the molasses substrate yields a cleaner alcohol; consequently, the purifying column in the distillation unit requires fewer stoppages for descaling, and reduction in the build-up of sludges in the boiling column permits longer operating runs. Most importantly, from the standpoint of effluent treatment, the slops coming from the stills are cleaner and would be expected to cause less scaling of mechanical treatment equipment, e.g., evaporation units (61).

However, there is a large energy committment and capital expense involved in molasses pretreatment (80, 67). In addition, there is reportedly some loss of fermentable sugars (80). This is more of a problem as molasses becomes more expensive, there being a trade-off between benefits gained from pretreatment versus sugar losses (decreased rum yields).

A partial pretreatment of molasses can be effected simply by dilution and then centrifugation. Some distillers prefer this method, which does not involve heating, or forced sedimentation (67, 80). Without heating, however, neither pasteurization of the molasses nor precipitation of calcium salts is achieved. Figure IX-1 presents a typical molasses centrifugation operation.

YEAST RECOVERY

Yeast may be eliminated from the fermenter beer by centrifugation (Figure IX-2). The centrifuged yeast may then be recycled for further use in the fermenters, sold for an animal feedstuff (with or without drying), or land disposed.

The Bols Distillery in Scheidam, The Netherlands, practices yeast centrifugation and recycling (24). Yeast used in the fermentation is removed from the beer by a Westphalia centrifuge and is recycled. The separated yeast is acidulated with hydrochloric acid to a pH of 1.8 to 2.0 to prevent spoilage during storage. When needed again for fermentation, sodium hydroxide is added to produce a yeast cream of pH ~5, which reportedly has a total solids content of 10 percent and contains 45 percent protein and 3 percent P_2O_5. Urea and phosphorus are added as nutrients; fermentation is accomplished in about 12 hr. The yeast is continuously recycled for 3 to 4 mo, at which time it is discarded to the local sewer system (24).

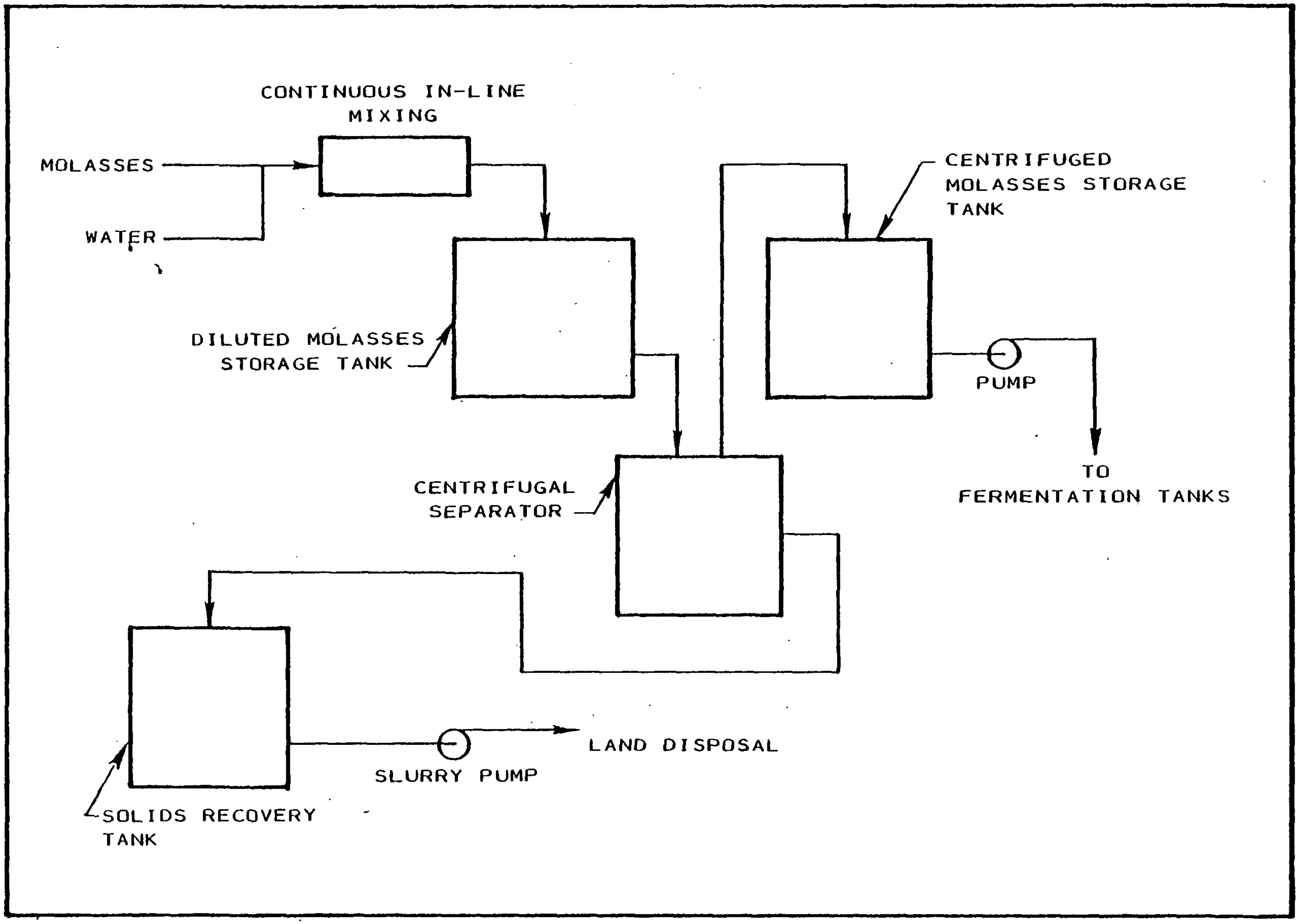

Figure IX-1. Molasses centrifugation (80).

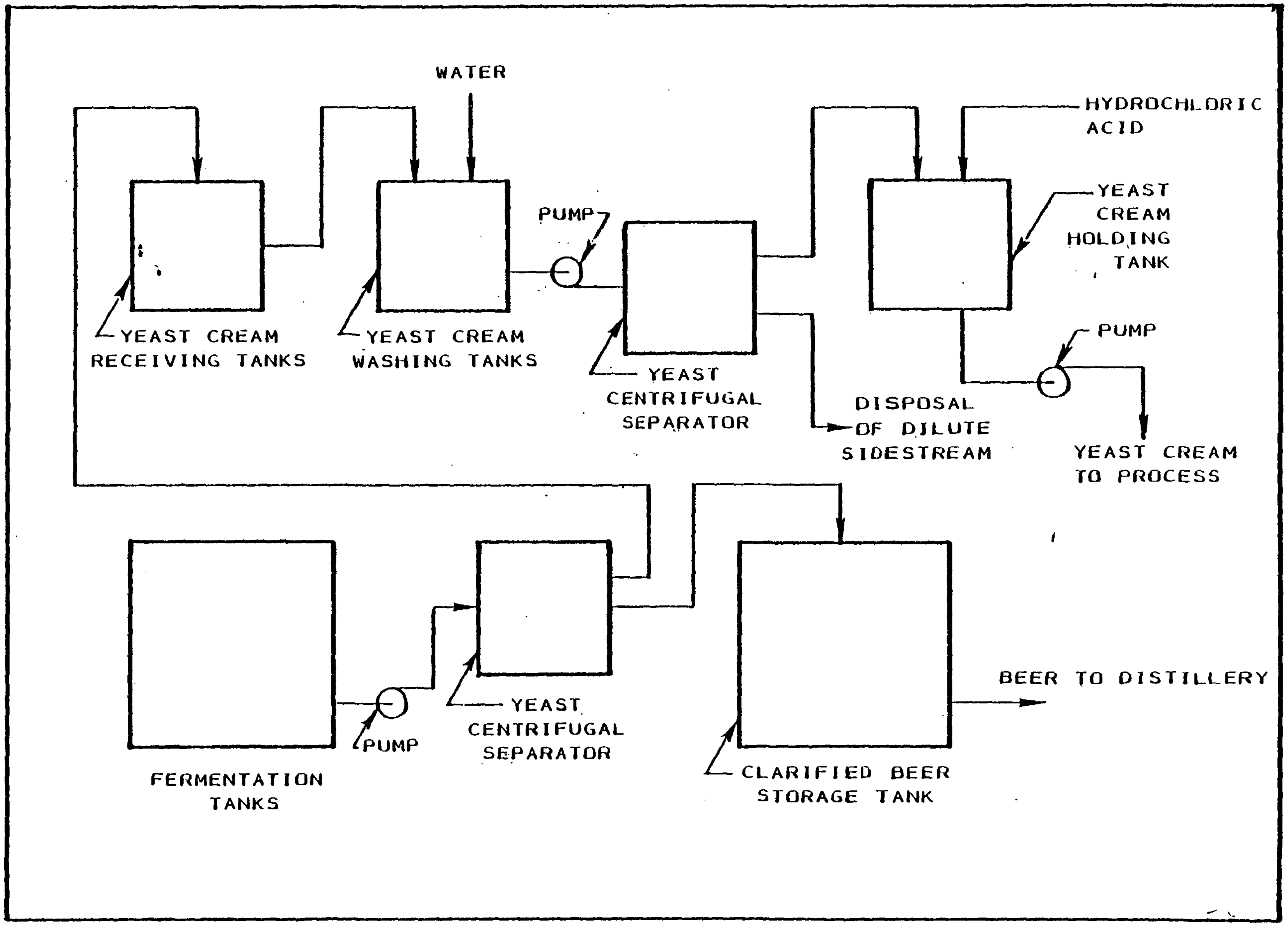

Figure IX-2. Yeast recycling by centrifugation of fermenter beer (80).

The advantages of yeast recycling are reported to include:

- Shorter fermentation times (61)
- Increased alcohol yield (61)
- Greatly diminished demand for new bakers' yeast
- Short technology implementation time (80)
- Less clogging of evaporation equipment used for treatment of mostos (24)
- Reduction of the amount of yeast requiring disposal to a small amount that is wasted (80)
- Suitability of the wasted yeast for land application or use as an animal feedstuff
- Availability of an alternative option for by-product recovery: sale of yeast as a high-protein animal feed supplement.

Possible disadvantages of yeast recycling include:

- Requirement for molasses pretreatment (61, 67)
- Unknown and perhaps undesirable effects of molasses pretreatment on alcohol yield and/or quality (67, 80)
- Production of higher temperatures in the fermenter, possibly necessitating installation of a fermenter chiller (80)
- Requirement of land disposal of molasses pretreatment residue and wasted yeast.

A particular version of yeast recycling is known as the Melle-Boinet technique. With this technique, fermentation times can be shortened to 14 hr, with up to a 5 percent increase in alcohol yield, according to Kujala, et al. (61); without yeast recycling, fermentation times can take 24 to 72 hr (36).

With this technique, a high yeast concentration is maintained in the fermenter and cell reproduction is almost eliminated, transforming sugars previously used for yeast growth into alcohol. Providing the yeast is handled properly and biological infections in the fermentation are controlled, it can be recycled up to 30 times before an appreciable loss in activity occurs (61).

Use of the Melle-Boinet technique in industrial spirits manufacture can only be made where molasses has first been pasteurized and pretreated to remove components which inhibit the yeast (61). Therefore, there is the risk that sugar losses will offset any gain in alcohol production from increased efficiency of sugar utilization.

REMOVAL OF FERMENTER BOTTOMS

Distilleries have the option of eliminating suspended inorganic and organic materials (other than the live yeast) which could become part of the rum slops in either of two ways: by molasses pretreatment, which has already been discussed, or by the removal of fermenter bottoms.

Fermenter bottoms are the unfermentable solids and dead yeast cells which settle to the bottom of a fermentation tank. The sludge is both inorganic and organic, being derived mainly from the impurities of the original molasses. Fermenter bottom sludge is minimized if molasses pretreatment is practiced; otherwise, several hundred gallons per fermentation tank of a high BOD sludge is formed (61). When fermentation ceases, the liquid containing the live yeast cells is drained off for yeast recovery and/or distillation and the bottom sludge must be washed out of the tanks before they are reused for fermentation. A schematic flow diagram which shows how fermenter bottoms are removed is included as Figure IX-3.

It has been the practice at many distilleries to either run this material down a sewer or to dispose of it with the slops. An alternative is removal via a sludge pump to a holding tank and then land disposal (80). It is generally accepted that this material cannot be treated with the rum slops due to its effect on mechanical equipment, especially evaporation equipment (15, 24).

The advantages of removal of fermenter bottoms over molasses pretreatment are reported to be lower capital and operating (energy) costs and higher alcohol yields (80, 67). If yeast recycling is practiced, however, alcohol yields may, in fact, be higher with molasses pretreatment (61).

RECOVERY OF FUSEL OILS AND "HEADS"

The "heads" are the aldehydes and esters which are drawn off the top of the second distilling column, the aldehyde column. The fusel oils and amyl oils are separated in a third column, the rectifying column. To recover these streams as fuel, they are pumped from the distilling columns to a storage tank and then to a second burner installed in the plants' boiler.

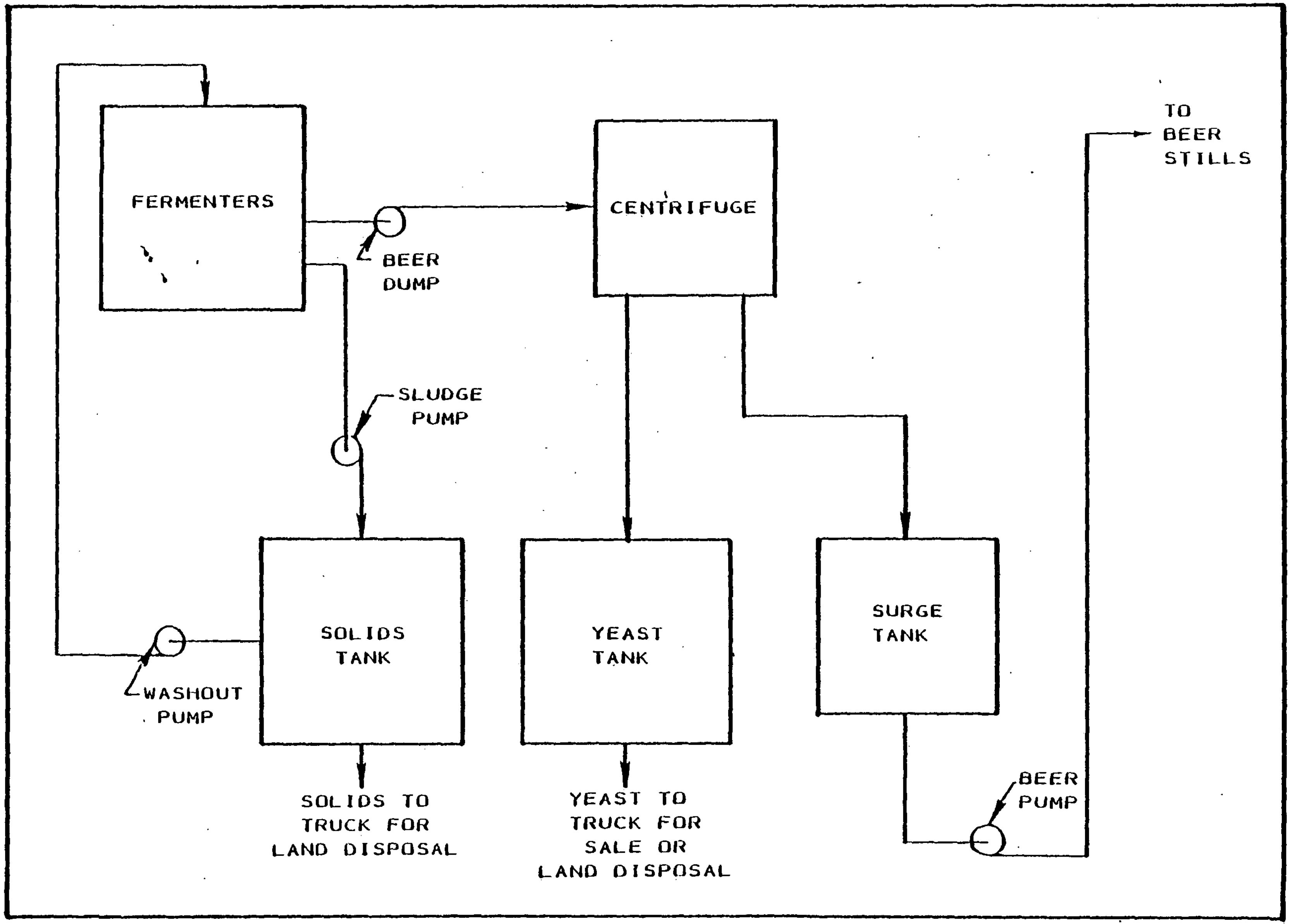

Figure IX-3. Removal of fermenter bottoms and yeast (80).

Both VIRIL and Puerto Rico Distillers already recover fusel oils and heads and burn them as fuel on a continuous basis. The heads and fusel oils would otherwise become part of the waste load requiring treatment.

COST

Cost estimates from Puerto Rico Distillers and VIRIL (80) for some of the options which have been discussed are presented in Table IX-1. Estimates were available for the removal of fermenter bottoms, centrifugation of molasses, yeast recycling (without molasses pretreatment), and burning of fusel oils and heads. Cost breakdowns for each are given in Appendix IX-11 (80). Except for the estimate for oil burning, none of these estimates incorporate any cost savings due to by-product recovery, or to positive impacts on rum production or waste treatment. Such savings could be considerable.

TABLE IX-1. COST ESTIMATES FOR POLLUTANT REDUCTION THROUGH PROCESS MODIFICATIONS, FROM PUERTO RICO DISTILLERS AND VIRIL* (80)

Process	Puerto Rico Distillers Capital	Puerto Rico Distillers Annual	VIRIL Capital	VIRIL Annual
Removal of Fermenter Bottoms	$50,000	$38,260	$58,000	$26,840
Yeast Recycling by Centrifugation	$200,000	$77,150	$232,000	$87,660
Molasses Centrifugation	$110,000	$59,585	N/A†	N/A
Burning of Fusel Oils and Heads	$15,000	$0#	$11,500	$0

*Submitted January 30, 1978.
†N/A = Not available.
#Assumed to be offset by fuel savings.

TABLE IX-2. BREAKDOWN OF COST ESTIMATES FOR POLLUTANT REDUCTION THROUGH PROCESS MODIFICATIONS, FROM PUERTO RICO DISTILLERS AND VIRIL (80)*

REMOVAL OF FERMENTER BOTTOMS (VIRIL)

Capital Costs

Solids tank	$15,000
Pumps, piping and electrical	$15,000
Structural	$8,000
Dump truck	$20,000
Total	$58,000

Annual Operating Costs

Depreciation	$5,800
Maintenance	$1,740
Labor	$12,000
Electricity	$1,500
Financing	$5,800
Total	$26,840

REMOVAL OF FERMENTER BOTTOMS (PUERTO RICO DISTILLERS)

Capital Costs

Pit tank	$2,000
Slurry pump	$3,000
Thickeners	$10,000
Water storage tank	$5,000
Water pump	$1,500
Piping, rearrangment of fermenters, etc.	$3,500
Dump truck	$20,000
Electrical installation, etc.	$2,000
Contingencies	$3,000
Total	$50,000

Annual Operating Costs (Direct)

Transportation and dumping of decanted slurry	$14,400
Subtotal	$14,400

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*Submitted January 30, 1978.

Table IX-2 (continued)

Annual Operating Costs (Indirect)

Repairs and maintenance	$2,500
Property tax	$1,200
Truck license	$400
Depreciation	
Truck	$4,000
Other equipment	$3,000
Insurance	$500
Payroll benefits (40% in statutory and corporate benefits)	$5,760
Financing	$4,500
Contingencies	$2,000
Subtotal	$23,860
Total	$38,260

CENTRIFUGATION OF FERMENTER BEER (PUERTO RICO DISTILLERS)

Capital Costs

Centrifuges (2)	$120,000
Centrifuged mash receiving tank	$18,000
Centrifuge feed pumps (2)	$6,000
Yeast cream receiving tanks (2)	$5,000
Yeast cream pump	$3,000
Yeast washing tank	$3,000
pH controller	$4,000
Piping, valves, electrical, installation, etc.	$10,000
Engineering consulting fees	$25,000*
Contingencies	$6,000
Total	$200,000

Annual Operating Costs (Direct)

Labor (1 laborer)	$8,280
Chemicals	$4,000
Electric power	$5,000
Subtotal	$17,280

Annual Operating Costs (Indirect)

Repairs and Maintenance	$5,000
Property Tax	$7,860
Depreciation	$20,000
Insurance	$700
Payroll Benefits (40% in statutory and corporate benefits)	$3,310

Table IX-2 (continued)

Financing	$18,000
Contingencies	$5,000
Subtotal	$59,870
Total	$77,150

*For study of yeast recycling following centrifugation.

CENTRIFUGATION OF FERMENTER BEER (VIRIL)

Capital Costs

Centrifuges (2) (Sharples Model P-3400)	$160,000
Electric generators	$50,000
Pumps, piping and electrical	$10,000
Structural	$12,000
Total	$232,000

Annual Operating Costs

Depreciation	$23,200
Maintenance	$4,860
Labor	$6,000
Electricity	$30,400
Financing	$23,200
Total	$87,660

CENTRIFUGATION OF MOLASSES (PUERTO RICO DISTILLERS)

Capital Costs

Molasses diluting	$5,000
Mixer, in line	$5,000
Centrifuge	$60,000
Solids recovery tank	$2,000
Centrifuged molasses tank	$5,000
Pump for 60° Brix molasses	$3,000
Piping, valves, eletrical installation, etc.	$4,000
Dump truck	$20,000
Slurry pump	$3,000
Contingencies	$3,000
Total	$110,000

Annual Operating Costs (Direct)

Transportation and dumping slurry	$14,400
Electric power	$3,000
Subtotal	$17,400

Table IX-2 (continued)

Annual Operating Costs (Indirect)	
Repairs and Maintenance	$3,000
Property tax	$4,325
Depreciation	
Truck	$4,000
Other equipment	$9,000
Insurance	$800
Truck license	$400
Payroll Benefits (40% in statutory and corporate benefits)	$5,760
Financing	$9,900
Contingencies	$5,000
Subtotal	$42,185
Total	$59,585
BURNING OF FUSEL OILS AND HEADS (PUERTO RICO DISTILLERS)	
Capital Costs	
Storage tank	$5,000
Pump	$1,500
Burner	$3,500
Piping and installation	$3,000
Other	$2,000
Total	$15,000
BURNING OF FUSEL OILS AND HEADS (VIRIL)	
Capital Costs	
Storage tank	$5,000
Burner	$2,500
Pump and piping	$4,000
Total	$11,500

X. AQUACULTURE

INTRODUCTION

The fermentation and distillation of rum from cane molasses produces relatively large quantities of hot acidic wastes, high in BOD, COD, solids, and Kjeldahl nitrogen (80). Presently, these wastes are disposed of untreated to inshore waters off Puerto Rico and St. Croix, Virgin Islands. In an effort to develop a satisfactory solution to the problem of rum slops disposal, the rum distillers have given more attention to evaluating aquaculture as a method for utilizing these wastes. Aquaculture has the advantages of requiring little or no pretreatment of the effluent, considerable potential for recycling nutrients from the waste into a harvestable crop, and providing acceptable levels of predischarge treatment.

In concept, the advantages of aquaculture are numerous; however, several obstacles stand between the concept and its practical application. Currently, there is limited knowledge of the manner in which rum slops can best be used in an aquaculture project, and what species or chain of species leading to a harvestable crop can utilize the slops efficiently. Questions as to the physical facility requirements, whether these facilities can be located in reasonable proximity to the rum distilleries, and what the projected capital and operating costs would be are still unanswered.

PREVIOUS RESEARCH IN MOSTOS UTILIZATION BY AQUATIC ORGANISMS

The industry has solicited proposals for research into mostos utilization in aquaculture in an effort to answer these questions. A preliminary proposal for a feasibility study was received from Dr. Colin E. Nash, Oceanic Institute, Makapuu Point, Waimanalo, Hawaii (80). A draft proposal was also solicited and received from Dr. Oswald A. Roels, University of Texas Marine Science Institute, Port Aransas Marine Laboratory (80). Dr. Roels has previous experience with an aquaculture project on St. Croix, although this earlier study did not involve mostos. Dr. Roels has proposed to analyze the nutritive value of slops which will, in turn, aid in the selection of an organism or organisms suitable for treating and recycling each component of the waste. Selection of suitable organisms will be based on the following criteria:

- Potential for removal of dissolved inorganic nitrogen and/or phosphate
- Removal of particulate protein and carbohydrate
- Removal of soluble protein and carbohydrate through culturing of unicellular heterotrophs. These, in turn, may be harvested and used directly as a protein source or fed to a higher trophic level aquatic organism.

Determination of tolerance levels to various concentrations of mostos and the ability of test organisms to grow and provide satisfactory waste treatment will also be investigated. Finally, Dr. Roels's study would attempt to provide preliminary data on the input requirements and potential yields of aquaculture systems.

The University of Puerto Rico is actively involved in aquaculture research. The principal objective of their studies has been to discover additional sources of protein-rich foods for human consumption in Puerto Rico. Most of the current research concerns the growth of the fresh-water fish, Tilapia aurea. Only one study utilizing mostos wastes has been conducted. This study investigated the effects of mostos on Tilapia aurea under culture conditions and on the water quality of the culture system (80).

A method for efficiently breeding and culturing fish, shellfish, and zooplankton with waste cane molasses has been developed by Kawano, et al (53). Applicability of this research to potential mostos aquaculture experiments, however, is questionable due to an inadequate description of the waste molasses used in Kawano, et al, studies. Characteristics of the waste molasses and its similarities to mostos are not provided in the patent information filed by the authors (53).

Tosteson, et al (107) have conducted numerous studies with mostos to determine its effect on marine organisms. Their work examined four components of mostos:

- Filtered crude mostos suspension (Fraction F1)
- Crude mostos dialyzed against distilled water (Fraction F2)
- Precipitate formed by the addition of three volumes of cold ethyl alcohol to crude mostos fraction (Fraction F3)
- Fraction of crude mostos soluble in cold ethyl alcohol (Fraction F4).

In their experiments, they used cultures of the marine algae *Chlorella vulgaris*, and isolated the marine bacterium *Photobacterium fischer* from sea water. Their results indicated the following:

- Fraction F1 appeared to promote the growth of marine bacteria while inhibiting that of micro-algal cells. The crude mostos fraction may have inhibited the algal growth by acting directly on the cells or by simply promoting the growth of bacteria in the algal suspensions.
- Nondialyzable high molecular weight components of Fraction 2 promoted the growth of algae and inhibited bacterial growth. This suggested that the alcohol-treated material (Fractions 3 and 4) promoted both the growth of the algae and the bacteria.
- The inhibitory effect of Fraction F1 on algal growth appeared to be due to the presence of low molecular weight components which were removed by dialysis. These dialyzable materials at high concentrations appeared to stimulate bacterial growth while obscuring the inhibitory effects of high molecular weight material.
- The crude mostos fraction (F1) contained materials of high molecular weight that were stimulators to micro-algal growth; however, the presence of dialyzable low molecular weight substances in this same fraction promoted greater bacterial growth which, in turn, restricted or inhibited algal growth.

POTENTIAL FOR UTILIZATION OF NUTRIENTS

SCS Engineers contacted two noted authorities in aquaculture research for information on the potential for utilization of mostos in crustacean and higher organism aquaculture systems; Dr. Douglas Conklin, Associate Director of the Aquaculture Program, Bodega Marine Laboratry of the University of California, and Dr. Michael Hartman, Division of Natural Sciences, Savanah State College, Georgia. Copies of their correspondence are included in Appendix A. Both agreed that the mostos material was not adaptable as a feed ingredient in aquaculture systems. Their evaluation was based on several factors including the following:

- The BOD and COD are very high indicating that the mostos is very high in organic carbon compounds.
- High carbon content is further substantiated by high carbohydrate content.
- Presence of significant amounts of carbon compounds will enhance growth of heterotrophic bacteria. These bacteria can create situations of lowered dissolved oxygen, as well as destroy the bacterial flora of a biological filter system,should a system of this type be in use as part of the treatment process.
- Levels of copper in mostos (average 32.8 ppm) are toxic to most shellfish and acutely toxic to the larval stages.
- Potential for bioaccumulation of copper and other metals by aquatic organisms may be considerable considering concentrations available.

Although additional research is needed in this area, the information currently available in the literature and from individuals active in this research field suggests that mostos is unsuitable for aquaculture systems.

XI. BIOLOGICAL TREATMENT SYSTEMS

INTRODUCTION

Biological treatment of rum slops has long been a proposed solution to the rum waste disposal problem (11). However, the consistently high BOD_5 has not favored aerobic treatment, and the effluent from anaerobic treatment has been demonstrated to be high in BOD_5 (2,000 to 10,000 mg/ℓ). Consequently, research has been directed at the use of combinations of biological systems (mainly anaerobic followed by aerobic processes) for the treatment of rum slops.

AEROBIC TREATMENT OF MOSTOS

A review of the literature indicates that the application of conventional aerobic processes (activated sludge or trickling filters) is beset by problems. In general, the literature reports that to be amenable to aerobic treatment the raw mostos would first have to be cooled to a temperature range conducive to mesophillic organisms (25 to 35°C), neutralized to pH 7.0-8.0, and have supplemental nutrients added (phosphorus and/or nitrogen).

Sen, et al. (92), reported that trickling filter treatment of undiluted molasses distillery waste was found to remove 75 percent of the BOD_5. A large filter area was needed due to the high concentration of BOD_5 in undiluted slops (18,000 to 50,000 mg/ℓ) and the low BOD_5 loading rate that can be applied to the filter. The process was dismissed as inapplicable because of the space required by the filters.

Burnett (19) reported that the activated sludge process was unsatisfactory when used with a 10 percent solution of rum slops in domestic sewage. The maximum BOD_5 removal observed was 28 percent. Also, difficulties were caused by extensive foaming. However, the investigator found that the activated sludge process was highly efficient for the treatment of one percent slops in domestic sewage. Over 90 percent efficiency in BOD_5 and suspended solids removal was observed.

Kujala, et al. (61), estimated that in 1972 the cost for operating an activated sludge treatment plant for an incoming slops stream of 35,000 mg/ℓ BOD_5 at a flow of 1,000 m^3/day (0.26 MGD) would exceed $2.5 million per annum. Space requirements for the installation and the electrical loads for the necessary aeration equipment were estimated to be large. Consequently, the authors rejected activated sludge treatment of the raw slops on economic grounds.

ANAEROBIC TREATMENT OF MOSTOS

Anaerobic digestion has been widely investigated as a method for the treatment of molasses distilling mostos, and has been found to be a partially effective treatment alternative. Anaerobic digestion has the ability to handle the raw undiluted slops without the problems associated with aerobic biological treatment, e.g., sludge bulking. Various designed and operational methods for anaerobic digestion of mostos have been researched. The findings will be presented on the following pages.

Sen, et al., conducted experiments on laboratory scale anaerobic digestion of molasses distillery mostos in India (92). They found that it was possible to carry out anaerobic digestion of the waste at 37°C using a cow manure seed at a BOD_5 loading of 3.0 $kg/m^3/day$ with a retention period of 10 days. The digestion gave an off-gas to waste volume ratio of 25:1, with an overall efficiency of 0.86 m^3 of gas per kg of BOD_5 digested. The gas was 60 percent methane. BOD_5 removals of more than 90 percent were obtained with a BOD_5 reduction from about 30,000 mg/ℓ to less than 1,000 mg/ℓ. Digester failure was experienced at a loading of 3.8 $kg/m^3/day$ with a retention time of eight days. Nutrient addition was found to be unnecessary. Recirculation of CO_2 after separation from other constituents of the digester gas was more effective than mechanical stirring or recirculation of the entire digester gas in improving BOD_5 and volatile solids reduction and the percentage of methane in the gas.

Shea, et al., in a study for the EPA investigated an anaerobic digestion pilot plant for the determination of design criteria for the full-scale application of anaerobic treatment and to estimate the full-scale costs for such a process (93). The pilot system gave a COD removal efficiency of 57 to 70 percent at a solids retention time greater than 40 days. The influent mostos stream contained 70,000 to 100,000 mg/ℓ. The range of total annual costs (including amortization and operating and maintenance costs) was estimated to vary from \$3.74/m^3 treated at a design flow of 190 m^3/day to \$2.13/m^3 treated at a design flow of 1,140 m^3/day (January 1974 cost levels). The recovery of methane gas as an energy by-product of the anaerobic treatment was estimated to reduce the above-mentioned unit treatment costs from one-third at the 190-m^3/day flow rate to two-thirds at the 1,140-m^3/day flow. It was also concluded that additional treatment would be required to meet the proposed effluent quality levels as defined in the distillery's respective NPDES permits.

Basu and Leclerc compared the treatment of beet molasses distillery mostos by thermophilic and mesophilic anaerobic digestion (9). This research determined that gas production was less consistent in conventional digestion when compared to units with the thermophilic or mesophilic digestion. This was attributed to the loss of gas during settling and entrained in effluent solutions. Digester loading had no direct bearing on gas production, and instead was related to retention time. The efficiency of rate of methane production during high rate digestion was related to CO_2 recirculation, as shown by Sen and Bhaskaran (92), or to efficient mechanical stirring.

All the experiments were done with 10 days retention time at varying BOD loadings of 2.0, 2.5, 3.2, and 3.5 kg/m^3/day. The thermophilic digestion BOD removal for the first three loadings were 97.2, 95.7, and 87.5 percent respectively, as against corresponding removals of 96.0, 96.4, and 95.9 percent BOD removal for mesophilic digestion. Both thermophilic and mesophilic digestion exhibited digester upset at the 3.5 kg BOD/m^3/day loading. Basu and Leclerc concluded that, taking all aspects into consideration, thermophilic digestion performs as well as mesophilic digestion, but the process yields only minor benefits at the expense of higher costs needed to maintain the digester at 55°C rather than 35°C (9).

Hiatt, et al., found that the start-up and initial acclimatization period was very significant in the anaerobic treatment of mostos (48). They determined that nearly three months were required for the biological system to acclimatize itself to a new substrate. After stabilization, a change in the loading rate required 10 to 15 days for a return to normal operating conditions. Dilution varied the COD loading rate by between 2.7 to 11.5 $kg/m^3/day$. The COD reduction was between 70 and 80 percent. The greatest COD reduction (75 to 80 percent) was found with loadings in the 2.7 to 4.8 $kg/m^3/day$ range.

Additional references concerning anaerobic digestion of rum mostos are included in the bibliography.

In conclusion, the properties associated with anaerobic treatment of rum distillery mostos are:

- The loading rate upper limits (before digester upset) for undiluted mostos are approximately 3.2 kg $BOD/m^3/day$ and 6.0 to 10.0 kg $COD/m^3/day$.
- Dilution with municipal wastewater improves digester performance and stability and adds valuable nutrients.
- The anaerobic digester for optimum performance must be fed an equalized waste stream.

- Recirculating CO_2 gas (scrubbed to remove H_2S) and/or mechanical agitation of the digester contents improves the organic matter removal efficiency of the digester and can lower the retention time necessary for treatment.
- The retention time for anaerobic digestion could be as short as 5.6 days, although normal performance requires about 10 days.
- Volatile acid production must be controlled by either chemical addition or by dilution with other wastewater.
- Gas production is approximately 55 to 65 percent methane and 45 to 55 percent carbon dioxide.
- The effluent from anaerobic digesters treating rum distillery mostos must have some form of additional treatment to meet the proposed NPDES limitations.

ANAEROBIC/AEROBIC SYSTEMS

Cosculluela, in Cuba, investigated a biological system for the treatment of molasses distillery waste (11). His studies ran for a period of three years. Cosculluela recommended that mostos be diluted four times with water, mixed with a bacterial culture rich in ammonifying organisms, and then digested in an open concrete tank for a period of four days. He suggested that the effluent then be passed through biological filters for additional stability.

Recent research in Russia and Poland has indicated the feasibility of biological systems for the treatment of molasses fermenting and distilling wastes. In Russia, stillage was treated by anaerobic fermentation which reduced the initial BOD_T of greater than 10 g/ℓ by 90 percent. This anaerobic effluent was adjusted to BOD_T 800 to 1,300 mg/ℓ by dilution with municipal wastewater and treated by activated sludge to give an effluent of BOD_T 24 to 60 mg/ℓ, and COD 180 to 240 mg/ℓ (114). In Poland, spent molasses from feed yeast production with a BOD_5 of 12,870 mg/ℓ and a pH of 4.4 were anaerobically fermented and then treated by the activated sludge process. Without phosphate nutrient addition the effluent from the system had a BOD_5 of 70 to 600 mg/ℓ; with phosphate addition the effluent BOD_5 concentration was 75 to 300 mg/ℓ (106).

Bhaskaran (10) reported that laboratory-scale anaerobic digestion reduced the BOD_5 of molasses distillery slops from about 30,000 mg/ℓ to the order of 1,000 mg/ℓ. The BOD-to-nitrogen ratio of the digested slops effluent indicated that it was suitable for activated sludge treatment. In the laboratory, activated sludge was built up by aerating sewage for a number of days. The activated sludge was then gradually acclimatized to the digester effluent. When stable conditions of operation were established, the results showed that aeration for 8 hr effected 93 percent BOD_5 removal and yielded an effluent with 63 mg/ℓ BOD_5.

THE ANAMET PROCESS

A proprietary biological system has been developed in Sweden incorporating anaerobic and aerobic treatment. This process, the

Anamet process, differs from other biological systems in that it has all of the following characteristics:

1. Use of a closed tank for the anaerobic stage rather than an open pond.
2. Recovery of methane gas for reuse as fuel.
3. Recycle of digester sludge within the anaerobic process after separation from the digester effluent.
4. Recycle of waste-activated sludge to the digester.
5. Optional nitrogen stripping with recovery of ammonium salts.

Other biological systems may have some of these characteristics, but Anamet necessarily has all of them.

Applicability to Rum Wastes

The rights to the Anamet process are held by the Swedish engineering firm of AB Sorigona, located in Staffanstorp, Sweden. Anamet was developed especially to handle wastes from fermentation and food industries, rich in carbohydrates and nitrogen compounds. Anamet has not been used to treat rum distillery wastes, but it is in full-scale operation at four beet sugar refineries and one potato alcohol distillery in Sweden. The process has also been in use for approximately two months on a pilot plant basis at a beet molasses alcohol distillery in Belgium (99). According to representatives of Sorigona, the results of existing Anamet plants have been excellent, with BOD_5 reductions of up to 99 percent being achieved. After visiting the facilities of Puerto Rico Distillers and laboratory testing of the mostos, Sorigona's representatives expressed the belief that mostos could be treated successfully with Anamet (49). Subsequently, a pilot plant was constructed and began operating in July of 1978. The plant has a rated capacity of about 6,000 ℓ/day, or 0.7 percent of the total waste flow. Initial tests were begun with a 25-percent-by-volume digester seed of digested municipal sludge. Preliminary results are not yet available from this operation.

Equipment and Design

The equipment used and the design of Anamet plants vary with different wastewaters and with the required final BOD (99). Figure XI-1 presents a typical Anamet system. The anaerobic step is carried out in a steel tank. The tank has a side-mounted stirrer for mixing and to keep the sludge suspended. It also has a sedimentation zone in which sludge is separated from the wastewater and retained. From the top of the tank, methane gas is drawn off to a gas supply. The pH and temperature are optimized for the anaerobic conversion of the wastes into methane gas.

The aerobic step is carried out as an activated sludge process in a concrete basin or pond. Aeration is performed by surface aerators or in cold climates by submerged aerators.

Sedimentation of aerobic sludge and final clarification of the wastewater are carried out in a horizontal thickener with rakes or in other suitable equipment. Waste sludge is pumped to the anaerobic tank for stabilization.

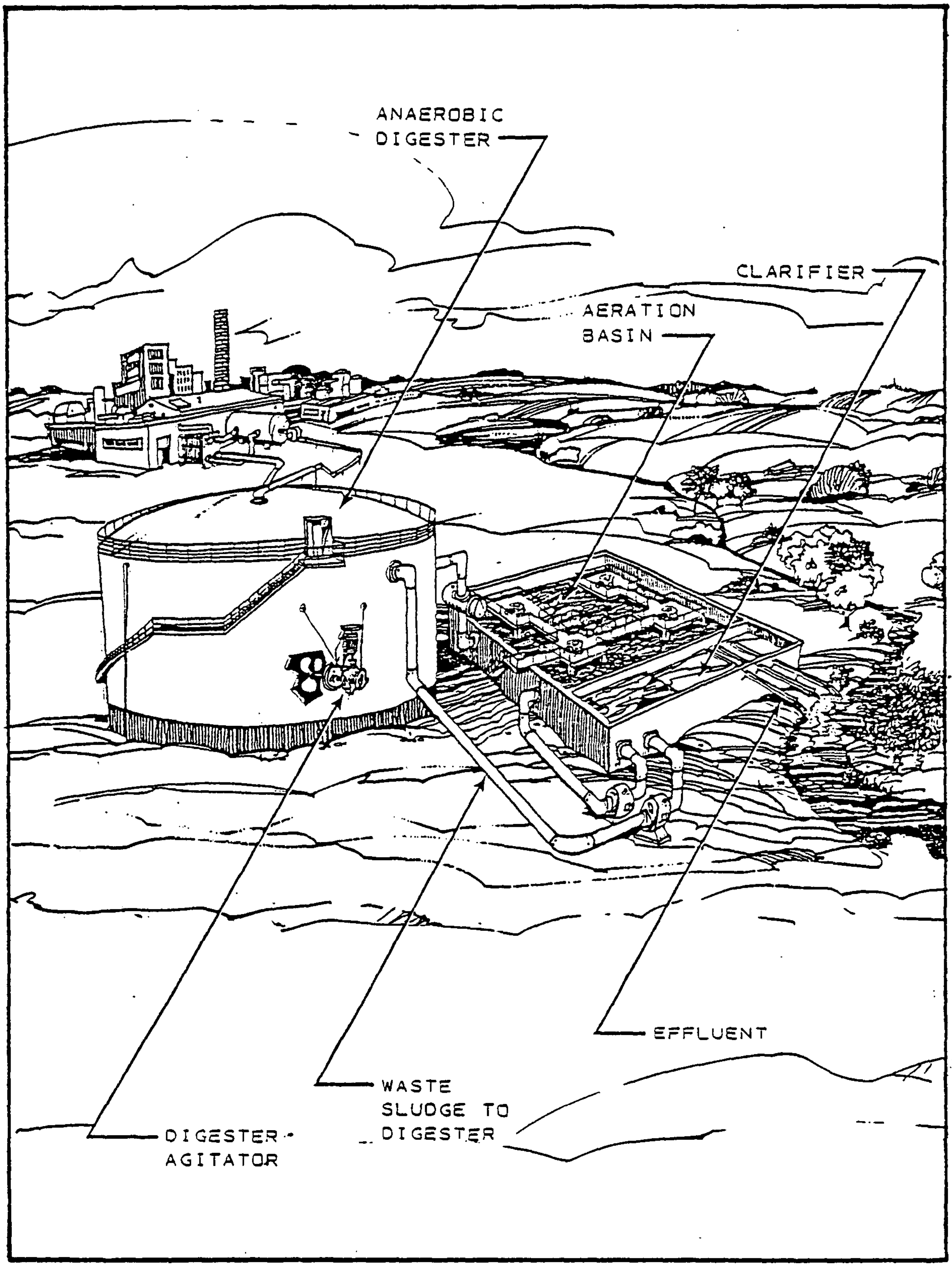


Figure XI-1. Typical Anamet System.

Where nitrogen reduction is involved, it is achieved by stripping the water with air after the anaerobic step. Most of the organic nitrogen compounds have by then been decomposed and the nitrogen remains as ammonium ions. Lime is added in order to increase the pH of the solution and this frees the ammonia before stripping. The ammonia is absorbed and a concentrated ammonium salt solution is produced which permits recovery of ammonia for reuse as a nutrient in the fermentation process.

Process Performance

The specific improvements in performance which Anamet systems attempt to provide over other anaerobic/aerobic systems include:

- Low overall sludge generation
- Short digester retention time
- High methane gas production
- Excellent BOD removal.

These features are discussed below.

In the Anamet process the sludge created in the aerobic stage is recycled into the anaerobic stage and converted into methane and carbon dioxide, thus reducing to a minimum the amount of solid waste which would have to be disposed of upon completion of the process. A Swedish sugar factory using the Anamet process reported no surplus sludge generated for the first three months after start-up of the full-scale plant (99).

The hydraulic retention time for the wastewaters in the anaerobic step may vary between two and 15 days, depending upon the nature of the wastewater. In order to avoid extensive digester retention times, which would be a problem in the treatment of rum distillery wastes, the anaerobic sludge is retained in the system. This is usually achieved by separation in a settler and recirculation of the thickened sludge. The accelerated activity in the anaerobic step is also facilitated by the return of the biosludge from the aerobic step. This sludge acts as a "support" for the enzymes of the anaerobic bacteria (99).

The operating conditions of the system are maintained so as to maximize the anaerobic conversion of the waste into methane gas. The amount of gas produced depends on the wastewater and is reported to vary from 0.3 to 0.5 m^3 CH_4/kg BOD_7 digested. Sorigona suggests that the digester operating parameters as shown in Table XI-1 be maintained to optimize the conditions for the methane-forming bacteria (49).

TABLE XI-1. RECOMMENDED OPERATING PARAMETERS FOR ANAEROBIC DIGESTION IN THE ANAMET SYSTEM (49)

Parameter	Typical Operating Range
pH	6.8 - 7.5
Temperature	35 - 60°C
Bacterial retention time	>6 days
Wastewater retention time	2 - 20 days
Process toxicity levels	NH_4 <1,000 mg/ℓ
	K^+, Na^+ < 5,000 mg/ℓ
	H_2S < 100 mg/ℓ

Wastewaters with high inorganic salt concentrations, such as mostos, may tend to increase the minimum bacterial retention time shown in Table XI-1. In addition, there are toxic effects from high concentrations of inorganic compounds such as ammonium, potassium, sodiuum, and hydrogen sulfide in the wastewater. By adapting the bacteria, however, it may be possible to operate at concentrations higher than the normal toxic levels shown in Table XI-1 (49).

BOD reductions with Anamet vary depending upon the specific wastewater and the retention time, but Sorigona claims that BOD reductions of up to 99 percent have been experienced in the treatment of wastes other than rum distillery effluents. Sorigona reports that in various situations when the Anamet process has been used, between 70 and 90 percent of the original BOD was removed in the anaerobic step, leaving 10 to 30 percent to be treated in the aerobic step. This high degree of BOD reduction in the anaerobic step is primarily attributable to the production of methane gas. Methane has a low water solubility and, consequently, nearly all of it escapes from solution, thereby significantly reducing BOD (99).

The BOD reduction which has been reported for the second step of the Anamet process is very high, with up to approximately 93 percent reduction reported for some wastes. The efficiency of the BOD reduction in the aerobic step is attributed to the anaerobic pretreatment where the large molecules are hydrolyzed into substances which are easily assimilated. Moreover, a sufficient amount of inorganic nitrogen remains in the water to facilitate the conversion of the biomass in the aerobic step (99).

A complete list of Anamet facilities existing and under construction is contained in Appendix B. It includes the type of waste treated and the BOD_5 reduction achieved at each plant, as reported by Sorigona (50). The types of wastes which have been treated with Anamet generally have had BOD_5 and COD concentrations considerably lower than those of Caribbean mostos (49,95,99). BOD_5 concentrations have been in the range of 4,000 to 13,000 mg/ℓ for many of the wastes treated, while mostos has a typical BOD_5 concentration of about 35,000 mg/ℓ. Therefore the results which will become available from Puerto Rico Distillers' pilot Anamet facility at Arecibo are of great importance in determining the adaptability of the process to mostos.

Costs

The pilot plant results are also critical to determing the costs of a full-scale operation. According to Sorigona (99), the investment costs for an Anamet plant are generally low, on the order of \$50 to \$100/kg of BOD_7 removed per day, due to the compactness of the plant. Operating costs are reportedly negligible since no nutrients are needed, and energy as well as personnel requirements are low. Sludge handling costs are also small. The value of methane gas produced is said to more than cover the operating costs for many applications (99).

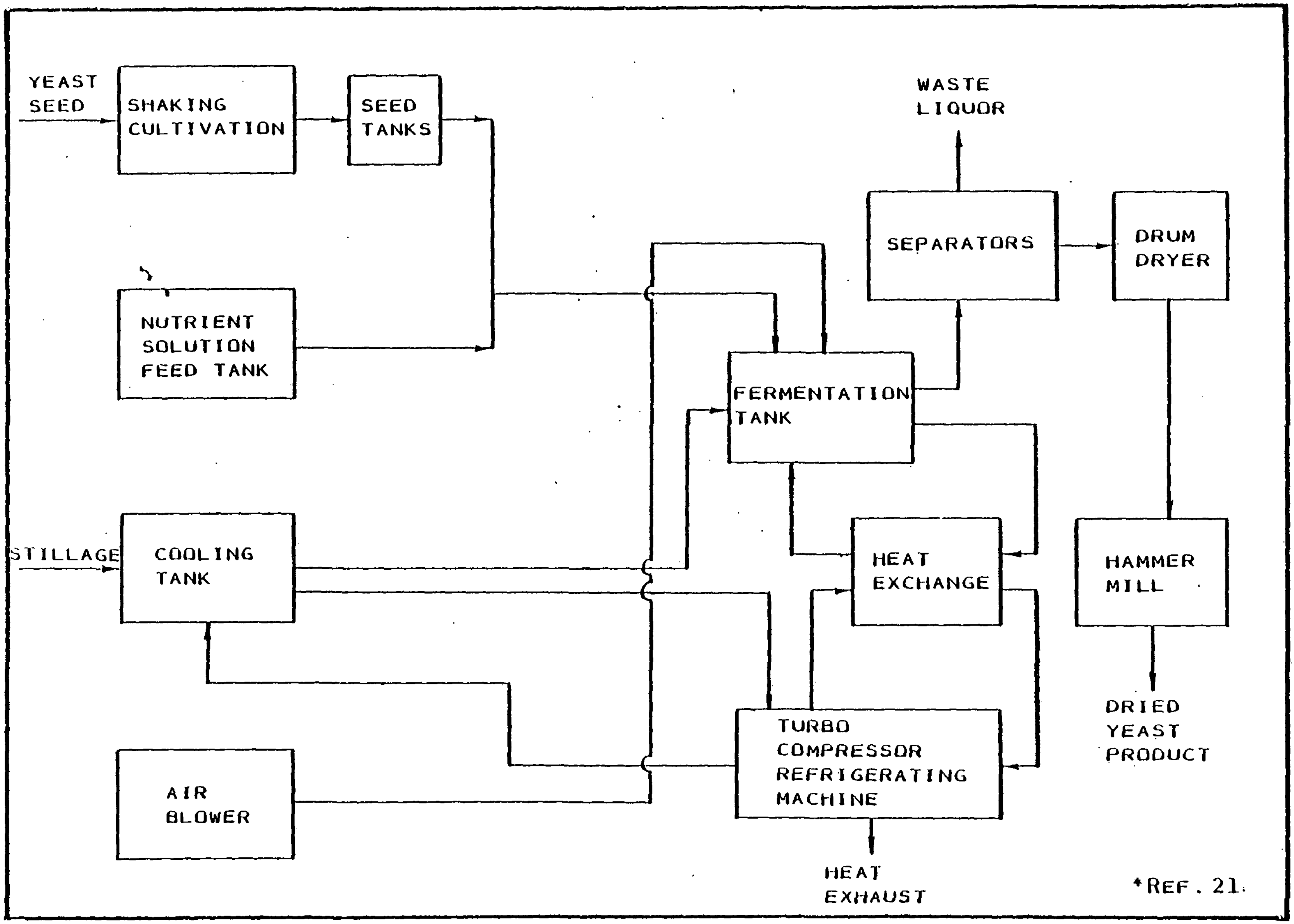
AB Sorigona has provided Puerto Rico Distillers with a turnkey investment price estimate for a full-scale facility (50). The estimate is for a loading rate of 65,000 lb of BOD/day, 225,000 gal of mostos/day, and assuming 95 percent BOD_5 reduction. The turnkey investment cost estimate submitted April 4, 1978, in U.S. dollars was \$2.55 x 10^6. This is a cost of approximately \$91/kg of BOD_5 removed per day. Methane gas production was estimated at the equivalent of 2,340 tons of fuel oil per year. Electrical power consumption was estimated at 1 x 10^6 kWh/yr; and sludge production at 6,700 m^3/yr. The cost of sludge transport was calculated at \$5/ton, but this does not include land (50).

One of the relative disadvantages of any of the anaerobic/aerobic biological treatment systems is that the effluent remains very dark in color. It would be technologically possible to remove the color from the effluent by means of large quantities of activated carbon or by ozone oxidation. Either method would be prohibitively expensive, however (24).

CULTIVATION OF FODDER YEASTS, BACTERIA, AND FUNGI IN SLOPS

The propagation of single strains of various yeasts, bacteria, and fungi in waste liquids is sometimes referred to as single-cell protein synthesis. Since these organisms can metabolize the organic materials of a substrate which itself contains relatively little protein, the high protein content of the biomass represents a transformation of the nitrogen of the substrate to form a protein biosynthesis. Previous investigations utilizing rum slops as a substrate have been performed primarily with certain yeasts and molds (considered fungi). When extracted and dried, the yeast or mold biomass (containing approximatley 40 to 46 percent protein) has a relatively high market value as an animal feed supplement (52).

A flow sheet for yeast manufacturing from molasses alcohol stillage, as it was performed at Hsinying By-Product Factory (21), is shown in Figure XI-2. Preceding the fermentation of the stillage, yeast inoculum was prepared using a shaking cultivation and two seed tanks. Molasses was employed for the culture to maintain strong and active yeast. The stillage coming from the distillery was cooled, but neither dilution nor sterilization was required. Stillage was continuously fed to a fermentation tank by displacement. Supplemental nitrogen and phosphorus were provided by the addition of a cream solution of urea, ammonium sulfate, and calcium superphosphate. Air was provided with a turbo blower. The temperature was regulated by a refrigeration cooling system designed with a heat exchanger to eliminate the possibility of contamination of the fermenter. The fermented stillage flowed from the tank to a



*REF. 21.

Figure XI-2, Yeast Cultivation in Molasses Distillery Stillage* yeast separator. The separated yeast went through a drum dryer and hammer mill to form the final product.

Yeast cultivation of molasses alcohol stillage has been investigated in Taiwan (21, 64). Successful work has been performed with Torula utilis, which has a protein content of 46 percent. One ton of dry torula yeast was produced from 60 to 65 tons of stillage in a small, factory-scale aerobic fermenter. In spite of these excellent results, it is expected that in most cases up to 100 tons or more of stillage may be required to yield one ton of dry torula feed yeast (47), mainly due to the high BOD_5 of the Taiwanese stillage (approximately 60,000 ppm). Stillage BOD_5 values from Puerto Rican rum processors, in contrast, have been shown to be lower (average total BOD values were reported to be 32,900 and 54,900 ppm for 6 and 5 samples, respectively) (93).

Researchers in Taiwan (21) have reported that the carbon source for yeast growth is derived principally from the organic matter portion of the stillage. In laboratory and factory fermentations, the pH increased rapidly from 6.8 to 7.9 during yeast formation, indicating that much of the energy being used was from volatile acids, lactic acid, and other combined organic acids in the stillage. Stillages from beet and cane molasses are different in organic composition: the relative ash content of cane molasses is about 40 percent higher than that of its beet counterpart (96). It is well known that beet molasses provides a better substrate for yeast production than cane molasses. Therefore, it is expected that beet molasses stillage will make a better substrate than cane molasses stillage.

In the Taiwanese experiments (64) with Torula utilis, the BOD_5 concentration of the stillage was reduced by 33 percent, and the total solids concentration by 29 percent. In Soviet experiments (51) with de-yeasted beet molasses stillage, the cultivation of various fodder yeasts decreased the BOD_5 by 41 to 54 percent, and the total solids by approximately 37 percent. The Soviet experiments involved dilution of the stillage prior to yeast cultivation, as have experiments carried out by French investigators (61). These latter experiments indicated that dilution promoted the yeast activity.

The amount of income to be derived from yeast production is dependent upon the yeast yield and its marketability. The production costs may vary considerably, depending upon the extent to which additional nutrients must be supplied for the process, the retention times required, and the steps necessary to separate the yeast from the liquid. Research in some of these areas (80) is underway at Puerto Rico Distillers' laboratories in Arecibo, Puerto Rico. Experiments have already been conducted using Aspergillus phoenicius (a fungus) in fermentation tanks with up to 1,500-liter volumes. The highest BOD_5 reduction achieved in these tests was 59 percent at a retention time of seven days. Puerto Rico Distillers (80) regards a retention time of greater than two to three days as excessive to be useful in a full-scale operation, due to a lack of space and the high costs for tanks. These experiments also yielded disappointing results concerning the separation of the yeast from solution. Based on earlier experiments of a smaller scale at the

Rum Pilot Plant of the University of Puerto Rico, Puerto Rico Rum Distillers had hoped for strong formation of a mycelium, a visible mass of microbial cell matter, which would easily be removed from solution. However, mycelium formation in the experiments was not as consistent as had been expected. Further information in these areas, and on supplementary nutrient requirements as well, is needed to make production cost estimates.

Another important cost consideration is electrical power. Power is consumed primarily for aeration purposes, as many as 400 volumes of air being required per volume of rum slops (61). Power requirements for the operation of a cooling system may also be considerable since a large amount of heat is evolved during feed yeast cultivation, and must be continuously removed to safeguard fermentation activity and maximize yield.

After yeast cultivation and separation, the slops will still pose a substantial treatment problem due to the remaining high BOD_5 level. Because much of the organic matter of the waste will have been used in producing yeast, the value of the waste in the production of a gas by anaerobic digestion will be reduced. Its mineral content would be extremely high if evaporated to CMS for use as an animal feedstuff and, if the CMS were incinerated, the amount of heat recoverable for the needs of evaporation would be lower. On the positive side, however, the reduced strength of the waste could improve the operation and performance of aerobic biological treatment.

(REVISED)

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APPENDIX A

Aquaculture Correspondence

UNIVERSITY OF CALIFORNIA

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO • SANTA BARBARA • SANTA CRUZ

AQUACULTURE PROGRAM
BODEGA MARINE LABORATORY

P. O. BOX 247
BODEGA BAY, CALIFORNIA 94923
(707) 875-3662

September 22, 1978

Michael A. Caponigro
SCS Engineers
4014 Long Beach Boulevard
Long Beach, CA 90807

Dear Mr. Caponigro:

I've examined the material you sent concerning the waste characteristics of molasses slops. My initial judgment is that this material is not readily adaptable to use for crustacean aquaculture in terms of a feed ingredient. It may have some usefulness in a more complex aquaculture scheme involving its use as a nutrient source for algae or some sort of detrital feeder which in turn could be utilized by higher organisms. Along these lines, I have forwarded the material to Dr. Michael Hartman, Professor, Savannah State College, for his input. Dr. Hartman who has had extensive experience with a wide variety of aquaculture systems, both here and at the University of Delaware, is probably the best suited to evaluate any possible utilization of this product in relationship to aquaculture.

If I can be of further assistance on matters relating to crustacean aquaculture in the future, please don't hesitate to write.

Sincerely,

Douglas E. Conklin

Douglas E. Conklin
Associate Director

DEC:ta
cc: M.C. Hartman

SAVANNAH STATE COLLEGE
STATE COLLEGE BRANCH
SAVANNAH, GEORGIA

DIVISION OF
NATURAL SCIENCES

October 9, 1978

Mr. Michael A. Caponigro
SCS Engineers
4014 Long Beach Blvd.
Long Beach, California 90807

Dear Mr. Caponigro:

Dr. Conklin, a past associate of mine, forwarded your material to me. After reading over it carefully, I'm afarid that there would not be too much use for the waste molasses slops in an aquaculture foodchains. My evaluation is based on several factors: The BOD and COD are very high, (table 4, p.44) indicating that the material is very high in organic carbon compounds. This is further substaniated by the high carbohydrate content mentioned in a later part of the report. These compunds being very water souble enhance the growth of Hetertrophic bacteria which, besides creating a situation of lower dissolved oxygen, they can destroy the bacterial flora of a biological filter system should such a system be in use.

Table 4 (p. 45) gives a Mg/L figure for copper as ranging from 2.0-124 with 32.8 as the mean. A concentration this high would be toxic to most shellfish, and acutely toxic to the larval stages. To introduce this material into an aquaculture foodchain, should it be taken up, would further concentrate the heavy metals.

Sincerely,

Michael Hartman, Ph.D.
Assistance Professor
Department of Biology

MH/ls

APPENDIX B

Anamet Plants

REFERENCE LIST

Anamet plants under operation:

Swedish Sugar Company
Ortofta Factory

24100 ESLOV - SWEDEN

Capacity	20 ton BOD_5/day
Reduction	98% BOD_5
Construction year	1972

Attention: Plant Manager Per Schmidt

Swedish Sugar Company
Hasslarps Factory

Capacity	10 ton BOD_5/day
Reduction	95% BOD_5
Construction year	1972

Swedish Sugar Company
Karpalund Factory

Capacity	4.5 ton BOD_5/day
Reduction	99% BOD_5
Construction year	1975

Swedish Sugar Company
Jordberga Factory

Capacity	10 ton BOD_5/day
Reduction	98% BOD_5
Construction year	1975

REFERENCE LIST (CONTINUED)

AB Skanebrannerier (Potato Distillery)
Gards Factory

Capacity	2 ton BOD_5/day
Reduction	99% BOD_5
Construction year	1977

ADDRESS LIST

Swedish Sugar Company
Ortofta sockerbruk
241 00 ESLOV - Sweden
Attention: Plant manager Per Schmidt

Swedish Sugar Company
Hasslarps sockerbruk
260 39 Hasslarp Sweden
Attention: Plant manager Sven Idoff

Swedish Sugar Company
Karpalunds sockerbruk
29100 Kristianstad Sweden
Attention: Plant manager Lennart Rantzow

Swedish Sugar Company
Jordberga sockerbruk
230 20 Klagstorp Sweden
Attention: Plant manager Bengt Lundborg

AB Skanebrannerier
Box 89
291 01 Kristianstad Sweden
Attention: Managing director Karl - Axel Kornell

ANAMET PLANTS UNDER CONSTRUCTION IN U.S.

American Crystal Sugar Company
Moorhead, Minnesota

Capacity	19 ton BOD_5/day
Reduction	95% BOD_5
Contact:	Mr. Ira Fordyce

ANAMET PILOT PLANT TEST SITES

Universal Foods Corporation
Red Star Yeast Operations
Belle Chasse, LA
Application: Bakers yeast waste
Contact: Mr. James L. Martin

Puerto Rico Distillers Inc.
Arecibo, Puerto Rico
Application: Rum distillery waste
Contact: Mr. Raul Ramirez

Talpe - Star Foods
Kotemark, Belgium
Application: Vegetable canning waste
Contact: Mr. Joseph Talpe

Tirlemont Distillery
Ruisbruek, Belgium
Application: Molasses distillery waste

Fruit Brandy Distillery
Sewen, Switzerland

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[Code of Federal Regulations]
[Title 21, Volume 1]
[Revised as of April 1, 2009]
[CITE: 21CFR73.85]
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TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER A--GENERAL

PART 73 -- LISTING OF COLOR ADDITIVES EXEMPT FROM CERTIFICATION

Subpart A--Foods

Sec. 73.85 Caramel.

(a)*Identity.* (1) The color additive caramel is the dark-brown liquid or solid material resulting from the carefully controlled heat treatment of the following food-grade carbohydrates:

Dextrose.

Invert sugar.

Lactose.

Malt sirup.

Molasses.

Starch hydrolysates and fractions thereof.

Sucrose.

(2) The food-grade acids, alkalis, and salts listed in this subparagraph may be employed to assist caramelization, in amounts consistent with good manufacturing practice.

(i) Acids:

Acetic acid.

Citric acid.

Phosphoric acid.

Sulfuric acid.

Sulfurous acid.

(ii) Alkalis:

Ammonium hydroxide.

Calcium hydroxide U.S.P.

Potassium hydroxide.

Sodium hydroxide.

(iii) Salts: Ammonium, sodium, or potassium carbonate, bicarbonate, phosphate (including dibasic phosphate and monobasic phosphate), sulfate, and sulfite.

(3) Polyglycerol esters of fatty acids, identified in 172.854 of this chapter, may be used as antifoaming agents in amounts not greater than that required to produce the intended effect.

(4) Color additive mixtures for food use made with caramel may contain only diluents that are suitable and that are listed in this subpart as safe in color additive mixtures for coloring foods.

(b)*Specifications.* Caramel shall conform to the following specifications:

Lead (as Pb), not more than 10 parts per million.

Arsenic (as As), not more than 3 parts per million.

Mercury (as Hg), not more than 0.1 part per million.

(c)*Uses and restrictions.* Caramel may be safely used for coloring foods generally, in amounts consistent with good manufacturing practice, except that it may not be used to color foods for which standards of identity have been promulgated under section 401 of the act unless added color is authorized by such standards.

(d)*Labeling.* The label of the color additive and any mixtures prepared therefrom and intended solely or in part for coloring purposes shall conform to the requirements of 70.25 of this chapter.

(e)*Exemption from certification.* Certification of this color additive is not necessary for the protection of the public health and therefore batches thereof are exempt from the certification requirements of section 721(c) of the act.

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[Title 21, Volume 3]
[Revised as of April 1, 2009]
[CITE: 21CFR173.320]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER B--FOOD FOR HUMAN CONSUMPTION
(CONTINUED)

PART 173 -- SECONDARY DIRECT FOOD ADDITIVES PERMITTED IN FOOD FOR HUMAN CONSUMPTION

Subpart D--Specific Usage Additives

Sec. 173.320 Chemicals for controlling microorganisms in cane-sugar and beet-sugar mills.

Agents for controlling microorganisms in cane-sugar and beet-sugar mills may be safely used in accordance with the following conditions:

(a) They are used in the control of microorganisms in cane-sugar and/or beet-sugar mills as specified in paragraph (b) of this section.

(b) They are applied to the sugar mill grinding, crusher, and/or diffuser systems in one of the combinations listed in paragraph (b) (1), (2), (3), or (5) of this section or as a single agent listed in paragraph (b) (4) or (6) of this section. Quantities of the individual additives in parts per million are expressed in terms of the weight of the raw cane or raw beets.

(1) Combination for cane-sugar mills:

	Parts per million
Disodium cyanodithioimidocarbonate	2.5
Ethylenediamine	1.0
Potassium*N*-methyldithiocarbamate	3.5

(2) Combination for cane-sugar mills:

	Parts per million
Disodium ethylenebisdithiocarbamate	3.0
Sodium dimethyldithiocarbamate	3.0

(3) Combinations for cane-sugar mills and beet-sugar mills:

	Parts per million
(i) Disodium ethylenebisdithiocarbamate	3.0
Ethylenediamine	2.0
Sodium dimethyldithiocarbamate	3.0
(ii) Disodium cyanodithioimidocarbonate	2.9
Potassium*N*-methyldithiocarbamate	4.1

(4) Single additive for cane-sugar mills and beet-sugar mills.

	Parts per million
2,2-Dibromo-3-nitrilopropionamide (CAS Reg. No. 10222-01-2).*Limitations:*Byproduct molasses, bagasse, and pulp containing residues of 2,2-dibromo-3-nitrilopropionamide are not authorized for use in animal feed	Not more than 10.0 and not less than 2.0.

(5) Combination for cane-sugar mills:

	Parts per million
n-Dodecyl dimethyl benzyl ammonium chloride	0.05+/-0.005
n-Dodecyl dimethyl ethylbenzyl ammonium chloride	0.68+/-0.068
n-Hexadecyl dimethyl benzyl ammonium chloride	0.30+/-0.030
n-Octadecyl dimethyl benzyl ammonium chloride	0.05+/-0.005
n-Tetradecyl dimethyl benzyl ammonium chloride	0.60+/-0.060
n-Tetradecyl dimethyl ethylbenzyl ammonium chloride	0.32+/-0.032

Limitations. Byproduct molasses, bagasse, and pulp containing residues of these quaternary ammonium salts are not authorized for use in animal feed.

(6) Single additive for beet-sugar mills:

	Parts per million
Glutaraldehyde (CAS Reg. No. 111-30-8)	Not more than 250.

(c) To assure safe use of the additives, their label and labeling shall conform to that registered with the Environmental Protection Agency.

[42 FR 14526, Mar. 15, 1977, as amended at 47 FR 35756, Aug. 17, 1982; 50 FR 3891, Jan. 29, 1985; 57 FR 8065, Mar. 6, 1992]

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[Code of Federal Regulations]
[Title 21, Volume 3]
[Revised as of April 1, 2009]
[CITE: 21CFR184.1007]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER B--FOOD FOR HUMAN CONSUMPTION (CONTINUED)

PART 184 -- DIRECT FOOD SUBSTANCES AFFIRMED AS GENERALLY RECOGNIZED AS SAFE

Subpart B--Listing of Specific Substances Affirmed as GRAS

Sec. 184.1007 Aconitic acid.

(a) Aconitic acid (1,2,3-propenetricarboxylic acid ($C_6H_6O_6$), CAS Reg. No. 000499-12-7) occurs in the leaves and tubers of*Aconitum napellus* L. and other*Ranunculaceae.* Transaconitic acid can be isolated during sugarcane processing, by precipitation as the calcium salt from cane sugar or molasses. It may be synthesized by sulfuric acid dehydration of citric acid, but not by the methanesulfonic acid method.

(b) The ingredient meets the following specifications:

(1)*Assay.* Not less than 98.0 percent of $C_3H_3(COOH)_3$, using the "Food Chemicals Codex," 4th ed. (1996), pp. 102-103, test for citric acid, which is incorporated by reference in accordance with 5 U.S.C. 552(a) and 1 CFR part 51, and a molecular weight of 174.11. Copies of the material incorporated by reference are available from the National Academy Press, Box 285, 2101 Constitution Ave. NW., Washington, DC 20055 (Internet address*http://www.nap.edu*), or may be examined at the Center for Food Safety and Applied Nutrition's Library, Food and Drug Administration, 5100 Paint Branch Pkwy., College Park, MD 20740, or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to:*http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.*

(2)*Melting point.* Not less than 195 deg. C and the determination results in decomposition of aconitic acid.

(3)*Heavy metals* (*as Pb*). Not more than 10 parts per million.

(4)*Arsenic* (*as As*). Not more than 3 parts per million.

(5)*Oxalate.* Passes test.

(6)*Readily carbonizable substances.* Passes the test for citric acid of the "Food Chemicals Codex," 4th ed. (1996), pp. 102-103, which is incorporated by reference in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. The availability of this incorporation by reference is given in paragraph (b)(1) of this section.

(7)*Residue on ignition.* Not more than 0.1 percent as determined by the "Food Chemicals Codex," 4th ed. (1996), pp. 102-103, test for citric acid, which is incorporated by reference in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. The availability of this incorporation by reference is given in paragraph (b)(1) of this section.

(c) The ingredient is used as a flavoring substance and adjuvant as defined in 170.3(o)(12) of this chapter.

(d) The ingredient is used in food, in accordance with 184.1(b)(1), at levels not to exceed good manufacturing practice. Current good manufacturing practice results in a maximum level, as served, of 0.003 percent for baked goods as defined in 170.3(n)(1) of this chapter, 0.002 percent for alcoholic beverages as defined in 170.3(n)(2) of this chapter, 0.0015 percent for frozen dairy products as defined in 170.3(n)(20) of this chapter, 0.0035 percent for soft candy as defined in 170.3(n)(38) of this chapter, and 0.0005 percent or less for all other food categories.

(e) Prior sanctions for this ingredient different from the uses established in this section do not exist or have been waived.

[43 FR 47724, Oct. 17, 1978, as amended at 49 FR 5610, Feb. 14, 1984; 64 FR 1759, Jan. 12, 1999]

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[CITE: 21CFR184.1854]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER B--FOOD FOR HUMAN CONSUMPTION
(CONTINUED)

PART 184 -- DIRECT FOOD SUBSTANCES AFFIRMED AS GENERALLY RECOGNIZED AS SAFE

Subpart B--Listing of Specific Substances Affirmed as GRAS

Sec. 184.1854 Sucrose.

(a) Sucrose (C12H22O11, CAS Reg. No. 57-50-11-1) sugar, cane sugar, or **beet** sugar is the chemical [beta]-D-fructofuranosyl-[alpha]-D-glucopyranoside. Sucrose is obtained by crystallization from sugar cane or sugar **beet** juice that has been extracted by pressing or diffusion, then clarified and evaporated.

(b) The ingredient must be of a purity suitable for its intended use.

(c) In accordance with 184.1(b)(1), the ingredient is used in food with no limitation other than current good manufacturing practice.

(d) Prior sanctions for this ingredient different from the uses established in this section do not exist or have been waived.

[53 FR 44876, Nov. 7, 1988; 54 FR 228, Jan. 4, 1989, as amended at 73 FR 8608, Feb. 14, 2008]

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[Revised as of April 1, 2009]
[CITE: 21CFR501.110]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER E--ANIMAL DRUGS, FEEDS, AND RELATED PRODUCTS

PART 501 -- ANIMAL FOOD LABELING

Subpart F--Exemptions From Animal Food Labeling Requirements

Sec. 501.110 Animal feed labeling; collective names for feed ingredients.

(a) An animal feed shall be exempt from the requirements of section 403(i)(2) of the act with respect to its label bearing the common or usual names of the animal feed ingredients listed in paragraph (b) of this section under the following prescribed conditions:

(1) The animal feed is intended solely for livestock and poultry.

(2) The label of the animal feed bears the collective name(s) prescribed in paragraph (b) of this section in lieu of the corresponding common or usual names of the individual feed ingredients contained therein.

(3) The label of the animal feed otherwise conforms to the requirements of section 403(i)(2) of the act.

(4) The ingredients of any feed listed in paragraph (b) of this section neither contain nor are food additives as defined in section 201(s) of the act unless provided for by and in conformity with applicable regulations established pursuant to section 409 of the act.

(b) Each collective name referred to in this paragraph may be used for the purpose of labeling where one or more of the ingredients listed for that collective name are present. The animal feed ingredients listed under each of the collective names are the products defined by the Association of American Feed Control Officials. The collective names are as follows:

(1)*Animal protein products* include one or more of the following: Animal products, marine products, and milk products.

(2)*Forage products* include one or more of the following: Alfalfa meals, entire plant meals, hays, and stem meals.

(3)*Grain products* include one or more of the following: Barley, grain sorghums, maize (corn), oats, rice, rye, and wheat.

(4)*Plant protein products* include one or more of the following: Algae meals, coconut meals (copra), cottonseed meals, guar meal, linseed meals, peanut meals, safflower meals, soybean meals, sunflower meals, and yeasts.

(5)*Processed grain byproducts* include one or more of the following: Brans, brewers dried grains, distillers grains, distillers solubles, flours, germ meals, gluten feeds, gluten meals, grits, groats, hominy feeds, malt sprouts, middlings, pearled, polishings, shorts, and wheat mill run.

(6)*Roughage products* include one or more of the following: Cobs, hulls, husks, pulps, and straws.

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[CITE: 21CFR501.4]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER E--ANIMAL DRUGS, FEEDS, AND RELATED PRODUCTS

PART 501 -- ANIMAL FOOD LABELING

Subpart A--General Provisions

Sec. 501.4 Animal food; designation of ingredients.

(a) Ingredients required to be declared on the label of a food, including foods that comply with standards of identity that require labeling in compliance with this part 501, except those exempted by 501.100, shall be listed by common or usual name in descending order of predominance by weight on either the principal display panel or the information panel in accordance with the provisions of 501.2.

(b) The name of an ingredient shall be a specific name and not a collective (generic) name, except that:

(1) Spices, flavorings, colorings and chemical preservatives shall be declared according to the provisions of 501.22.

(2) An ingredient which itself contains two or more ingredients and which has an established common or usual

name, conforms to a standard established pursuant to the Meat Inspection or Poultry Products Inspection Acts by the U.S. Department of Agriculture, or conforms to a definition and standard of identity established pursuant to section 401 of the Federal Food, Drug, and Cosmetic Act, shall be designated in the statement of ingredients on the label of such food by either of the following alternatives:

(i) By declaring the established common or usual name of the ingredient followed by a parenthetical listing of all ingredients contained therein in descending order of predominance except that, if the ingredient is a food subject to a definition and standard of identity established in this subchapter E, only the ingredients required to be declared by the definition and standard of identity need be listed; or

(ii) By incorporating into the statement of ingredients in descending order of predominance in the finished food, the common or usual name of every component of the ingredient without listing the ingredient itself.

(3) Skim milk, concentrated skim milk, reconstituted skim milk, and nonfat dry milk may be declared as*skim milk* or*nonfat milk* .

(4) Milk, concentrated milk, reconstituted milk, and dry whole milk may be declared as*milk* .

(5) Bacterial cultures may be declared by the word*cultured* followed by the name of the substrate, e.g.,*made from cultured skim milk or cultured buttermilk* .

(6) Sweetcream buttermilk, concentrated sweetcream buttermilk, reconstituted sweetcream buttermilk, and dried sweetcream buttermilk may be declared as*buttermilk* .

(7) Whey, concentrated whey, reconstituted whey, and dried whey may be declared as*whey* .

(8) Cream, reconstituted cream, dried cream, and plastic cream (sometimes known as concentrated milkfat) may be declared as*cream* .

(9) Butteroil and anhydrous butterfat may be declared as*butterfat* .

(10) Dried whole eggs, frozen whole eggs, and liquid whole eggs may be declared as*eggs* .

(11) Dried egg whites, frozen egg whites, and liquid egg

whites may be declared as *egg whites* .

(12) Dried egg yolks, frozen egg yolks, and liquid egg yolks may be declared as *egg yolks* .

(13) A livestock or poultry feed may be declared by a collective name listed in 501.110 if it is an animal feed within the meaning of section 201(w) of the act and meets the requirements for the use of a collective name as prescribed in 501.110 for certain feed ingredients.

(14) [Reserved]

(15) When all the ingredients of a wheat flour are declared in an ingredient statement, the principal ingredient of the flour shall be declared by the name(s) specified in 137.105, 137.200, 137.220, 137.225 of this chapter, i.e., the first ingredient designated in the ingredient list of flour, or bromated flour, or enriched flour, or self-rising flour is *flour, white flour, wheat flour,* or *plain flour* ; the first ingredient designated in the ingredient list of durum flour is *durum flour* ; the first ingredient designated in the ingredient list of whole wheat flour, or bromated whole wheat flour is *whole wheat flour, graham flour,* or *entire wheat flour* ; and the first ingredient designated in the ingredient list of whole durum wheat flour is *whole durum wheat flour* .

(c) When water is added to reconstitute, completely or partially, an ingredient permitted by paragraph (b) of this section to be declared by a class name, the position of the ingredient class name in the ingredient statement shall be determined by the weight of the unreconstituted ingredient plus the weight of the quantity of water added to reconstitute that ingredient, up to the amount of water needed to reconstitute the ingredient to single strength. Any water added in excess of the amount of water needed to reconstitute the ingredient to single strength shall be declared as *water* in the ingredient statement.

[41 FR 38619, Sept. 10, 1976, as amended at 42 FR 14091, Mar. 15, 1977; 60 FR 38480, July 27, 1995]

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[Title 21, Volume 6]
[Revised as of April 1, 2009]
[CITE: 21CFR502.5]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER E--ANIMAL DRUGS, FEEDS, AND RELATED PRODUCTS

PART 502 -- COMMON OR USUAL NAMES FOR NONSTANDARDIZED ANIMAL FOODS

Sec. 502.5 General principles.

(a) The common or usual name of a food, which may be a coined term, shall accurately identify or describe, in as simple and direct terms as possible, the basic nature of the food or its characterizing properties or ingredients. The name shall be uniform among all identical or similar products and may not be confusingly similar to the name of any other food that is not reasonably encompassed within the same name. Each class or subclass of food shall be given its own common or usual name that states, in clear terms, what it is in a way that distinguishes it from different foods.

(b) The common or usual name of a food shall include the percentage(s) of any characterizing ingredient(s) or component(s) when the proportion of such ingredient(s) or component(s) in the food has a material bearing on price or consumer acceptance or when the labeling or the appearance of the food may otherwise create an erroneous impression that such ingredient(s) or component(s) is present in an amount greater than is actually the case. The following requirements shall apply unless modified by a specific regulation in this part.

(1) The percentage of a characterizing ingredient or component shall be declared on the basis of its quantity in the finished product (i.e., weight/weight in the case of solids, or volume/volume in the case of liquids).

(2) The percentage of a characterizing ingredient or component shall be declared by the words "containing (or contains) __ percent (or %) __" or "__ percent (or %) __" with the first blank filled in with the percentage expressed as a whole number not greater than the actual percentage of the ingredient or component named and the second blank filled in with the common or usual name of the ingredient or component. The word "containing" (or "contains"), when used, shall appear on a line immediately below the part of the common or usual name of the food required by paragraph (a) of this section. For each characterizing ingredient or component, the words "__ percent (or %) __"shall appear following or directly below the word "containing" (or "contains"), or directly below the part of the common or usual name of the food required by paragraph (a) of this section when the word "containing" (or "contains") is not used, in easily legible boldface print or type in distinct contrast to other printed or graphic matter, and in a height not less than the larger of the following alternatives:

(i) Not less than one-sixteenth inch in height on packages having a principal display panel with an area of 5 square inches or less and not less than one-eighth inch in height if the area of the principal display panel is greater than 5 square inches; or

(ii) Not less than one-half the height of the largest type appearing in the part of the common or usual name of the food required by paragraph (a) of this section.

(c) The common or usual name of a food shall include a statement of the presence or absence of any characterizing ingredient(s) or component(s) and/or the need for the user to add any characterizing ingredient(s) or component(s) when the presence or absence of such ingredient(s) or component(s) in the food has a material bearing on price or consumer acceptance or when the labeling or the appearance of the food may otherwise create an erroneous impression that such ingredient(s) or component(s) is present when it is not, and consumers may otherwise be misled about the presence or absence of the ingredient(s) or component(s) in the food. The following requirements shall apply unless modified by a specific regulation in this part.

(1) The presence or absence of a characterizing ingredient or component shall be declared by the words "containing (or contains) ____" or "containing (or contains) _____" or "no _____" or "does not contain _____", with the blank being filled in with the common or usual name of the ingredient or component.

(2) The need for the user of a food to add any characterizing ingredient(s) or component(s) shall be declared by an appropriate informative statement.

(3) The statement(s) required under paragraph (c) (1) and/or (2) of this section shall appear following or directly below the part of the common or usual name of the food required by paragraphs (a) and (b) of this section, in easily legible boldface print or type in distinct contrast to other printed or graphic matter, and in a height not less than the larger of the alternatives established under paragraph (b)(2) (i) and (ii) of this section.

(d) A common or usual name of a food may be established by common usage or by establishment of a regulation in this part, in a standard of identity, or in other regulations in this chapter.

[41 FR 38627, Sept. 10, 1976. Redesignated at 42 FR 14091, Mar. 15, 1977]

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(a) *Energy sources.* Ionizing radiation is limited to gamma rays from sealed units of cobalt-60.

(b) *Limitation.* The ionizing radiation is used for feed or feed ingredients that do not contain drugs.

(c) *Use.* Ionizing radiation is used as a single treatment for rendering complete poultry diets or poultry feed ingredients salmonella negative as follows:

(1) Minimum dose 2.0 kiloGrays (kGy) (0.2 megarad (Mrad)); maximum dose 25 kGy (2.5 megarads Mrad). The absorbed dose of irradiation is to be based on initial concentration of salmonella using the relationship that 1.0 kGy (0.1 Mrad) reduces salmonella concentration by one log cycle (one decimal reduction).

(2) Feeds treated by irradiation should be formulated to account for nutritional loss.

(3) If an irradiated feed ingredient is less than 5 percent of the final product, the final product can be irradiated without being considered to be reirradiated.

[60 FR 50099, Sept. 28, 1995]

PART 582—SUBSTANCES GENERALLY RECOGNIZED AS SAFE

Subpart A—General Provisions

Subpart B—General Purpose Food Additives

582.1973 Beeswax.
582.1975 Bleached beeswax.
582.1978 Carnauba wax.

Subpart C—Anticaking Agents

582.2122 Aluminum calcium silicate.
582.2227 Calcium silicate.
582.2437 Magnesium silicate.
582.2727 Sodium aluminosilicate.
582.2729 Hydrated sodium calcium aluminosilicate.
582.2906 Tricalcium silicate.

Subpart D—Chemical Preservatives

582.3013 Ascorbic acid.
582.3021 Benzoic acid.
582.3041 Erythorbic acid.
582.3081 Propionic acid.
582.3089 Sorbic acid.
582.3109 Thiodipropionic acid.
582.3149 Ascorbyl palmitate.
582.3169 Butylated hydroxyanisole.
582.3173 Butylated hydroxytoluene.
582.3189 Calcium ascorbate.
582.3221 Calcium propionate.
582.3225 Calcium sorbate.
582.3280 Dilauryl thiodipropionate.
582.3336 Gum guaiac.
582.3490 Methylparaben.
582.3616 Potassium bisulfite.
582.3637 Potassium metabisulfite.
582.3640 Potassium sorbate.
582.3660 Propyl gallate.
582.3670 Propylparaben.
582.3731 Sodium ascorbate.
582.3733 Sodium benzoate.
582.3739 Sodium bisulfite.
582.3766 Sodium metabisulfite.
582.3784 Sodium propionate.
582.3795 Sodium sorbate.
582.3798 Sodium sulfite.
582.3845 Stannous chloride.
582.3862 Sulfur dioxide.
582.3890 Tocopherols.

Subpart E—Emulsifying Agents

582.4101 Diacetyl tartaric acid esters of mono- and diglycerides of edible fats or oils, or edible fat-forming fatty acids.
582.4505 Mono- and diglycerides of edible fats or oils, or edible fat-forming acids.
582.4521 Monosodium phosphate derivatives of mono- and diglycerides of edible fats or oils, or edible fat-forming fatty acids.
582.4666 Propylene glycol.

Subpart F—Nutrients and/or Dietary Supplements

582.5013 Ascorbic acid.
582.5017 Aspartic acid.
582.5049 Aminoacetic acid.
582.5065 Linoleic acid.
582.5118 Alanine.
582.5145 Arginine.
582.5159 Biotin.
582.5191 Calcium carbonate.
582.5195 Calcium citrate.
582.5201 Calcium glycerophosphate.
582.5210 Calcium oxide.
582.5212 Calcium pantothenate.
582.5217 Calcium phosphate.
582.5223 Calcium pyrophosphate.
582.5230 Calcium sulfate.
582.5245 Carotene.
582.5250 Choline bitartrate.
582.5252 Choline chloride.
582.5260 Copper gluconate.
582.5271 Cysteine.
582.5273 Cystine.
582.5301 Ferric phosphate.
582.5304 Ferric pyrophosphate.
582.5306 Ferric sodium pyrophosphate.
582.5308 Ferrous gluconate.
582.5311 Ferrous lactate.
582.5315 Ferrous sulfate.
582.5361 Histidine.
582.5370 Inositol.
582.5375 Iron reduced.
582.5381 Isoleucine.
582.5406 Leucine.
582.5411 Lysine.
582.5431 Magnesium oxide.
582.5434 Magnesium phosphate.
582.5443 Magnesium sulfate.
582.5446 Manganese chloride.
582.5449 Manganese citrate.
582.5452 Manganese gluconate.
582.5455 Manganese glycerophosphate.
582.5458 Manganese hypophosphite.
582.5461 Manganese sulfate.
582.5464 Manganous oxide.
582.5470 Mannitol.
582.5475 Methionine.
582.5477 Methionine hydroxy analog and its calcium salts.
582.5530 Niacin.
582.5535 Niacinamide.
582.5580 D-Pantothenyl alcohol.
582.5590 Phenylalanine.
582.5622 Potassium chloride.
582.5628 Potassium glycerophosphate.
582.5634 Potassium iodide.
582.5650 Proline.
582.5676 Pyridoxine hydrochloride.
582.5695 Riboflavin.
582.5697 Riboflavin-5-phosphate.
582.5701 Serine.
582.5772 Sodium pantothenate.
582.5778 Sodium phosphate.
582.5835 Sorbitol.
582.5875 Thiamine hydrochloride.
582.5878 Thiamine mononitrate.
582.5881 Threonine.
582.5890 Tocopherols.
582.5892 *α*-Tocopherol acetate.
582.5915 Tryptophane.
582.5920 Tyrosine.
582.5925 Valine.
582.5930 Vitamin A.
582.5933 Vitamin A acetate.
582.5936 Vitamin A palmitate.

Subpart G—Sequestrants

Subpart H—Stabilizers

AUTHORITY: 21 U.S.C. 321, 342, 348, 371.

SOURCE: 41 FR 38657, Sept. 10, 1976, unless otherwise noted.

Subpart A—General Provisions

§ 582.1 Substances that are generally recognized as safe.

(a) It is impracticable to list all substances that are generally recognized as safe for their intended use. However, by way of illustration, the Commissioner regards such common food ingredients as salt, pepper, sugar, vinegar, baking powder, and monosodium glutamate as safe for their intended use. The lists in subparts B through H of this part include additional substances that, when used for the purposes indicated, in accordance with good manufacturing or feeding practice, are regarded by the Commissioner as generally recognized as safe for such uses.

(b) For the purposes of this section, good manufacturing or feeding practice shall be defined to include the following restrictions:

(1) The quantity of a substance added to animal food does not exceed the amount reasonably required to accomplish its intended physical, nutritional, or other technical effect in food; and

(2) The quantity of a substance that becomes a component of animal food as a result of its use in the manufacturing, processing, or packaging of food, and which is not intended to accomplish any physical or other technical effect in the food itself, shall be reduced to the extent reasonably possible.

(3) The substance is of appropriate grade and is prepared and handled as a food ingredient. Upon request the Commissioner will offer an opinion, based on specifications and intended use, as to whether or not a particular grade or lot of the substance is of suitable purity for use in food and would generally be regarded as safe for the purpose intended, by experts qualified to evaluate its safety.

(c) The inclusion of substances in the list of nutrients does not constitute a finding on the part of the Department that the substance is useful as a supplement to the diet for animals.

(d) Substances that are generally recognized as safe for their intended use within the meaning of section 409 of the Act are listed in subparts B through H of this part. When the status of a substance has been reevaluated and affirmed as GRAS or deleted from subparts B through H of this part, an appropriate explanation will be noted, e.g., ''affirmed as GRAS,'' ''food additive regulation,'' ''interim food additive regulation,'' or ''prohibited from use in food,'' with a reference to the appropriate new regulation. Such notation will apply only to the specific use covered by the review, e.g., direct animal food use and/or indirect animal food use and/or animal feed use and will not affect its status for other uses not specified in the referenced regulation, pending a specific review of such other uses.

§ 582.10 Spices and other natural seasonings and flavorings.

Spices and other natural seasonings and flavorings that are generally recognized as safe for their intended use, within the meaning of section 409 of the act, are as follows:

Common name	Botanical name of plant source
Alfalfa herb and seed	*Medicago sativa* L.
Allspice	*Pimenta officinalis* Lindl.
Ambrette seed	*Hibiscus abelmoschus L.*
Angelica	*Angelica archangelica* L. or other spp. of Angelica.
Angelica root	Do.
Angelica seed	Do.
Angostura (cusparia bark)	*Galipea officinalis* Hancock.
Anise	*Pimpinella anisum* L.
Anise, star	*Illicium verum Hook.* f.
Balm (lemon balm)	*Melissa officinalis* L.
Basil, bush	*Ocimum minimum* L.
Basil, sweet	*Ocimum basilicum L.*
Bay	*Laurus nobilis* L.
Calendula	*Calendula officinalis* L.
Camomile (chamomile), English or Roman	*Anthemis nobilis* L.
Camomile (chamomile), German or Hungarian	*Matricaria chamomilla* L.
Capers	*Capparis spinosa* L.
Capsicum	*Capsicum frutescens* L. or *Capsicum annuum* L.
Caraway	*Carum carvi* L.
Caraway, black (black cumin)	*Nigella sativa* L.
Cardamom (cardamon)	*Elettaria cardamomum* Maton.
Cassia, Chinese	*Cinnamomum cassia* Blume.
Cassia, Padang or Batavia	*Cinnamomum burmanni* Blume.
Cassia, Saigon	*Cinnamomum loureirii* Nees.
Cayenne pepper	*Capsicum frutescens* L. or *Capsicum annuum* L.
Celery seed	*Apium graveolens* L.
Chervil	*Anthriscus cerefolium* (L.) Hoffm.
Chives	*Allium schoenoprasum* L.
Cinnamon, Ceylon	*Cinnamomum zeylanicum* Nees.
Cinnamon, Chinese	*Cinnamomum cassia* Blume.
Cinnamon, Saigon	*Cinnamomum loureirii* Nees.
Clary (clary sage)	*Salvia sclarea L.*
Clover	*Trifolium* spp.
Cloves	*Eugenia caryophyllata* Thunb.
Coriander	*Coriandrum sativum* L.
Cumin (cummin)	*Cuminum cyminum* L.
Cumin, black (black caraway)	*Nigella sativa* L.
Dill	*Anethum graveolens* L.
Elder flowers	*Sambucus canadensis* L.
Fennel, common	*Foeniculum vulgare* Mill.
Fennel, sweet (finocchio, Florence fennel)	*Foeniculum vulgare* Mill. var. duice (DC.) Alex.
Fenugreek	*Trigonella foenum-graecum* L.
Galanga (galangal)	*Alpina officinarum* Hance.
Garlic	*Allium sativum* L.
Geranium	*Pelargonium* spp.
Ginger	*Zingiber officinale* Rosc.
Glycyrrhiza	*Glycyrrhiza glabra* L. and other spp. of *Glycyrrhiza.*
Grains of paradise	*Amomum melegueta* Rosc.
Horehound (hoarhound)	*Marrubium vulgare* L.
Horseradish	*Armoracia lapathifolia* Gilib.
Hyssop	*Hyssopus officinalis* L.
Lavender	*Lavandula officinalis* Chaix.
Licorice	*Glycyrrhiza glabra* L. and other spp. of *Glycyrrhiza.*
Linden flowers	*Tilia* spp.
Mace	*Myristica fragrans* Houtt.
Marigold, pot	*Calendula officinalis* L.
Marjoram, pot	*Majorana onites* (L.) Benth.
Marjoram, sweet	*Majorana hortensis* Moench.
Mustard, black or brown	*Brassica nigra* (L.) Koch.

Common name	Botanical name of plant source
Mustard, brown	*Brassica juncea* (L.) Coss.
Mustard, white or yellow	*Brassica hirta* Moench.
Nutmeg	*Myristica fragrans* Houtt.
Oregano (oreganum, Mexican oregano, Mexican sage, origan)	*Lippia* spp.
Paprika	*Capsicum annuum* L.
Parsley	*Petroselinum crispum* (Mill.) Mansf.
Pepper, black	*Piper nigrum* L.
Pepper, cayenne	*Capsicum frutescens* L. or *Capsicum annuum* L.
Pepper, red	Do.
Pepper, white	*Piper nigrum* L.
Peppermint	*Mentha piperita* L.
Poppy seed	*Papaver somniferum* L.
Pot marigold	*Calendula officinalis* L.
Pot marjoram	*Majorana onites* (L.) Benth.
Rosemary	*Rosmarinus officinalis* L.
Rue	*Ruta graveolens* L.
Saffron	*Crocus sativus* L.
Sage	*Salvia officinalis* L.
Sage, Greek	*Salvia triloba* L.
Savory, summer	*Satureia hortensis* L. (Satureja).
Savory, winter	*Satureia montana* L. (Satureja).
Sesame	*Sesamum indicum* L.
Spearmint	*Mentha spicata* L.
Star anise	*Illicium verum* Hook. f.
Tarragon	*Artemisia dracunculus* L.
Thyme	*Thymus vulgaris* L.
Thyme, wild or creeping	*Thymus serpyllum* L.
Turmeric	*Curcuma longa* L.
Vanilla	*Vanilla planifolia* Andr. or *Vanilla tahitensis* J. W. Moore.
Zedoary	*Curcuma zedoaria* Rosc.

§ 582.20 Essential oils, oleoresins (solvent-free), and natural extractives (including distillates).

Essential oils, oleoresins (solvent-free), and natural extractives (including distillates) that are generally recognized as safe for their intended use, within the meaning of section 409 of the act, are as follows:

Common name	Botanical name of plant source
Alfalfa	*Medicago sativa* L.
Allspice	*Pimenta officinalis* Lindl.
Almond, bitter (free from prussic acid)	*Prunus amygdalus* Batsch, *Prunus armeniaca* L. or *Prunus persica* (L.) Batsch.
Ambrette (seed)	*Hibiscus moschatus* Moench.
Angelica root	*Angelica archangelica* L.
Angelica seed	Do.
Angelica stem	Do.
Angostura (cusparia bark)	*Galipea officinalis* Hancock.
Anise	*Pimpinella anisum* L.
Asafetida	*Ferula assa-foetida* L. and related spp. of Ferula.
Balm (lemon balm)	*Melissa officinalis* L.
Balsam of Peru	*Myroxylon pereirae* Klotzsch.
Basil	*Ocimum basilicum* L.
Bay leaves	*Laurus nobilis* L.
Bay (myrcia oil)	*Pimenta racemosa* (Mill.) J. W. Moore.
Bergamot (bergamot orange)	*Citrus aurantium* L. subsp. bergamia Wright et Arn.
Bitter almond (free from prussic acid)	*Prunus amygdalus* Batsch, *Prunus armeniaca* L., or *Prunus persica* (L.) Batsch.
Bois de rose	*Aniba rosaeodora* Ducke.
Cacao	*Theobroma cacao* L.
Camomile (chamomile) flowers, Hungarian	*Matricaria chamomilla* L.
Camomile (chamomile) flowers, Roman or English	*Anthemis nobilis* L.
Cananga	*Cananga odorata* Hook. f. and Thoms.
Capsicum	*Capsicum frutescens* L. and *Capsicum annuum* L.
Caraway	*Carum carvi* L.
Cardamom seed (cardamon)	*Elettaria cardamomum* Maton.
Carob bean	*Ceratonia siliqua* L.
Carrot	*Daucus carota* L.
Cascarilla bark	*Croton eluteria* Benn.
Cassia bark, Chinese	*Cinnamomum cassia* Blume.

Common name	Botanical name of plant source
Cassia bark, Padang or Batavia	*Cinnamomum burmanni* Blume.
Cassia bark, Saigon	*Cinnamomum loureirii* Nees.
Celery seed	*Apium graveolens* L.
Cherry, wild, bark	*Prunus serotina* Ehrh.
Chervil	*Anthriscus cerefolium* (L.) Hoffm.
Chicory	*Cichorium intybus* L.
Cinnamon bark, Ceylon	*Cinnamomum zeylanicum* Nees.
Cinnamon bark, Chinese	*Cinnamomum cassia* Blume.
Cinnamon bark, Saigon	*Cinnamomum loureirii* Nees.
Cinnamon leaf, Ceylon	*Cinnamomum zeylanicum* Nees.
Cinnamon leaf, Chinese	*Cinnamomum cassia* Blume.
Cinnamon leaf, Saigon	*Cinnamomum loureirii* Nees.
Citronella	*Cymbopogon nardus* Rendle.
Citrus peels	*Citrus* spp.
Clary (clary sage)	*Salvia sclarea* L.
Clove bud	*Eugenia caryophyllata* Thunb.
Clove leaf	Do.
Clove stem	Do.
Clover	*Trifolium* spp.
Coca (decocainized)	*Erythroxylum coca* Lam. and other spp. of Erythroxylum.
Coffee	*Coffea* spp.
Cola nut	*Cola acuminata* Schott and Endl., and other spp. of Cola.
Coriander	*Coriandrum sativum* L.
Corn silk	*Zea mays* L.
Cumin (cummin)	*Cuminum cyminum* L.
Curacao orange peel (orange, bitter peel)	*Citrus aurantium* L.
Cusparia bark	*Galipea officinalis* Hancock.
Dandelion	*Taraxacum officinale* Weber and *T. laevigatum* DC.
Dandelion root	Do.
Dill	*Anethum graveolens* L.
Dog grass (quackgrass, triticum)	*Agropyron repens* (L.) Beauv.
Elder flowers	*Sambucus canadensis* L. and S. nigra L.
Estragole (esdragol, esdragon, tarragon)	*Artemisia dracunculus* L.
Estragon (tarragon)	Do.
Fennel, sweet	*Foeniculum vulgare* Mill.
Fenugreek	*Trigonella foenum-graecum* L.
Galanga (galangal)	*Alpinia officinarum* Hance.
Garlic	*Allium sativum* L.
Geranium	*Pelargonium* spp.
Geranium, East Indian	*Cymbopogon martini* Stapf.
Geranium, rose	*Pelargonium graveolens* L'Her.
Ginger	*Zingiber officinale* Rosc.
Glycyrrhiza	*Glycyrrhiza glabra* L. and other spp. of Glycyrrhiza.
Glycyrrhizin, ammoniated	Do.
Grapefruit	*Citrus paradisi* Macf.
Guava	*Psidium* spp.
Hickory bark	*Carya* spp.
Horehound (hoarhound)	*Marrubium vulgare* L.
Hops	*Humulus lupulus* L.
Horsemint	*Monarda punctata* L.
Hyssop	*Hyssopus officinalis* L.
Immortelle	*Helichrysum augustifolium* DC.
Jasmine	*Jaminum officinale* L. and other spp. of Jasminum.
Juniper (berries)	*Juniperus communis* L.
Kola nut	*Cola acuminata* Schott and Endl., and other spp. of Cola.
Laurel berries	*Laurus nobilis* L.
Laurel leaves	*Laurus* spp.
Lavender	*Lavandula officinalis* Chaix.
Lavender, spike	*Lavandula latifolia* Vill.
Lavandin	Hybrids between *Lavandula officinalis* Chaix and *Lavandula latifolin* Vill.
Lemon	*Citrus limon* (L.) Burm. f.
Lemon balm (see balm).	
Lemon grass	*Cymbopogon citratus* DC. and *Cymbopogon flexuosus* Stapf.
Lemon peel	*Citrus limon* (L.) Burm. f.
Licorice	*Glycyrrhiza glabra* L. and other spp. of Glycyrrhiza.
Lime	*Citrus aurantifolia* Swingle.
Linden flowers	*Tilia* spp.
Locust bean	*Ceratonia siliqua* L.
Lupulin	*Humulus lupulus* L.
Mace	*Myristica fragrans* Houtt.
Malt (extract)	*Hordeum vulgare* L., or other grains.
Mandarin	*Citrus reticulata* Blanco.
Marjoram, sweet	*Majorana hortensis* Moench.

Common name	Botanical name of plant source
Mate 1	*Ilex paraguariensis* St. Hil.
Melissa (see balm).	
Menthol	*Mentha* spp.
Menthyl acetate	Do.
Molasses (extract)	*Saccharum officinarum* L.
Mustard	*Brassica* spp.
Naringin	*Citrus paradisi* Macf.
Neroli, bigarade	*Citrus aurantium* L.
Nutmeg	*Myristica fragrans* Houtt.
Onion	*Allium cepa* L.
Orange, bitter, flowers	*Citrus aurantium* L.
Orange, bitter, peel	Do.
Orange leaf	*Citrus sinensis* (L.) Osbeck.
Orange, sweet	Do.
Orange, sweet, flowers	Do.
Orange, sweet, peel	Do.
Origanum	*Origanum* spp.
Palmarosa	*Cymbopogon martini* Stapf.
Paprika	*Capsicum annuum* L.
Parsley	*Petroselinum crispum* (Mill.) Mansf.
Pepper, black	*Piper nigrum* L.
Pepper, white	*Piper nigrum* L.
Peppermint	*Mentha piperita* L.
Peruvian balsam	*Myroxylon pereirae* Klotzsch.
Petitgrain	*Citrus aurantium* L.
Petitgrain lemon	*Citrus limon* (L.) Burm. f.
Petitgrain mandarin or tangerine	*Citrus reticulata* Blanco.
Pimenta	*Pimenta officinalis* Lindl.
Pimenta leaf	*Primenta officinalis* Lindl.
Pipsissewa leaves	*Chimaphila umbellata* Nutt.
Pomegranate	*Punica granatum* L.
Prickly ash bark	*Xanthoxylum* (*or Zanthoxylum*) *Americanum* Mill. or *Xanthoxylum clava-herculis* L.
Rose absolute	*Rosa alba* L., *Rosa centifolia* L., *Rosa damascena* Mill., *Rosa gallica* L., and vars. of these spp.
Rose (otto of roses, attar of roses)	Do.
Rose buds	Do.
Rose flowers	Do.
Rose fruit (hips)	Do.
Rose geranium	*Pelargonium graveolens* L'Her.
Rose leaves	*Rosa* spp.
Rosemary	*Rosmarinus officinalis* L.
Rue	*Ruta graveolens* L.
Saffron	*Crocus sativus* L.
Sage	*Salvia officinalis* L.
Sage, Greek	*Salvia triloba* L.
Sage, Spanish	*Salvia lavandulaefolia* Vahl.
St. John's bread	*Ceratonia siliqua* L.
Savory, summer	*Satureia hortensis* L.
Savory, winter	*Satureia montana* L.
Schinus molle	*Schinus molle* L.
Sloe berries (blackthorn berries)	*Prunus spinosa* L.
Spearmint	*Mentha spicata* L.
Spike lavender	*Lavandula latifolia* Vill.
Tamarind	*Tamarindus indica* L.
Tangerine	*Citrus reticulata* Blanco.
Tannic acid	Nutgalls of *Quercus infectoria* Oliver and related spp. of Quercus. Also in many other plants.
Tarragon	*Artemisia dracunculus* L.
Tea	*Thea sinensis* L.
Thyme	*Thymus vulgaris* L. and *Thymus zygis* var. gracilis Boiss.
Thyme, white	Do.
Thyme, wild or creeping	*Thymus serpyllum* L.
Triticum (see dog grass).	
Tuberose	*Polianthes tuberosa* L.
Turmeric	*Curcuma longa* L.
Vanilla	*Vanilla planifolia* Andr. or *Vanilla tahitensis* J. W. Moore.
Violet flowers	*Viola odorata* L.
Violet leaves	Do.
Violet leaves absolute	Do.
Wild cherry bark	*Prunus serotina* Ehrh.
Ylang-ylang	*Cananga odorata* Hook. f. and Thoms.
Zedoary bark	*Curcuma zedoaria* Rosc.

§ 582.30 Natural substances used in conjunction with spices and other natural seasonings and flavorings.

Natural substances used in conjunction with spices and other natural seasonings and flavorings that are generally recognized as safe for their intended use, within the meaning of section 409 of the act, are as follows:

Common name	Botanical name of plant source
Algae, brown (kelp)	*Laminaria* spp. and *Nereocystis* spp.
Algae, red	*Porphyra* spp. and *Rhodymenia palmata* (L.) Grev.
Dulse	*Rhodymenia palmata* (L.)

§ 582.40 Natural extractives (solvent-free) used in conjunction with spices, seasonings, and flavorings.

Natural extractives (solvent-free) used in conjunction with spices, seasonings, and flavorings that are generally recognized as safe for their intended use, within the meaning of section 409 of the act, are as follows:

Common name	Botanical name of plant source
Algae, brown	*Laminaria* spp. and *Nereocystis* spp.
Algae, red	*Porphyra* spp. and *Rhodymenia palmata* (L.) Grev.
Apricot kernel (persic oil)	*Prunus armeniaca* L.
Dulse	*Rhodymenia palmata* (L.) Grev.
Kelp (see algae, brown).	
Peach kernel (persic oil)	*Prunus persica* Sieb. et Zucc.
Peanut stearine	*Arachis hypogaea* L.
Persic oil (see apricot kernel and peach kernel).	
Quince seed	*Cydonia oblonga* Miller.

§ 582.50 Certain other spices, seasonings, essential oils, oleoresins, and natural extracts.

Certain other spices, seasonings, essential oils, oleoresins, and natural extracts that are generally recognized as safe for their intended use, within the meaning of section 409 of the act, are as follows:

Common name	Derivation
Ambergris	*Physeter macrocephalus* L.
Castoreum	Castor fiber L. and C. *canadensis* Kuhl.
Civet (zibeth, zibet, zibetum)	Civet cats, *Viverra civetta* Schreber and *Viverra zibetha* Schreber.
Cognac oil, white and green	*Ethyl oenanthate,* so-called.
Musk (Tonquin musk)	Musk deer, *Moschus moschiferus* L.

§ 582.60 Synthetic flavoring substances and adjuvants.

Synthetic flavoring substances and adjuvants that are generally recognized as safe for their intended use, within the meaning of section 409 of the act, are as follows:

Acetaldehyde (ethanal).
Acetoin (acetyl methylcarbinol).
Aconitic acid (equisetic acid, citridic acid, achilleic acid).
Anethole (parapropenyl anisole).
Benzaldehyde (benzoic aldehyde).
N-Butyric acid (butanoic acid).
d- or *l*-Carvone (carvol).
Cinnamaldehyde (cinnamic aldehyde).
Citral (2,6-dimethyloctadien-2,6-*al*-8, geranial, neral).
Decanal (*N*-decylaldhehyde, capraldehyde, capric aldehyde, caprinaldehyde, aldehyde *C*-10).
Diacetyl (2,3-butandeione). Ethyl acetate. Ethyl butyrate.
3-Methyl-3-phenyl glycidic acid ethyl ester (ethyl-methyl-phenyl-glycidate, so-called strawberry aldehyde, C-16 aldehyde).
Ethyl vanillin.
Eugenol.
Geranoil (3,7-dimethyl-2,6 and 3,6-octadien-1-*ol*).
Geranyl acetate (geraniol acetate).

Glycerol (glyceryl) tributyrate (tributyrin, butyrin).
Limonene (*d-*, *l-*, *and dl-*).
Linalool (linalol, 3,7-dimethyl-1,6-octadien-3-*ol*).
Linalyl acetate (bergamol).
1-Malic acid.
Methyl anthranilate (methyl-2-aminobenzoate).
Piperonal (3,4-methylenedioxy-benzaldehyde, heliotropin).
Vanillin.

§ 582.80 Trace minerals added to animal feeds.

These substances added to animal feeds as nutritional dietary supplements are generally recognized as safe when added at levels consistent with good feeding practice.[1]

Element	Source compounds
Cobalt	Cobalt acetate.
	Cobalt carbonate.
	Cobalt chloride.
	Cobalt oxide.
	Cobalt sulfate.
Copper	Copper carbonate.
	Copper chloride.
	Copper gluconate.
	Copper hydroxide.
	Copper orthophosphate.
	Copper oxide.
	Copper pyrophosphate.
	Copper sulfate.
Iodine	Calcium iodate.
	Calcium iodobehenate.
	Cuprous iodide.
	3,5-Diiodosalicylic acid.
	Ethylenediamine dihydroiodide.
	Potassium iodate.
	Potassium iodide.
	Sodium iodate.
	Sodium iodide.
	Thymol iodide.
Iron	Iron ammonium citrate.
	Iron carbonate.
	Iron chloride.
	Iron gluconate.
	Iron oxide.
	Iron phosphate.
	Iron pyrophosphate.
	Iron sulfate.
	Reduced iron.
Manganese	Manganese acetate.
	Manganese carbonate.
	Manganese citrate (soluble).
	Manganese chloride.
	Manganese gluconate.
	Manganese orthophosphate.
	Manganese phosphate (dibasic).
	Manganese sulfate.
	Manganous oxide.
Zinc	Zinc acetate.
	Zinc carbonate.
	Zinc chloride.
	Zinc oxide.
	Zinc sulfate.

§ 582.99 Adjuvants for pesticide chemicals.

Adjuvants, identified and used in accordance with 40 CFR 180.1001(c) and (d), which are added to pesticide use dilutions by a grower or applicator prior to application to the raw agricultural commodity, are exempt from the requirement of tolerances under section 409 of the act.

Subpart B—General Purpose Food Additives

§ 582.1005 Acetic acid.

(a) *Product*. Acetic acid.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1009 Adipic acid.

(a) *Product*. Adipic acid.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation*. This substance is generally recognized as safe when used as a buffer and neutralizing agent in accordance with good manufacturing or feeding practice.

§ 582.1033 Citric acid.

(a) *Product*. Citric acid.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1057 Hydrochloric acid.

(a) *Product*. Hydrochloric acid.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation*. This substance is generally recognized as safe when used as a buffer and neutralizing agent in accordance with good manufacturing or feeding practice.

§ 582.1061 Lactic acid.

(a) *Product*. Lactic acid.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1069 Malic acid.

(a) *Product*. Malic acid.

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[1] All substances listed may be in anhydrous or hydrated form.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1073 Phosphoric acid.

(a) *Product.* Phosphoric acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1077 Potassium acid tartrate.

(a) *Product.* Potassium acid tartrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1087 Sodium acid pyrophosphate.

(a) *Product.* Sodium acid pyrophosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1091 Succinic acid.

(a) *Product.* Succinic acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1095 Sulfuric acid.

(a) *Product.* Sulfuric acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1099 Tartaric acid.

(a) *Product.* Tartaric acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1125 Aluminum sulfate.

(a) *Product.* Aluminum sulfate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1127 Aluminum ammonium sulfate.

(a) *Product.* Aluminum ammonium sulfate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1129 Aluminum potassium sulfate.

(a) *Product.* Aluminum potassium sulfate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1131 Aluminum sodium sulfate.

(a) *Product.* Aluminum sodium sulfate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1135 Ammonium bicarbonate.

(a) *Product.* Ammonium bicarbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1137 Ammonium carbonate.

(a) *Product.* Ammonium carbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1139 Ammonium hydroxide.

(a) *Product.* Ammonium hydroxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1141 Ammonium phosphate.

(a) *Product.* Ammonium phosphate (mono- and dibasic).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1143 Ammonium sulfate.

(a) *Product.* Ammonium sulfate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1155 Bentonite.

(a) *Product.* Bentonite.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1165 Butane.

(a) *Product.* Butane.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1191 Calcium carbonate.

(a) *Product.* Calcium carbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1193 Calcium chloride.

(a) *Product.* Calcium chloride.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1195 Calcium citrate.

(a) *Product.* Calcium citrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1199 Calcium gluconate.

(a) *Product.* Calcium gluconate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1205 Calcium hydroxide.

(a) *Product.* Calcium hydroxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1207 Calcium lactate.

(a) *Product.* Calcium lactate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1210 Calcium oxide.

(a) *Product.* Calcium oxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1217 Calcium phosphate.

(a) *Product.* Calcium phosphate (mono-, di-, and tribasic).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1235 Caramel.

(a) *Product.* Caramel.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1240 Carbon dioxide.

(a) *Product.* Carbon dioxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1275 Dextrans.

(a) *Product.* Dextrans of average molecular weight below 100,000.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1320 Glycerin.

(a) *Product.* Glycerin.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1324 Glyceryl monostearate.

(a) *Product.* Glyceryl monostearate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1355 Helium.

(a) *Product.* Helium.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1366 Hydrogen peroxide.

(a) *Product.* Hydrogen peroxide.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used as a bleaching agent in accordance with good manufacturing or feeding practice.

§ 582.1400 Lecithin.

(a) *Product.* Lecithin.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1425 Magnesium carbonate.

(a) *Product.* Magnesium carbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1428 Magnesium hydroxide.

(a) *Product.* Magnesium hydroxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1431 Magnesium oxide.

(a) *Product.* Magnesium oxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1480 Methylcellulose.

(a) *Product.* U.S.P. methylcellulose, except that the methoxy content shall not be less than 27.5 percent and not more than 31.5 percent on a dry-weight basis.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1500 Monoammonium glutamate.

(a) *Product.* Monoammonium glutamate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1516 Monopotassium glutamate.

(a) *Product.* Monopotassium glutamate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1540 Nitrogen.

(a) *Product.* Nitrogen.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1585 Papain.

(a) *Product.* Papain.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1613 Potassium bicarbonate.

(a) *Product.* Potassium bicarbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1619 Potassium carbonate.

(a) *Product.* Potassium carbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1625 Potassium citrate.

(a) *Product.* Potassium citrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1631 Potassium hydroxide.

(a) *Product.* Potassium hydroxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1643 Potassium sulfate.

(a) *Product.* Potassium sulfate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1655 Propane.

(a) *Product.* Propane.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1666 Propylene glycol.

(a) *Product.* Propylene glycol.

(b) *Conditions of use.* This substance is generally recognized as safe (except in cat food) when used in accordance with good manufacturing or feeding practice.

[41 FR 38657, Sept. 10, 1976, as amended at 61 FR 19544, May 2, 1996]

§582.1685 Rennet.

(a) *Product.* Rennet (rennin).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1711 Silica aerogel.

(a) *Product.* Silica aerogel as a finely powdered microcellular silica foam having a minimum silica content of 89.5 percent.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used as a component of antifoaming agents in accordance with good manufacturing or feeding practice.

§582.1721 Sodium acetate.

(a) *Product.* Sodium acetate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1736 Sodium bicarbonate.

(a) *Product.* Sodium bicarbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1742 Sodium carbonate.

(a) *Product.* Sodium carbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1745 Sodium carboxymethylcellulose.

(a) *Product.* Sodium carboxymethylcellulose is the sodium salt of carboxymethylcellulose not less than 99.5 percent on a dry-weight basis, with maximum substitution of 0.95 carboxymethyl groups per anhydroglucose unit, and with a minimum viscosity of 25 centipoises for 2 percent by weight aqueous solution at 25 °C.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1748 Sodium caseinate.

(a) *Product.* Sodium caseinate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1751 Sodium citrate.

(a) *Product.* Sodium citrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1763 Sodium hydroxide.

(a) *Product.* Sodium hydroxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1775 Sodium pectinate.

(a) *Product.* Sodium pectinate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1778 Sodium phosphate.

(a) *Product.* Sodium phosphate (mono-, di-, and tribasic).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1781 Sodium aluminum phosphate.

(a) *Product.* Sodium aluminum phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§582.1792 Sodium sesquicarbonate.

(a) *Product.* Sodium sesquicarbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when

used in accordance with good manufacturing or feeding practice.

§ 582.1804 Sodium potassium tartrate.

(a) *Product.* Sodium potassium tartrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1810 Sodium tripolyphosphate.

(a) *Product.* Sodium tripolyphosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1901 Triacetin.

(a) *Product.* Triacetin (glyceryl triacetate).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1973 Beeswax.

(a) *Product.* Beeswax (yellow wax).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1975 Bleached beeswax.

(a) *Product.* Bleached beeswax (white wax).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.1978 Carnauba wax.

(a) *Product.* Carnauba wax.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

Subpart C—Anticaking Agents

§ 582.2122 Aluminum calcium silicate.

(a) *Product.* Aluminum calcium silicate.

(b) *Tolerance.* 2 percent.

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in table salt in accordance with good manufacturing or feeding practice.

§ 582.2227 Calcium silicate.

(a) *Product.* Calcium silicate.

(b) *Tolerance.* 2 percent and 5 percent.

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used at levels not exceeding 2 percent in table salt and 5 percent in baking powder in accordance with good manufacturing or feeding practice.

§ 582.2437 Magnesium silicate.

(a) *Product.* Magnesium silicate.

(b) *Tolerance.* 2 percent.

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in table salt in accordance with good manufacturing or feeding practice.

§ 582.2727 Sodium aluminosilicate.

(a) *Product.* Sodium aluminosilicate (sodium silicoaluminate).

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 2 percent in accordance with good manufacturing or feeding practice.

§ 582.2729 Hydrated sodium calcium aluminosilicate.

(a) *Product.* Hydrated sodium calcium aluminosilicate (sodium calcium silicoaluminate).

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 2 percent in accordance with good manufacturing or feeding practice.

§ 582.2906 Tricalcium silicate.

(a) *Product.* Tricalcium silicate.

(b) *Tolerance.* 2 percent.

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in table salt in accordance with good manufacturing or feeding practice.

Subpart D—Chemical Preservatives

§ 582.3013 Ascorbic acid.

(a) *Product.* Ascorbic acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3021 Benzoic acid.

(a) *Product.* Benzoic acid.

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 0.1 percent in accordance with good manufacturing or feeding practice.

§ 582.3041 Erythorbic acid.

(a) *Product.* Erythorbic acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3081 Propionic acid.

(a) *Product.* Propionic acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3089 Sorbic acid.

(a) *Product.* Sorbic acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3109 Thiodipropionic acid.

(a) *Product.* Thiodipropionic acid.

(b) *Tolerance.* This substance is generally recognized as safe for use in food when the total content of antioxidants is not over 0.02 percent of fat or oil content including essential (volatile) oil content of the food, provided the substance is used in accordance with good manufacturing or feeding practice.

§ 582.3149 Ascorbyl palmitate.

(a) *Product.* Ascorbyl palmitate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3169 Butylated hydroxyanisole.

(a) *Product.* Butylated hydroxyanisole.

(b) *Tolerance.* This substance is generally recognized as safe for use in food when the total content of antioxidants is not over 0.02 percent of fat or oil content, including essential (volatile) oil content of food provided the substance is used in accordance with good manufacturing or feeding practice.

§ 582.3173 Butylated hydroxytoluene.

(a) *Product.* Butylated hydroxytoluene.

(b) *Tolerance.* This substance is generally recognized as safe for use in food when the total content of antioxidants is not over 0.02 percent of fat or oil content, including essential (volatile) oil content of food provided the substance is used in accordance with good manufacturing or feeding practice.

§ 582.3189 Calcium ascorbate.

(a) *Product.* Calcium ascorbate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3221 Calcium propionate.

(a) *Product.* Calcium propionate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3225 Calcium sorbate.

(a) *Product.* Calcium sorbate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3280 Dilauryl thiodipropionate.

(a) *Product.* Dilauryl thiodipropionate.

(b) *Tolerance.* This substance is generally recognized as safe for use in food when the total content of antioxidants is not over 0.02 percent of fat or oil content, including essential (volatile) oil content of the food, provided the substance is used in accordance with good manufacturing or feeding practice.

§ 582.3336 Gum guaiac.

(a) *Product.* Gum guaiac.

(b) *Tolerance.* 0.1 percent (equivalent antioxidant activity 0.01 percent).

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in edible fats or oils in accordance with good manufacturing or feeding practice.

§ 582.3490 Methylparaben.

(a) *Product.* Methylparaben (methyl *p*-hydroxybenzoate).

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 0.1 percent in accordance with good manufacturing or feeding practice.

§ 582.3616 Potassium bisulfite.

(a) *Product.* Potassium bisulfite.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice, except that it is not used in meats or in food recognized as source of vitamin B_1.

§ 582.3637 Potassium metabisulfite.

(a) *Product.* Potassium metabisulfite.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice, except that it is not used in meats or in food recognized as source of vitamin B_1.

§ 582.3640 Potassium sorbate.

(a) *Product.* Potassium sorbate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3660 Propyl gallate.

(a) *Product.* Propyl gallate.

(b) *Tolerance.* This substance is generally recognized as safe for use in food when the total content of antioxidants is not over 0.02 percent of fat or oil content, including essential (volatile) oil content of the food, provided the substance is used in accordance with good manufacturing or feeding practice.

§ 582.3670 Propylparaben.

(a) *Product.* Propylparaben (propyl *p*-hydroxybenzoate).

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 0.1 percent in accordance with good manufacturing or feeding practice.

§ 582.3731 Sodium ascorbate.

(a) *Product.* Sodium ascorbate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3733 Sodium benzoate.

(a) *Product.* Sodium benzoate.

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 0.1 percent in accordance with good manufacturing or feeding practice.

§ 582.3739 Sodium bisulfite.

(a) *Product.* Sodium bisulfite.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice, except that it is not used in meats or in food recognized as source of vitamin B_1.

§ 582.3766 Sodium metabisulfite.

(a) *Product.* Sodium metabisulfite.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice, except that it is not used in meats or in food recognized as source of vitamin B_1.

§ 582.3784 Sodium propionate.

(a) *Product.* Sodium propionate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3795 Sodium sorbate.

(a) *Product.* Sodium sorbate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.3798 Sodium sulfite.

(a) *Product.* Sodium sulfite.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice, except that it is not used in meats or in food recognized as source of vitamin B_1.

§ 582.3845 Stannous chloride.

(a) *Product.* Stannous chloride.

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 0.0015 percent calculated as tin in accordance with good manufacturing or feeding practice.

§ 582.3862 Sulfur dioxide.

(a) *Product.* Sulfur dioxide.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice, except that it is not used in meats or in food recognized as source of vitamin B_1.

§ 582.3890 Tocopherols.

(a) *Product.* Tocopherols.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

Subpart E—Emulsifying Agents

§ 582.4101 Diacetyl tartaric acid esters of mono- and diglycerides of edible fats or oils, or edible fat-forming fatty acids.

(a) *Product.* Diacetyl tartaric acid esters of mono- and diglycerides of edible fats or oils, or edible fat-forming fatty acids.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.4505 Mono- and diglycerides of edible fats or oils, or edible fat-forming acids.

(a) *Product.* Mono- and diglycerides of edible fats or oils, or edible fat-forming acids.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.4521 Monosodium phosphate derivatives of mono- and diglycerides of edible fats or oils, or edible fat-forming fatty acids.

(a) *Product.* Monosodium phosphate derivatives of mono- and diglycerides of edible fats or oils, or edible fat-forming fatty acids.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.4666 Propylene glycol.

(a) *Product.* Propylene glycol.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

Subpart F—Nutrients and/or Dietary Supplements[1]

§ 582.5013 Ascorbic acid.

(a) *Product.* Ascorbic acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5017 Aspartic acid.

(a) *Product.* Aspartic acid (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5049 Aminoacetic acid.

(a) *Product.* Glycine (aminoacetic acid).

(b) [Reserved]

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in animal feeds in accordance with good manufacturing or feeding practice.

§ 582.5065 Linoleic acid.

(a) *Product.* Linoleic acid prepared from edible fats and oils and free from chick-edema factor.

(b) *Conditions of use.* This substance is generally recognized as safe when

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[1] Amino acids listed in this subpart may be free hydrochloride salt, hydrated, or anhydrous form, where applicable.

used in accordance with good manufacturing or feeding practice.

§ 582.5118 Alanine.

(a) *Product.* Alanine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5145 Arginine.

(a) *Product.* Arginine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5159 Biotin.

(a) *Product.* Biotin.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5191 Calcium carbonate.

(a) *Product.* Calcium carbonate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5195 Calcium citrate.

(a) *Product.* Calcium citrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5201 Calcium glycerophosphate.

(a) *Product.* Calcium glycerophosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5210 Calcium oxide.

(a) *Product.* Calcium oxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5212 Calcium pantothenate.

(a) *Product.* Calcium pantothenate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5217 Calcium phosphate.

(a) *Product.* Calcium phosphate (mono-, di-, and tribasic).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5223 Calcium pyrophosphate.

(a) *Product.* Calcium pyrophosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5230 Calcium sulfate.

(a) *Product.* Calcium sulfate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5245 Carotene.

(a) *Product.* Carotene.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5250 Choline bitartrate.

(a) *Product.* Choline bitartrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5252 Choline chloride.

(a) *Product.* Choline chloride.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5260 Copper gluconate.

(a) *Product.* Copper gluconate.

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 0.005 percent in accordance with good manufacturing or feeding practice.

§ 582.5271 Cysteine.

(a) *Product.* Cysteine (L-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5273 Cystine.

(a) *Product.* Cystine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5301 Ferric phosphate.

(a) *Product.* Ferric phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5304 Ferric pyrophosphate.

(a) *Product.* Ferric pyrophosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5306 Ferric sodium pyrophosphate.

(a) *Product.* Ferric sodium pyrophosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5308 Ferrous gluconate.

(a) *Product.* Ferrous gluconate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5311 Ferrous lactate.

(a) *Product.* Ferrous lactate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5315 Ferrous sulfate.

(a) *Product.* Ferrous sulfate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5361 Histidine.

(a) *Product.* Histidine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5370 Inositol.

(a) *Product.* Inositol.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5375 Iron reduced.

(a) *Product.* Iron reduced.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5381 Isoleucine.

(a) *Product.* Isoleucine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5406 Leucine.

(a) *Product.* Leucine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5411 Lysine.

(a) *Product.* Lysine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5431 Magnesium oxide.

(a) *Product.* Magnesium oxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5434 Magnesium phosphate.

(a) *Product.* Magnesium phosphate (di- and tribasic).

(b) *Conditions of use.* This substance is generally recognized as safe when

used in accordance with good manufacturing or feeding practice.

§ 582.5443 Magnesium sulfate.

(a) *Product*. Magnesium sulfate.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5446 Manganese chloride.

(a) *Product*. Manganese chloride.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5449 Manganese citrate.

(a) *Product*. Manganese citrate.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5452 Manganese gluconate.

(a) *Product*. Manganese gluconate.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5455 Manganese glycerophosphate.

(a) *Product*. Manganese glycerophosphate.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5458 Manganese hypophosphite.

(a) *Product*. Manganese hypophosphite.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5461 Manganese sulfate.

(a) *Product*. Manganese sulfate.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5464 Manganous oxide.

(a) *Product*. Manganous oxide.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5470 Mannitol.

(a) *Product*. Mannitol.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5475 Methionine.

(a) *Product*. Methionine.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation*. This substance is generally recognized as safe when used in animal feeds in accordance with good manufacturing or feeding practice.

§ 582.5477 Methionine hydroxy analog and its calcium salts.

(a) *Product*. Methionine hydroxy analog and its calcium salts.

(b) [Reserved]

(c) *Limitations, restrictions, or explanation*. This substance is generally recognized as safe when used in animal feeds in accordance with good manufacturing or feeding practice.

§ 582.5530 Niacin.

(a) *Product*. Niacin.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5535 Niacinamide.

(a) *Product*. Niacinamide.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5580 D-Pantothenyl alcohol.

(a) *Product*. D-Pantothenyl alcohol.

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5590 Phenylalanine.

(a) *Product*. Phenylalanine (L- and DL-forms).

(b) *Conditions of use*. This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5622 Potassium chloride.

(a) *Product.* Potassium chloride.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5628 Potassium glycerophosphate.

(a) *Product.* Potassium glycerophosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5634 Potassium iodide.

(a) *Product.* Potassium iodide.

(b) *Tolerance.* 0.01 percent.

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in table salt as a source of dietary iodine in accordance with good manufacturing or feeding practice.

§ 582.5650 Proline.

(a) *Product.* Proline (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5676 Pyridoxine hydrochloride.

(a) *Product.* Pyridoxine hydrochloride.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5695 Riboflavin.

(a) *Product.* Riboflavin.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5697 Riboflavin-5-phosphate.

(a) *Product.* Riboflavin-5-phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5701 Serine.

(a) *Product.* Serine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5772 Sodium pantothenate.

(a) *Product.* Sodium pantothenate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5778 Sodium phosphate.

(a) *Product.* Sodium phosphate (mono-, di-, and tribasic).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5835 Sorbitol.

(a) *Product.* Sorbitol.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5875 Thiamine hydrochloride.

(a) *Product.* Thiamine hydrochloride.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5878 Thiamine mononitrate.

(a) *Product.* Thiamine mononitrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5881 Threonine.

(a) *Product.* Threonine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5890 Tocopherols.

(a) *Product.* Tocopherols.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5892 *a*-Tocopherol acetate.

(a) *Product.* *a*-Tocopherol acetate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5915 Tryptophane.

(a) *Product.* Tryptophane (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5920 Tyrosine.

(a) *Product.* Tyrosine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5925 Valine.

(a) *Product.* Valine (L- and DL-forms).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5930 Vitamin A.

(a) *Product.* Vitamin A.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5933 Vitamin A acetate.

(a) *Product.* Vitamin A acetate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5936 Vitamin A palmitate.

(a) *Product.* Vitamin A palmitate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5945 Vitamin B_{12}.

(a) *Product.* Vitamin B_{12}.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5950 Vitamin D_2.

(a) *Product.* Vitamin D_2.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5953 Vitamin D_3.

(a) *Product.* Vitamin D_3.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5985 Zinc chloride.

(a) *Product.* Zinc chloride.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5988 Zinc gluconate.

(a) *Product.* Zinc gluconate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5991 Zinc oxide.

(a) *Product.* Zinc oxide.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5994 Zinc stearate.

(a) *Product.* Zinc stearate prepared from stearic acid free from chick-edema factor.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.5997 Zinc sulfate.

(a) *Product.* Zinc sulfate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

Subpart G—Sequestrants[2]

§ 582.6033 Citric acid.

(a) *Product.* Citric acid.

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[2] For the purpose of this subpart, no attempt has been made to designate those

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6085 Sodium acid phosphate.

(a) *Product.* Sodium acid phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6099 Tartaric acid.

(a) *Product.* Tartaric acid.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6185 Calcium acetate.

(a) *Product.* Calcium acetate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6193 Calcium chloride.

(a) *Product.* Calcium chloride.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6195 Calcium citrate.

(a) *Product.* Calcium citrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6197 Calcium diacetate.

(a) *Product.* Calcium diacetate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6199 Calcium gluconate.

(a) *Product.* Calcium gluconate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6203 Calcium hexametaphosphate.

(a) *Product.* Calcium hexametaphosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6215 Monobasic calcium phosphate.

(a) *Product.* Monobasic calcium phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6219 Calcium phytate.

(a) *Product.* Calcium phytate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6285 Dipotassium phosphate.

(a) *Product.* Dipotassium phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6290 Disodium phosphate.

(a) *Product.* Disodium phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6386 Isopropyl citrate.

(a) *Product.* Isopropyl citrate.

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 0.02 percent in accordance with good manufacturing or feeding practice.

§ 582.6511 Monoisopropyl citrate.

(a) *Product.* Monoisopropyl citrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6625 Potassium citrate.

(a) *Product.* Potassium citrate.

(b) *Conditions of use.* This substance is generally recognized as safe when

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sequestrants that may also function as chemical preservatives.

used in accordance with good manufacturing or feeding practice.

[41 FR 38657, Sept. 10, 1976. Redesignated at 42 FR 14091, Mar. 15, 1977]

§ 582.6751 Sodium citrate.

(a) *Product.* Sodium citrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

[41 FR 38657, Sept. 10, 1976. Redesignated at 42 FR 14091, Mar. 15, 1977]

§ 582.6754 Sodium diacetate.

(a) *Product.* Sodium diacetate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6757 Sodium gluconate.

(a) *Product.* Sodium gluconate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6760 Sodium hexametaphosphate.

(a) *Product.* Sodium hexametaphosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6769 Sodium metaphosphate.

(a) *Product.* Sodium metaphosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6778 Sodium phosphate.

(a) *Product.* Sodium phosphate (mono-, di-, and tribasic).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6787 Sodium pyrophosphate.

(a) *Product.* Sodium pyrophosphate.

(b) *Condition of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6789 Tetra sodium pyrophosphate.

(a) *Product.* Tetra sodium pyrophosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6801 Sodium tartrate.

(a) *Product.* Sodium tartrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6804 Sodium potassium tartrate.

(a) *Product.* Sodium potassium tartrate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6807 Sodium thiosulfate.

(a) *Product.* Sodium thiosulfate.

(b) *Tolerance.* 0.1 percent.

(c) *Limitations, restrictions, or explanation.* This substance is generally recognized as safe when used in salt in accordance with good manufacturing or feeding practice.

§ 582.6810 Sodium tripolyphosphate.

(a) *Product.* Sodium tripolyphosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.6851 Stearyl citrate.

(a) *Product.* Stearyl citrate.

(b) *Tolerance.* This substance is generally recognized as safe for use at a level not exceeding 0.15 percent in accordance with good manufacturing or feeding practice.

Subpart H—Stabilizers

§ 582.7115 Agar-agar.

(a) *Product.* Agar-agar.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7133 Ammonium alginate.

(a) *Product.* Ammonium alginate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7187 Calcium alginate.

(a) *Product.* Calcium alginate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7255 Chondrus extract.

(a) *Product.* Chondrus extract (carrageenin).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7330 Gum arabic.

(a) *Product.* Acacia (gum arabic).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7333 Gum ghatti.

(a) *Product.* Gum ghatti.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7339 Guar gum.

(a) *Product.* Guar gum.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7343 Locust bean gum.

(a) *Product.* Locust (carob) bean gum.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7349 Sterculia gum.

(a) *Product.* Sterculia gum (karaya gum).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7351 Gum tragacanth.

(a) *Product.* Tragacanth (gum tragacanth).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7610 Potassium alginate.

(a) *Product.* Potassium alginate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

§ 582.7724 Sodium alginate.

(a) *Product.* Sodium alginate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice.

PART 584—FOOD SUBSTANCES AFFIRMED AS GENERALLY RECOGNIZED AS SAFE IN FEED AND DRINKING WATER OF ANIMALS

Subpart A [Reserved]

Subpart B—Listing of Specific Substances Affirmed as GRAS

AUTHORITY: 21 U.S.C. 321, 342, 348, 371.

Subpart A [Reserved]

Subpart B—Listing of Specific Substances Affirmed as GRAS

§ 584.200 Ethyl alcohol containing ethyl acetate.

The feed additive ethyl alcohol containing ethyl acetate meets the requirement of 27 CFR 212.45, being not less than 92.5 percent ethyl alcohol, each 100 gallons having had added the equivalent of 4.25 gallons of 100 percent ethyl acetate. It is used in accordance with good feeding practices in ruminant feed supplements as a source of added energy.

[46 FR 52333, Oct. 27, 1981]

Biotechnological Production of Lactic Acid and Its Recent Applications

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Received: December 3, 2005
Accepted: March 12, 2006

Summary

Lactic acid is widely used in the food, cosmetic, pharmaceutical, and chemical industries and has received increased attention for use as a monomer for the production of biodegradable poly(lactic acid). It can be produced by either biotechnological fermentation or chemical synthesis, but the former route has received considerable interest recently, due to environmental concerns and the limited nature of petrochemical feedstocks. There have been various attempts to produce lactic acid efficiently from inexpensive raw materials. We present a review of lactic acid-producing microorganisms, raw materials for lactic acid production, fermentation approaches for lactic acid production, and various applications of lactic acid, with a particular focus on recent investigations. In addition, the future potentials and economic impacts of lactic acid are discussed.

Key words: lactic acid, poly(lactic acid), lactic acid bacteria, fermentation, biodegradable polymer

Introduction

Lactic acid has a long history of uses for fermentation and preservation of human foodstuffs (*1*). It was first discovered in sour milk by Scheele in 1780, who initially considered it a milk component. In 1789, Lavoisier named this milk component »acide lactique«, which became the possible origin of the current terminology for lactic acid. In 1857, however, Pasteur discovered that it was not a milk component, but a fermentation metabolite generated by certain microorganisms (*2*).

Lactic acid can be produced by either microbial fermentation or chemical synthesis (Fig. 1). In the early 1960s, a method to synthesize lactic acid chemically was developed due to the need for heat-stable lactic acid in the baking industry (*3*). There are two optical isomers of lactic acid: L(+)-lactic acid and D(–)-lactic acid. Lactic acid is classified as GRAS (generally recognized as safe) for use as a food additive by the US FDA (Food and Drug Administration), but D(–)-lactic acid is at times harmful to human metabolism and can result in acidosis and decalcification (*4*). Although racemic DL-lactic acid is always produced by chemical synthesis from petrochemical resources, an optically pure L(+)- or D(–)-lactic acid can be obtained by microbial fermentation of renewable resources when the appropriate microorganism that can produce only one of the isomers is selected (*5*). The optical purity of lactic acid is crucial to the physical properties of poly (lactic acid) (PLA), and an optically pure L(+)- or D(–)-lactic acid, rather than racemic DL-lactic acid, can be polymerized to a high crystalline PLA that is suitable for commercial uses (*6,7*). Therefore, the biotechnological production of lactic acid has received a significant amount of interest recently, since it offers an alternative to environmental pollution caused by the petrochemical industry and the limited supply of petrochemical resources.

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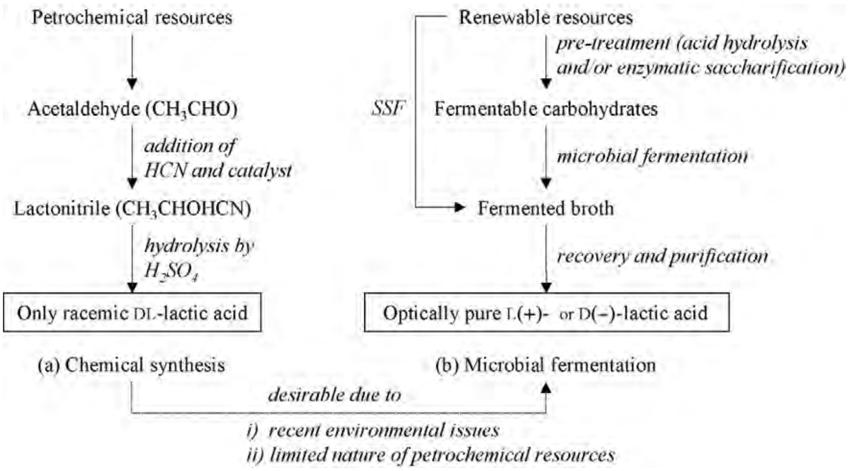

Fig. 1. Overview of the two manufacturing methods of lactic acid; chemical synthesis (a) and microbial fermentation (b). SSF represents simultaneous saccharification and fermentation

Lactic acid is now considered to be one of the most useful chemicals, used in the food industry as a preservative, acidulant, and flavouring, in the textile and pharmaceutical industries, and in the chemical industry as a raw material for the production of lactate ester, propylene glycol, 2,3-pentanedione, propanoic acid, acrylic acid, acetaldehyde, and dilactide (*8,9*). Recently, lactic acid consumption has increased considerably because of its role as a monomer in the production of biodegradable PLA, which is well-known as a sustainable bioplastic material (*4,10*). The worldwide demand for lactic acid is estimated roughly to be 130 000 to 150 000 (metric) tonnes per year (*11*). However, the global consumption of lactic acid is expected to increase rapidly in the near future. NatureWorks LLC, a major PLA manufacturer established in the US, expects that the global PLA market may increase to 500 000 (metric) tonnes per year by 2010 (*12*).

Biotechnological processes for the production of lactic acid usually include lactic acid fermentation and product recovery and/or purification. There have been numerous investigations on the development of biotechnological processes for lactic acid production, with the ultimate objectives to enable the process to be more efficient and economical. This article presents a review of recent advances in the biotechnological production of lactic acid, as well as its recent applications and the future prospects of biologically-derived lactic acid.

Lactic Acid-Producing Microorganisms

Microorganisms that can produce lactic acid can be divided into two groups: bacteria and fungi (*10*). The microorganisms selected for recent investigations of the biotechnological production of lactic acid are listed in Table 1 (*13–24*). Although most investigations of lactic acid production were carried out with lactic acid bacteria (LAB), filamentous fungi, such as *Rhizopus*, utilize glucose aerobically to produce lactic acid (*13,25,26*). *Rhizopus* species such as *R. oryzae* and *R. arrhizus* have amylolytic enzyme activity, which enables them to convert starch directly to L(+)-lactic acid (*27,28*). Fungal fermentation has some advantages in that *R. oryzae* requires only a simple medium and produces L(+)-lactic acid, but it also requires vigorous aeration because *R. oryzae* is an obligate aerobe (*25*). In fungal fermentation, the low production rate, below 3 g/(L·h), is probably due to the low reaction rate caused by mass transfer limitation (*14*). The lower product yield from fungal fermentation is attributed partially to the formation of by-products, such as fumaric acid and ethanol (*25*).

Table 1. Microorganisms used for recent investigations of the biotechnological production of lactic acid

Organism	γ(lactic acid) g/L	η(yield) g/g	Productivity g/(L·h)	Reference
Rhizopus oryzae ATCC 52311	83.0	0.88	2.6	(*13*)
Rhizopus oryzae NRRL 395	104.6	0.87	1.8	(*14*)
Enterococcus faecalis RKY1	144.0	0.96	5.1	(*15*)
Lactobacillus rhamnosus ATCC 10863	67.0	0.84	2.5	(*16*)
Lactobacillus helveticus ATCC 15009	65.5	0.66	2.7	(*17*)
Lactobacillus bulgaricus NRRL B-548	38.7	0.90	3.5	(*18*)
Lactobacillus casei NRRL B-441	82.0	0.91	5.6	(*19*)
Lactobacillus plantarum ATCC 21028	41.0	0.97	1.0	(*20*)
Lactobacillus pentosus ATCC 8041	21.8	0.77	0.8	(*21*)
Lactobacillus amylophilus GV6	76.2	0.70	0.8	(*22*)
Lactobacillus delbrueckii NCIMB 8130	90.0	0.97	3.8	(*23*)
Lactococcus lactis ssp. *lactis* IFO 12007	90.0	0.76	1.6	(*24*)

Several attempts have been made to achieve higher cell density, lactic acid yield, and productivity in fungal fermentation. Tay and Yang (*25*) immobilized *R. oryzae* cells in a fibrous bed to produce lactic acid from glucose and starch. Kosakai *et al.* (*26*) cultured *R. oryzae* cells with the use of mycelial flocs formed by the addition of mineral support and poly(ethylene oxide). They observed that cotton-like mycelial flocs were the optimal morphology in the culture of *R. oryzae*. Park *et al.* (*14*) reported that lactic acid production was enhanced in a culture of *R. oryzae*, by the induction of mycelial floc morphology. Their results also suggested that cotton-like mycelial flocs were the optimal morphology for use in the air-lift bioreactor culture of *R. oryzae*. Although there have been persistent attempts to produce lactic acid through fungal fermentation, LAB have been commonly used for the production of lactic acid due to the aforementioned disadvantages of fungal fermentation.

Lactic acid bacteria can be classified into two groups: homofermentative and heterofermentative. While the homofermentative LAB convert glucose almost exclusively into lactic acid, the heterofermentative LAB catabolize glucose into ethanol and CO_2 as well as lactic acid (Fig. 2) (*5*,*29*). The homofermentative LAB usually metabolize glucose *via* the Embden-Meyerhof pathway (*i.e.* glycolysis). Since glycolysis results only in lactic acid as a major end-product of glucose metabolism, two lactic acid molecules are produced from each molecule of glucose with a yield of more than 0.90 g/g (*30*,*31*). Only the homofermentative LAB are available for the commercial production of lactic acid (*5*,*15*).

Recently, strains used in the commercial production of lactic acid has become almost proprietary, and it is believed that most of the LAB used belong to the genus *Lactobacillus* (*4*,*5*). Berry *et al.* (*16*) attempted to produce lactic acid by batch culture of *L. rhamnosus* in a defined medium. Schepers *et al.* (*17*) used *L. helveticus* for the production of lactic acid from lactose and concentrated cheese whey, and Burgos-Rubio *et al.* (*18*) reported the kinetic investigation of the conversion of different substrates into lactic acid with the use of *L. bulgaricus*. Hujanen and Linko (*19*) investigated the effects of culture temperature and nitrogen sources on lactic acid production by *L. casei*, and Roukas and Kotzekidou (*32*) also used this strain for lactic acid production from deproteinized whey by mixed cultures of free and coimmobilized cells. Fu and Mathews (*20*) investigated the kinetic model of lactic acid production from lactose by batch culture of *L. plantarum*, and Bustos *et al.* (*21*) used *L. pentosus* for the production of lactic acid from vine-trimming wastes. The strains of amylase-producing *L. amylophilus* were used often for the direct conversion of starch into lactic acid (*22*,*33*,*34*).

However, among the genus *Lactobacillus*, *L. delbrueckii* has appeared commonly in many investigations on the production of lactic acid. Kotzanmanidis *et al.* (*23*) used *L. delbrueckii* NCIMB 8130 for lactic acid production from beet molasses. Monteagudo *et al.* (*35*) and Göksungur and Güvenç (*36*) also attempted to produce lactic acid from beet molasses with *L. delbrueckii*. In addition to lactobacilli, strains of lactococci were often used for lactic acid production. Roble *et al.* (*24*) co-cultured *Lactococcus lactis* ssp. *lactis* cells with *Aspergillus awamori* for lactic acid production from cassava starch, and Åkerberg *et al.* (*37*) used *L. lactis* ssp. *lactis* for modeling the kinetics of lactic acid production from whole wheat flour. Moreover, Yun *et al.* (*15*) and Wee *et al.* (*38*) reported the production of lactic acid by batch culture of a newly isolated species, *Enterococcus faecalis*.

Efforts have been made to improve the production of lactic acid through metabolic engineering approaches. Kylä-Nikkilä *et al.* (*39*) attempted to express L-lactate de-

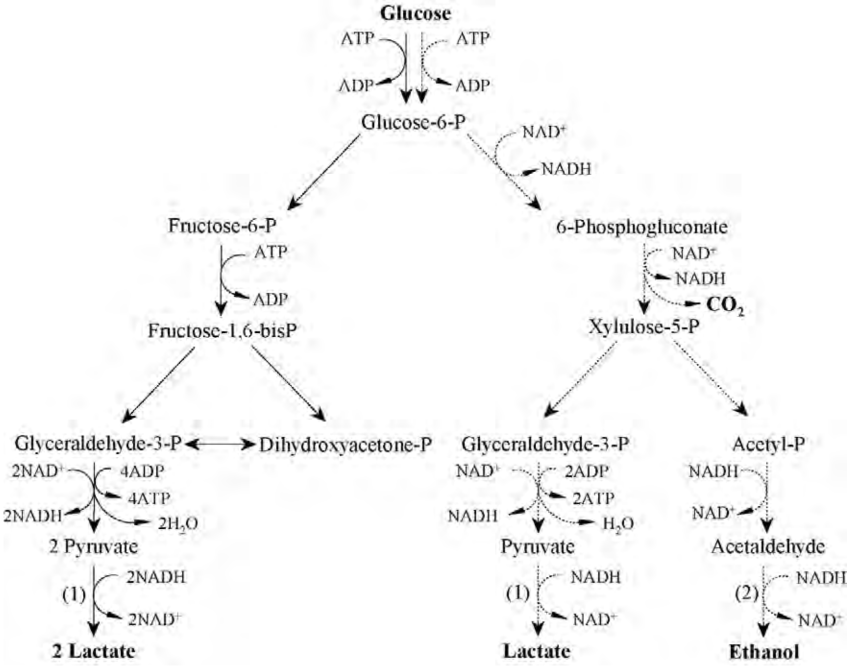

Fig. 2. Metabolic pathways of homofermentative (solid line) and heterofermentative (dotted line) lactic acid bacteria: P, phosphate; ADP, adenosine 5'-diphosphate; ATP, adenosine 5'-triphosphate; NAD^+, nicotinamide adenine dinucleotide; NADH, nicotinamide adenine dinucleotide (reduced form); (1), lactate dehydrogenase; (2), alcohol dehydrogenase

hydrogenase and D-lactate dehydrogenase genes in *L. helveticus* for the production of pure D(–)- and L(+)-lactic acids. They constructed two D-lactate dehydrogenase gene-negative *L. helveticus via* a gene replacement method for the production of pure L-lactic acid. Each L-lactate dehydrogenase activity of two D-lactate dehydrogenase-deficient *L. helveticus* was 53 or 93 % higher than that of the wild type strain. Dien *et al.* (*40,41*) constructed recombinant *Escherichia coli* for the conversion of hexose sugar, as well as pentose sugar, into L(+)-lactic acid, and they metabolically engineered the *E. coli* for the construction of carbon catabolite repression mutants. Similarly, Chang *et al.* (*42*) constructed recombinant *E. coli* for the production of optically pure D(–)- or L(+)-lactic acid. They introduced L-lactate dehydrogenase genes from *L. casei* into a *pta ldhA* strain, which lacked phosphotransacetylase and D-lactate dehydrogenase. Their results suggested that the central fermentation metabolism of *E. coli* can be reoriented to the production of D(–)- or L(+)-lactic acid. Recent advances in metabolic engineering of microorganisms may provide more opportunities for selective and efficient production of optically pure lactic acid through the improvement of future strains.

Lactic acid bacteria typically have complex nutritional requirements, due to their limited ability to synthesize their own growth factors such as B vitamins and amino acids. They require some elements for growth, such as carbon and nitrogen sources, in the form of carbohydrates, amino acids, vitamins, and minerals (*29,43,44*). There are several growth-stimulation factors that have a considerable effect on the production rate of lactic acid. The mixture of amino acids, peptides, and amino acid amides usually stimulates the growth of LAB, and the resulting growth rates are much higher than those obtained with free amino acids (*43*). Fatty acids also influence LAB growth, and phosphates are the most important salt in lactic acid fermentation. Ammonium ions cannot serve as the sole nitrogen source, but they seem to have some influence on the metabolism of certain amino acids. Since minerals do not seem to be essential to LAB growth, the amount found in commercial complex media is usually sufficient (*29,45*). Temperature and pH are also important factors influencing LAB growth and lactic acid production (*5*). In general, the desirable characteristics for industrial LAB are the abilities to rapidly and completely convert cheap raw materials into lactic acid with minimal nutritional requirements and to provide high yields of preferred stereoisomer without by-product formation.

Raw Materials for Biotechnological Production of Lactic Acid

In order for the biotechnological production of lactic acid to be feasible, cheap raw materials are necessary, because polymer producers and other industrial users usually require large quantities of lactic acid at a relatively low cost. Raw materials for lactic acid production should have the following characteristics: cheap, low levels of contaminants, rapid production rate, high yield, little or no by-product formation, ability to be fermented with little or no pre-treatment, and year-round availability (*3*). When refined materials are used for production, the costs for product purification should be significantly reduced. However, this is still economically unfavourable because the refined carbohydrates are so expensive that they eventually result in higher production costs (*5*). Therefore, there have been many attempts to screen for cheap raw materials for the economical production of lactic acid. Reports in the literature of recent investigations are listed in Table 2 (*23,38,46–61*).

Table 2. Reports in the literature about recent investigations on the biotechnological production of lactic acid from cheap raw materials

Raw material	Organism	γ(lactic acid) g/L	Productivity g/(L·h)	Reference
Molasses	*Lactobacillus delbrueckii* NCIMB 8130	90.0	3.8	(*23*)
	Enterococcus faecalis RKY1	95.7	4.0	(*38*)
Rye	*Lactobacillus paracasei* No. 8	84.5	2.4	(*46*)
Sweet sorghum	*Lactobacillus paracasei* No. 8	81.5	2.7	(*46*)
	Lactobacillus paracasei No. 8	106.0	3.5	(*47*)
Wheat	*Lactococcus lactis* ssp. *lactis* ATCC 19435	106.0	1.0	(*48*)
	Enterococcus faecalis RKY1	102.0	4.8	(*49*)
Corn	*Enterococcus faecalis* RKY1	63.5	0.5	(*49*)
	Lactobacillus amylovorus ATCC 33620	10.1	0.8	(*50*)
Cassava	*Lactobacillus amylovorus* ATCC 33620	4.8	0.2	(*50*)
Potato	*Lactobacillus amylovorus* ATCC 33620	4.2	0.1	(*51*)
Rice	*Lactobacillus* sp. RKY2	129.0	2.9	(*51*)
Barley	*Lactobacillus casei* NRRL B-441	162.0	3.4	(*52*)
	Lactobacillus amylophilus GV6	27.3	0.3	(*53*)
Cellulose	*Lactobacillus coryniformis* ssp. *torquens* ATCC 25600	24.0	0.5	(*54*)
Corncob	*Rhizopus* sp. MK-96-1196	24.0	0.3	(*55*)
Waste paper	*Lactobacillus coryniformis* ssp. *torquens* ATCC 25600	23.1	0.5	(*56*)
	Rhizopus oryzae NRRL 395	49.1	0.7	(*57*)
Wood	*Lactobacillus delbrueckii* NRRL B-445	108.0	0.9	(*58*)
	Enterococcus faecalis RKY1	93.0	1.7	(*59*)
Whey	*Lactobacillus helveticus* R211	66.0	1.4	(*60*)
	Lactobacillus casei NRRL B-441	46.0	4.0	(*61*)

Cheap raw materials, such as starchy and cellulosic materials, whey, and molasses, have been used for lactic acid production (*5*). Among these, starchy and cellulosic materials are currently receiving a great deal of attention, because they are cheap, abundant, and renewable (*9,46,62*). The starchy materials used for lactic acid production include sweet sorghum (*46,47*), wheat (*9,37,48, 49*), corn (*49,50*), cassava (*50*), potato (*50,63*), rice (*49,51*), rye (*46*), and barley (*49,52,53*). These materials have to be hydrolyzed into fermentable sugars before fermentation, because they consist mainly of α(1,4)- and α(1,6)-linked glucose (*47–49*). This hydrolysis can be carried out simultaneously with fermentation (*52*). Amylase-producing *L. amylophilus* and *L. amylovorus* are often used for the direct fermentation of starchy materials into lactic acid (*50,53,63*).

Cellulosic materials have been used for lactic acid production in similar ways as starchy materials (*5*). These materials consist mainly of β(1,4)-glucan, and often contain xylan, arabinan, galactan, and lignin (*5,10*). Venkatesh (*62*) and Yáñez *et al.* (*54*) have previously attempted to produce lactic acid from pure cellulose through simultaneous saccharification and fermentation (SSF). The utilization of corncob (*55,64*), waste paper (*56,57*), and wood (*58,59*), has been reported as well. Sreenath *et al.* (*65*) investigated the production of lactic acid from agricultural residues such as alfalfa fiber, wheat bran, corn stover, and wheat straw. They suggested that, during SSF of alfalfa fiber, lactic acid production was enhanced by adding pectinase and cellulase together. Garde *et al.* (*66*) used hemicellulose hydrolyzate from wheat straw for lactic acid production by co-culture of *L. brevis* and *L. pentosus*. This study demonstrated that complete substrate utilization was achieved with a mixed culture of two LAB. Fermentation of lignocellulosic hydrolyzate is inhibited usually by inhibitory compounds, such as furfural, 5-hydroxymethyl furfural, and acetic acid, which are generated during pre-treatment of lignocellulose (*67*). Most studies on methods to decrease this inhibition have been focused on the chemical and physical detoxification of the hydrolyzate (*68*). Wee *et al.* (*59*), however, reported that the inhibition of fermentation caused by wood hydrolyzate was reduced to a slight degree by direct adaptation of LAB to the wood hydrolyzate-based medium.

Some industrial waste products, such as whey and molasses, are of interest for common substrates for lactic acid production. Whey is a major by-product of the dairy industry, and it contains lactose, protein, fat, and mineral salts. For complete utilization of whey lactose, it is necessary to supplement whey with an additional nitrogen source (*5*). Amrane and Prigent (*69*), Kulozik and Wilde (*70*), and Schepers *et al.* (*60*) supplemented whey with yeast extract for rapid production of lactic acid with *L. helveticus*. According to Fitzpatrick and O'Keeffe (*71*), the addition of whey protein hydrolyzate to whey medium would make the fermentation more economically viable and would also reduce the amount of unused nutrients left during fermentation. Also, there have been several attempts to produce lactic acid from whey by batch culture of *L. casei* (*61,72,73*). Molasses is a waste product from the sugar manufacturing process, and it usually contains a large amount of sucrose (*5*). *L. delbrueckii* and *E. faecalis* have recently been used for lactic acid production from molasses (*23,35,36,38*). Shukla *et al.* (*74*) also reported D(–)-lactic acid production from molasses with recombinant *E. coli* strain.

It is necessary to supplement the fermentation media with sufficient nutrients for rapid lactic acid production. The most common nutrient for lactic acid production is yeast extract, but this may contribute significantly to an increase in production costs (*3,5*). As an alternative to yeast extract, corn steep liquor, a by-product from the corn steeping process, has been used successfully for lactic acid production (*49*). The nitrogen content of corn steep liquor is dependent on the steeping process used. Since it is derived from corn, 85 % of its total nitrogen content is composed of proteins, peptides, and amino acids (*75*). Yun *et al.* (*51*) suggested that rice bran and wheat bran play important roles as effective nutrients for lactic acid production, because they usually contain several nutritional factors as well as fermentable carbohydrates. Kurbanoglu and Kurbanoglu (*76*) demonstrated that ram horn waste was an effective supplement for lactic acid production. Similarly, Bustos *et al.* (*77*) proposed that vinification lees could be used for the formulation of low-cost media for lactic acid production. According to Wee *et al.* (*78*), wastewater from electrodialyzed fermentation broth still contained some nutrients that could be available to LAB. Their result indicated that, if small amounts of other nutrients were supplemented to electrodialysis wastewater, then the efficiencies of fermentation would be improved significantly.

Fermentation Approaches to Lactic Acid Production

Batch, fed-batch, repeated batch, and continuous fermentations are the most frequently used methods for lactic acid production. Higher lactic acid concentrations may be obtained in batch and fed-batch cultures than in continuous cultures, whereas higher productivity may be achieved by the use of continuous cultures (*5*). Another advantage of the continuous culture compared to the batch culture, is the possibility to continue the process for a longer period of time. Reports in the literature of recent studies on the biotechnological production of lactic acid by different fermentation approaches are listed in Table 3 (*32,79–86*).

The cell-recycle system, together with repeated batch and continuous processes, enables the achievement of a higher cell concentration and product productivity in the process (*79,80*). Oh *et al.* (*79*) produced lactic acid at a rate of 6.4 g/(L·h) through cell-recycle repeated batch fermentation. Their results also indicated that only 26 % of the yeast extract dosage, compared with conventional batch fermentation, should be required to produce the same amount of lactic acid, which might result in a considerable reduction of production costs. The maximum cell concentration in their experiment was greater than 28 g/L, which might contribute to the improvement of the productivity and reduction of nutrient supplementation. A successful approach to continuous production of lactic acid with cell retention has been reported by Kwon *et al.* (*80*), who recently attempted to produce lactic acid by a two-stage cell-recycle culture of *L. rhamno-*

Table 3. Reports in the literature of recent investigations on the biotechnological production of lactic acid by different fermentation approaches

Organism	Fermentation mode	γ(lactic acid)	Productivity	Reference
		g/L	g/(L·h)	
Lactobacillus casei SU No 22 + *Lactobacillus lactis* WS 1042	fed-batch, coimmobilization	47.0	2.0	(*32*)
Enterococcus faecalis RKY1	batch	95.7	4.0	(*79*)
	repeated batch, cell-recycle *via* membrane	93.2	6.4	(*79*)
Lactobacillus rhamnosus ATCC 10863	batch	~ 120.0	2.1	(*80*)
	continuous, cell-recycle *via* membrane	92.0	57.0	(*80*)
Lactobacillus casei ssp. *rhamnosus* ATCC 11443	continuous, cell-recycle *via* immobilization	22.4	9.0	(*81*)
Lactobacillus delbrueckii NRRL B445	fed-batch, *in situ* removal *via* solvent extraction	~ 23.1	0.2	(*82*)
Lactococcus lactis IO-1 JCM 7638	batch, *in situ* removal *via* electrodialysis	~ 39.0	0.9	(*83*)
Lactobacillus rhamnosus IFO 3863	batch	98.0	1.9	(*84*)
	continuous, *in situ* removal *via* electrodialysis	~ 20.0	8.2	(*84*)
Lactobacillus helveticus CNRZ 303	continuous, cell-recycle *via* membrane	55.0	7.1	(*85*)
Lactobacillus delbrueckii CECT 286	continuous, *in situ* removal *via* ion-exchange resin	26.1	10.4	(*86*)

sus. They connected the membrane cell-recycle bioreactors in a series, and obtained 92 g/L of lactic acid with a productivity of 57 g/(L·h).

Immobilization of cells has been one of the means for high cell retention in the bioreactor (*87*). Several materials, such as Ca-alginate gels, poly(ethyleneimine), and plastic composite support, have been used for immobilization of LAB in order to produce lactic acid (*36,81,87*). Senthuran *et al.* (*87*) reported the production of lactic acid by continuous culture of *L. casei* immobilized in poly(ethyleneimine). This system was coupled with a cell-recycle bioreactor, and the authors observed that the most important factor for operational stability was the bead size of the matrix. Cotton *et al.* (*81*) tested the immobilized-cell biofilm reactor for continuous production of lactic acid. For biofilm formation, they used a plastic composite support composed mainly of polypropylene.

Lactic acid production processes traditionally suffer from end-product inhibition. An undissociated lactic acid passes through the bacterial membrane and dissociates inside the cell. The inhibition mechanism of lactic acid is probably related to the solubility of the undissociated lactic acid within the cytoplasmic membrane and the insolubility of dissociated lactate, which causes acidification of cytoplasm and failure of proton motive forces. It eventually influences the transmembrane pH gradient and decreases the amount of energy available for cell growth (*29,88*). Therefore, to alleviate the inhibitory effect of lactic acid during the fermentation, it must be removed selectively *in situ* from the fermentation broth.

Recently, various attempts have been carried out to remove the lactic acid simultaneously as it is formed. Hano *et al.* (*89*) studied the reactive extraction of lactic acid from the fermented broth. They indicated that *in situ* extraction was possible with the use of di-*n*-octylamine and with adjustment of the fermentation broth to a pH=5.0 by ammonia. Iyer and Lee (*82*) attempted to extract lactic acid simultaneously with the use of a two-zone fermentor-extractor system. The system was operated under a fed-batch mode with *in situ* removal of lactic acid by solvent extraction. Electrodialysis fermentation with ion exchange membranes was often used for *in situ* removal of lactic acid (*83,90*). Min-Tian *et al.* (*84*) had previously developed a continuous electrodialysis fermentation system for the production of lactic acid. In their study, the system of electrodialysis fermentation with a level meter was the most efficient system and a higher yield could be obtained if the glucose concentration in the broth could be controlled to remain at a lower level. Nanofiltration membranes and ion exchange resins were occasionally coupled with the bioreactor for *in situ* removal of lactic acid (*85,86*).

Current Uses and Applications of Lactic Acid

Lactic acid has received a significant amount of attention as a chemical with many potential applications. There are four major categories for the current uses and applications of lactic acid: food, cosmetic, pharmaceutical, and chemical applications. The potential applications of lactic acid are illustrated in Fig. 3. Since lactic acid is classified as GRAS for use as a food additive by the US FDA (*4*), it is widely used in almost every segment of the food industry, where it serves in a wide range of functions, such as flavouring, pH regulation, improved microbial quality, and mineral fortification. Moreover, lactic acid is used commercially in the processed meat and poultry industries, to provide products with an increased shelf life, enhanced flavour, and better control of food-born pathogens. Due to the mild acidic taste of lactic acid, it is also used as an acidulant in salads and dressings, baked goods, pickled vegetables, and beverages. Lactic acid is used in confectionery, not only for flavour, but also to bring the pH of the cooked mix to the correct point for setting. The advantages of adding lactic acid in confectionery include its low inversion rate, ease of handling, and ability to produce clear candies. Another potential application of lactic acid in the food industry is the mineral fortification of food products (*91,92*).

Lactic acid offers natural ingredients for cosmetic applications. Although primarily used as moisturizers and pH regulators, they possess multiple other properties such as antimicrobial activity, skin lightening, and skin

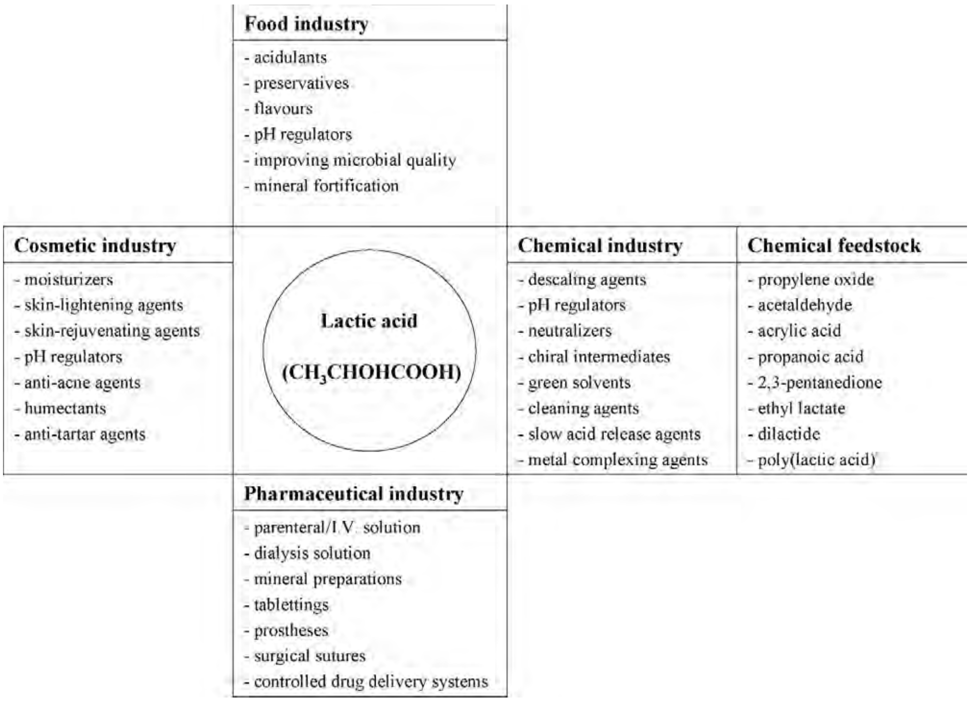

Fig. 3. Diagram of the commercial uses and applications of lactic acid and its salt

hydration. The moisturizing effect is related directly to lactate's water retaining capacity, and the skin-lightening action of lactic acid is produced by the suppression of the formation of tyrosinase. Since they are natural ingredients of the human body, lactic acid and its salt fit perfectly into the modern trend towards natural and safer formulations, and they produce such effects as skin lightening and rejuvenation, which makes them very useful as active ingredients in cosmetics (*91,92*).

Lactic acid is also used in the pharmaceutical industry as an electrolyte in many parenteral/I.V. (intravenous) solutions that are intended to replenish the bodily fluids or electrolytes. Examples include Lactated Ringer's or Hartmann's solutions, CAPD (continuous ambulatory peritoneal dialysis) solution, and dialysis solution for conventional artificial kidney machines. Moreover, lactic acid is used in a wide variety of mineral preparations, which include tablets, prostheses, surgical sutures, and controlled drug delivery systems (*91,92*).

Lactic acid and its salt are used increasingly in various types of chemical products and processes. In this category of applications, lactic acid functions as a descaling agent, pH regulator, neutralizer, chiral intermediate, solvent, cleaning agent, slow acid-release agent, metal complexing agent, antimicrobial agent, and humectant. Natural lactic acid has an emerging use as an excellent and safe solvent, which is alternative in many fine mechanical cleaning applications. Due to the high solvency power and solubility of lactic acid, it is an excellent remover of polymer and resins. It is available with an isomeric purity greater than 98 %, and is suitable as a starting material in the production of herbicides or pharmaceuticals. Since lactic acid offers better descaling properties than conventional organic descalers do, it is often used in many decalcification products, such as bathroom cleaners, coffee machines, and toilets. Ethyl lactate is used in many anti-acne preparations, because it combines excellent solvency power against oils and polymeric stains, with no environmental impact and toxicological effects (*4,91,92*).

Currently, lactic acid is considered the most potential feedstock monomer for chemical conversions, because it contains two reactive functional groups, a carboxylic group and a hydroxyl group. Lactic acid can undergo a variety of chemical conversions into potentially useful chemicals, such as propylene oxide (*via* hydrogenation), acetaldehyde (*via* decarboxylation), acrylic acid (*via* dehydration), propanoic acid (*via* reduction), 2,3-pentanedione (*via* condensation), and dilactide (*via* self-esterification) (*8*). Lactic acid has recently received a great deal of attention as a feedstock monomer for the production of PLA, which serves as a biodegradable commodity plastic. The optically pure lactic acid can be polymerized into a high molecular mass PLA through the serial reactions of polycondensation, depolymerization, and ring-opening polymerization (*7*). The resultant polymer, PLA, has numerous uses in a wide range of applications, such as protective clothing, food packaging, mulch film, trash bags, rigid containers, shrink wrap, and short shelf-life trays (*93,94*). The recent huge growth of the PLA market will stimulate future demands on lactic acid considerably (*4,6*).

Conclusions and Future Potentials

The current major markets for lactic acid are food-related industries, but the emerging markets for PLA polymer would cause a significant increase in growth of lactic acid consumption (*4,10*). Currently, the worldwide consumption of lactic acid is estimated to be 130 000–150 000 (metric) tonnes per year, and the commercial prices of food grade lactic acid range between 1.38 US$/kg (for 50 % purity) and 1.54 US$/kg (for 88 % purity). Technical grade lactic acid with 88 % purity has been priced as much as 1.59 US$/kg (*11,95*). Lactic acid consumption in chemical applications, which include PLA polymer and new »green« solvents, such as ethyl lactate, is expected to expand 19 % per year (*96*).

There are several major manufacturers of fermentative lactic acid, including Purac (Netherlands), Galactic (Belgium), Cargill (USA), and several Chinese companies (*91,92*). In late 1997, Cargill joined forces with Dow Chemical and established a Cargill-Dow PLA polymer venture, NatureWorks LLC, which exists today as a stand-alone company. In early 2002, NatureWorks LLC completed the construction of a PLA plant that has the capacity of producing 140 000 (metric) tonnes of PLA per year. Moreover, NatureWorks LLC has recently constructed a major lactic acid facility in Blair, Nebraska, USA, which has the capacity of producing 180 000 (metric) tonnes of lactic acid per year, and it began operating in late 2002 (*96,97*). NatureWorks LLC has stated publicly its belief that the PLA market will reach 500 000 (metric) tonnes per year worldwide by 2010, and the construction of two additional PLA plants are being considered presently (*12,97,98*).

On an industrial scale, the manufacturing cost of lactic acid monomer will be targeted to less than 0.8 US$/kg, because the selling price of PLA should decrease roughly by half from its present price of 2.2 US$/kg. According to the cost analysis by Datta *et al.* (*4*), although their analysis was sensitive to various factors such as plant size, raw material cost, and capital investment, the base manufacturing cost of lactic acid was estimated to be 0.55 US$/kg. However, there are still several issues that need to be addressed in order to produce lactic acid biotechnologically within the targeted cost, such as the development of high-performance lactic acid-producing microorganisms and the lowering of the costs of raw materials and fermentation processes. The biotechnological processes for the production of lactic acid from cheap raw materials should be improved further to make them competitive with the chemically-derived one.

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Email Date 04/3/2009

Sugar Tech

Vol. 6 (4) : 285 - 290 (2004)

SUGAR INDUSTRY

Eco-friendly Management of Sugar Industry Effluents in Guangxi, China

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The sugar industry is an important and growing part of China, in general, and of Guangxi province, in particular. This growth poses scientific and engineering challenges for dealing with the environmental impacts of the industry. The characteristics of the sugar production wastewater and the associated molasses production wastewater (vinasse) suggest a variety of options - each with its own advantages and disadvantages - for dealing with the problems.

KEYWORDS : China, Guangxi, wastewater, sugar, vinasse, treatment

Since 1980, there have been many changes in China. Some of these changes have had and will continue to have impacts on the environment of the country. This paper focuses on the environmental changes brought by the growing sugar industry and on the measures employed to address these challenges, particularly as they relate the increasingly fast-paced development of Guangxi province in southwestern China. Special attention is given to the treatment of effluents from sugar cane based distilleries. Prospects and suggestions for better management of wastewater in this sector are also discussed.

CHINA SUGAR INDUSTRY : A PROFILE

During the past two decades, great progress has been made in many aspects of the Chinese sugar industry. In the early 1980's, total sugar output was only around 3 million metric tons per year; by the 2002/2003 production season that figure had jumped to 10.66 million tones. Today, sugar is one of China's major farm commodities. During this period of time there have been significant changes in the amount of sugar produced from sugar cane versus the relative small amount of sugar produced from sugar beets (Table 1, Figure 1). The data show a significant rise in the production of sugar from sugar cane in recent years, compared to a generally stable level production from sugar beets over the past decade.

Sugarcane grows mainly in south and southwest of China; specifically in Guangxi, Yunnan, Guangdong, Fujian, and Shichuan provinces, among which Guangxi province is the largest producer of cane sugar in China. In 2002/2003 crushing campaign in China, sugarcane was planted on 17.47 million Chinese Mu (around 1.165 million hectares; each Mu equals 1/15 hectares) of farmland throughout the country and produced 82.45 million tons of sugarcane, yielding 9.4 million tons white sugar. Guangxi accounted for more than 50% of these totals; i.e., planting on 9.7 million Chinese Mu of land produced 47.8 million tons of cane that yielded 5.63 million tons of white sugar. The majority of the sugar mills (factories) in this region employ sulphitation processes to produce white sugar from sugarcane directly, although a few use carbonation processes (Huang *et al.*, 1999; He *et al.*, 2003; Wei *et al.*, 2002). Quantitatively, today in Guangxi, there are 95 sugar factories, 90% of which use sulphitation, while only 3~5 use carbonation processes. In addition, most of the sugar factories have an attached distillery and produce enthanol from cane molasses (Li *et al.*, 1999; Niu *et al.*, 1999; Hu *et al.*, 2003).

ENVIRONMENTAL PROBLEMS OF SUGAR FACTORIES IN CHINA

With such an impressive growth in sugar production, it is not surprising that the environmental problems associated with sugar factories have also increased. As the same in other sugar-producing, developing countries, wastewater from the sugar

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Table - 1 : Sugar production in China (1991-2003*)

Crop season	Cane: Planting area (10^4 hectare)	Cane: Cane output (10^4 T)	Cane: Sugar output (10^4 T)	Beet: Planting area (10^4 hectare)	Beet: Beet output (10^4 T)	Beet: Sugar output (10^4 T)	Total sugar output (10^4 T)
1991/92	116.37	6770.0	625.4	78.35	1633.0	166.6	791.6
1992/93	104.60	6063.0	628.0	61.33	1318.0	144.6	772.6
1993/94	91.07	5087.0	502.1	52.67	848.0	100.2	602.3
1994/95	80.52	4198.0	446.9	47.40	939.0	94.9	541.8
1995/96	90.17	4624.0	493.7	57.93	1132.0	129.1	622.8
1996/97	88.67	4922.0	537.9	51.33	1173.0	142.1	680.0
1997/98	103.05	6427.6	676.8	49.33	1189.0	134.4	811.2
1998/99	111.00	6844.0	756.8	42.13	1088.0	125.8	882.6
1999/00	101.20	5931.7	620.7	36.67	640.0	66.2	686.9
2000/01	97.47	4888.0	550.6	30.73	596.0	69.4	620.0
2001/02	102.90	6505.5	747.0	35.30	809.5	102.7	849.7
2002/03	116.55	8245.0	942.6	33.95	985.0	124.0	1066.6

*Source from China Sugar Association, (Taiwan data not included)

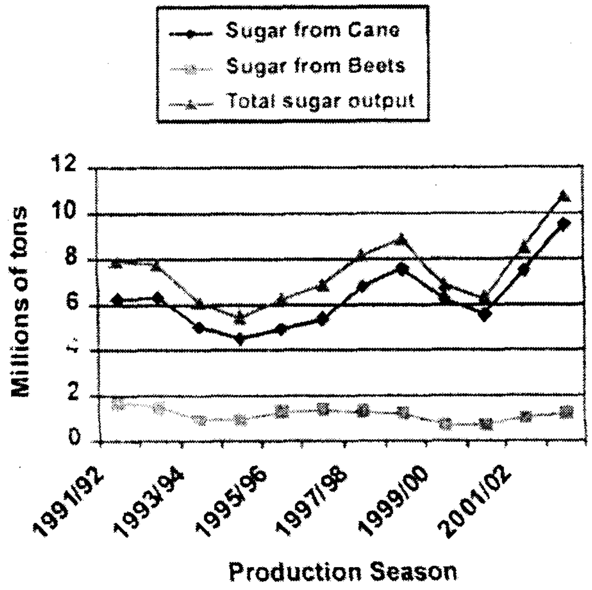

Fig. 1 : Sugar Production in China (1991-2003)

industry is one of the most serious environmental problems in this region of China. There are two major wastewater sources associated with the sugar factories: one is the waste process water from the sugar mills themselves, and the other is effluent from the cane molasses distilleries (Liang *et al.*, 1996). Currently, the sugar mills in China are big water consumers and effluent generators. On average, 20-30 tones of water are needed in order to process one ton of sugar (Bci *et al.*, 1996; Tao *et al.*, 2000). Much of the water is used just one time before it is drained out as wastewater. The wastewater from the mill house and the process house are combined with the wastewater from the boiler house to form a large amount of combined wastewater from the sugar mill, which has an enormous potential for pollution.

Table 2 presents data on the characteristics of the combined wastewater from sugar mills (Tang *et al.*, 2001; Zhang *et al.*, 1999; Cheng *et al.*, 2000).

As noted above, in China, many sugarcane mills have their own distilleries that use sugar cane molasses for the production of alcohol and carbon dioxide. In this process, a second source of a huge volume of wastewater, known as vinasse or spent wash, is generated. Four to five tones of molasses (having 3~6 % of fermentable sugar) are used to produce one ton alcohol (food-grade, 96.7% purity),

Table - 2 : Characteristics of Sugar Mill Effluent

Parameters	Values
pH	4.6-7.1
Suspended solid	400-2200 mg/L
Total dry material	870-3500 mg/L
Volatile material	300-2000 mg/L
Total nitrogen	10-40 mg/L
Biological Oxidation Demand (BOD)	300-2000 mg/L
Chemical Oxidation Demand (COD)	600-4300 mg/L

producing around 13 to 15 tones of vinasse in the process (Hu *et al.*, 2003; Niu *et al.*, 1999; Jiang *et al.*, 1999).

In Guangxi, such cane molasses-based alcohol distillery effluent — a large-volume, noxious smelling, almost black liquid — is becoming one of the most troublesome industrial wastewaters, polluting many rural areas. The characteristics of the effluent are shown in Table 3 (Hu *et al.*, 2003; Li *et al.*, 1999; Ou *et al.*, 2002; Zhou *et al.*, 2000; Chen *et al.*, 2002; Zeng *et al.*, 1996).

Table - 3 : Characteristics of Sugar Mill-Related Distillery Effluent

Parameters	Values
pH	3.8-5.0
Solid (or dry) matter	9-12%
Carbohydrate content	1.9-3%
Ash content	2-5%
Organic compounds (e.g. pectin, protein, etc)	6-9%
Phosphorous content (as P2O5)	0.01-0.03%
Potassium content (as K2O)	0.4-2.5%
Nitrogen content (as N2O)	0.02-0.23%
Total Nitrogen	0.17-0.38%
Calcium (as CaO)	0.20-0.55%
Magnesium (as MgO)	0.1-0.36%
BOD	45,000-70,000 mg/L
COD	100,000 -150,000 mg/L

The vinasse also contains significant amounts of sulphate and chloride ions.

It has been estimated that in Guangxi, each year around 2.2 million tones distillery effluent are generated, and that such wastewater contributes 380,000 tons of COD, accounting for 73% of the total COD from industry wastewater of the province (Li *et al.*, 1999; Niu *et al.*, 1999; Huang *et al.*, 2002; Zhang *et al.*, 1999a).

DISTILLERY EFFLUENT TREATMENT IN GUANGXI

Lagooning

About 50 distilleries in Guangxi practice primary-treatment-and-release of the vinasse through natural oxidation, conventional digestion systems (Li *et al.*, 1999; Chen *et al.*, 2002; Huang *et al.*, 2002). Treatment consists of simply storing vinasse in large open, unlined lagoons for one or two months, thereby allowing the suspended particles to precipitate and the BOD to reduce gradually. As a final step, the treated material is used to irrigate land in a controlled manner, or simply released into streams.

Such treatment is the cheapest option, but it requires a long time and without proper environmental care that could potentially result in overflow and/or run-off problems in periods of heavy rain. In regard to its effectiveness, this treatment results in about a 60% reduction of BOD and COD in most cases (Huang *et al.*, 2002). However, throughout the storage period, the bad odour released from the lagoon remains a serious environmental problem.

Land application and organic complex fertilizer

Some sugar factories had tried to apply the distillery effluent to farming land for irrigation and fertilization (Liang *et al.*, 1996; Zhou *et al.*, 2000; Chen *et al.*, 2002; Chen *et al.*, 1999). Direct farming land application is an inexpensive use of the effluent. However, the process has been found to pose several problems (Liang *et al.*, 1996; Ou *et al.*, 2002).

(1) Increase overall growth, but not increased seed or fruit production of crops;

(2) Resulted in a gradual change in soil structure that causes the soil to — clog and harden, which is harmful for growing crops.

(3) Left the treated land and the neighboring area with a bad odour.

These results are not surprising since according to the analysis (Table 3), the effluent has a relatively high carbohydrate content, but a low nutrient content for crops. With such a low nutrient content, there will be inadequate amounts of balanced nutrients in the applied waste to stimulate a healthy vegetative growth for normal production of seed or fruit. In short, if this waste material is applied to land, additional nutrients must be added to have adequate crop growth and seed production.

The waste is highly fermentable, as noted by the high BOD, and unless aerobic conditions are maintained during storage and transport, anaerobic conditions will result in odours being released as the material is applied to the land. These odours are associated with various reduced sulfur, nitrogen and carbon compounds that result from the conditions during storage and transport. In addition, if too high an application rate is used for the crops, there will be inadequate oxygenation conditions in the soil, and, again, reduced compounds and odours will result.

As mentioned above, the waste is an acidic material, and overloading and/or prolonged application to the field will cause compacting and clogging of the soil. To avoid the odour and soil overloading problem, only a relatively small application rate should be used. Based on experiments and experiences, the waste should be nutralized and diluted to the range of 0.6 to 1.0 mg/L of organic content for irrigation purpose.

In short, land application of these wastes can be an cost-effective technical solution. However, use of land application technologies will require sound calculations to determine the appropriate application rates.

As an alternative to direct application, more and more sugar factories now using a strategy of concentrating the effluent first and adding additional nutrients for the desired crop. The "tailored mixture" is then dried in order to produce so-called organic complex fertilizer for agricultural utilization (Jiang *et al.*, 1999; Chen *et al.*, 2000; Cen *et al.*, 1998; Fu *et al.*, 2000). Based on results of field tests, such organic complex fertilizer has a good effect. For example, in one trial the output of rice has been observed to have increased by 12% when the fertilizers were applied, compared to control regions that did not receive the fertilizer. Further, when these organic fertilizers were applied to sugarcane fields, the cane output was 17% higher than that when regular fertilizer was used (Liao *et al.*, 1995; Cheng *et al.*, 2002a; Jiang *et al.*, 2000).

Anaerobic Digestion

Another approach to the treatment of vinasse has been to take advantage of the fermentation capability and high strength of the waste, coupled with its use as a feedstock for anaerobic digestion systems. This method, anaerobic digestion, reduces the amount of pollutant organic matter in the waste and, at the same time, yields both fertilizer and energy (Wei *et al.*, 2001; Li *et al.*, 1999a; Cheng *et al.*, 2000; Xu *et al.*, 2002).

The Up-flow Anaerobic Sludge Blanket (UASB) process is one of the controlled anaerobic digestion systems that has been used to treat the distillery effluent (Chen *et al.*, 1994; Zhou *et al.*, 2000a). Studies with this process clearly show that operating conditions under which good results are obtained depend heavily on the type of distillery effluent being treated.

Methane and carbon dioxide are produced from the fermentation of the waste and are evidence of the reduction of the organic pollution in the waste. The methane can be a convenient source for energy to meet needs in the area of the digester. If the digester works well, the gas produced will have a methane content of about 60-65%. When operating under the best conditions, the digester can reduce the BOD by 85% (Li *et al.*, 1999; Chen *et al.*, 1994). However, due to changes in weather and other parameters, the BOD and COD of the original waste is more often reduced by 60 to 70% (Cheng *et al.*, 2000, 2003). The residual material is much more amenable to subsequent land application. The carbon content is reduced but the nutrient content is relatively higher, thereby resulting in a more balanced and useful fertiliser material for crops.

Hence, because of its multiple, positive effects (including generating more economic activity via job creation and thereby strengthening the local economy, particularly in rural areas) when this methods is effectively implemented along with better management practice, anaerobic digestion is expected to play an important role in sugar-related environmental protection in the future.

However, there are a number of problems that prevent the immediate realization of these benefits. Among the greatest of these problems is the need for large amounts of financial capital and physical space to construct the treatment plants that are needed to deal with the large volumes of wastewater involved (Li *et al.*, 1999).

Concentrating vinasse, followed by burning in a special boiler (Zero effluent technology)

Another seemingly reasonable solution to this challenging problem is to concentrate the vinasse and burn it in order to generate energy while also eliminating the liquid effluent in a cane sugar factory (Huang *et al.*, 2001; Li *et al.*, 2001; Feng *et al.*, 1999; Fu *et al.*, 2002). In fact, experiments have been conducted to concentrate the effluent (the three-effect flash evaporation technology (Fu *et al.*, 2002) into a liquid that is pumped into a special boiler as fuel to generate energy. The practice in a Nanning sugar factory (Huang *et al.*, 2001) showed that the project has certain advantages, in addition to the obvious one of energy production, over the anaerobic digester, as it is much easy in operation, it required reduced space, it needs shortened construction time and has lower operating costs and better overall economics.

However, there are a number of problems, including scale formation in the boiler and corrosion in the pumps and pipes of the concentrator which should be solved.

MANAGEMENT OPTIONS AND FUTURE PROSPECTS

As with every other environmental problem, the most important approach to the sugar industry effluent problem in China is source control. Therefore, it is necessary for the sugar factories to have a better sources management and improve production efficiency so as to reduce the quantity and the pollutant content of the wastes. In the meantime, there is a range of management options that are currently available for treatment of these wastes.

Reuse or reduce the processing water

Several on-going projects (Wei *et al.*, 2002; Bei *et al.*, 1996; Wang *et al.*, 2001) are aimed at reusing or recycling the processing water. As more experience is gained with this option, it can anticipated that more mill operators will be encouraged to - explore these options seriously.

Centralized use and treatment of the distillery effluents

Among the 70 to 80 distilleries attached to sugar mills in Guangxi, China, half of them will likely to be advised to cease operations in the foreseeable future (Niu *et al.*, 1999). The molasses produced by these sugar mills will likely be sold and the associated operations centralized in larger regional distilleries that have the ability and capacity to adopt the modern technologies to solve the effluent problem more effectively.

Installation of organic complex fertilizer plants

Conventional lagoon treatment will likely be abandoned gradually in the country in order to reduce the risk of large-scale pollution problems. At the same time nutrients in vinasse are well-suited for farming land soils in Guangxi province and should be utilized in some beneficial manner. Therefore, all the sugar mills with distilleries should consider installing an organic complex fertilizer plant, either before or after concentration of vinasse, to convert the vinasse into material that can be sold to the farmers as fertizers to enhance their crops.

Use of anaerobic digestion system, coupled with the use of treated effluent for fertilizer and irrigation purposes

As noted above, anaerobic fermentation of the distillery waste can produce methane while also reducing the environmentally hazardous characteristics of the waste.

Operators need to consider farming land application of the digester effluent under well designed and controlled conditions. The controlling conditions need to be developed with a specific crop or vegetation in mind. That crop must be one that can use the organics and nutrients in the applied waste. Randomly applying this waste, or any waste, to any available crop has not been found to be a successful strategy. Rather, the crop and the waste have to be considered together in an ecological balance that characterizes an environmentally sound solution. This rational approach to deal with vinasse may mean that, in some cases, it should be condensed and nutrients added in order to produce an appropriate fertilizer.

Zero effluent technology

To the extent possible, modern zero effluent technology should be considered for larger distillers as an affordable and technically viable process for effluent treatment.

CONCLUSION

Sugar production will continue to be an important factor in the social and economic structure of China, in general, and in Guangxi, in particular, for the foreseeable future. Therefore, it is important for the sugar industry to identify, develop, adapt, and adopt new technologies that will minimize the significant adverse environmental impact of this important industry on society.

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PERGAMON

Biomass and Bioenergy 19 (2000) 63–102

BIOMASS & BIOENERGY

www.elsevier.com/locate/biombioe

Stillage characterization and anaerobic treatment of ethanol stillage from conventional and cellulosic feedstocks[☆]

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Abstract

A technical evaluation of stillage characterization, treatment, and by-product recovery in the ethanol industry was performed through a review of the scientific literature, with particular emphasis on solutions pertinent to a cellulosic-based ethanol production system. This effort has generated substantial information supporting the viability of anaerobic digestion for stillage treatment followed by land application on biomass crops for nutrient recovery. Generally, the characteristics of stillage from cellulosic materials appear comparable to those of conventional sugar- and starch-based feedstocks. However, the data on cellulosic stillage characteristics and treatment parameters are extremely limited and highly variable. This has significant impacts on the capital costs and biogas recovery of anaerobic treatment systems predicted from these data. In addition, technical questions remain unanswered with regard to stillage toxicity from untested feedstocks and the impact of heavy metal leaching when acid hydrolysis reactors are fabricated from corrosion-resistant alloys. Thermophilic anaerobic digestion of ethanol stillage achieves similar treatment efficiencies and methane yields compared to mesophilic treatment, but at almost twice the organic loading rate. Therefore, application of thermophilic anaerobic digestion would improve process economics, since smaller digesters and less stillage cooling are required. Downstream processes for stillage utilization and by-product recovery considered worthy of continued investigation include the production of feed (from single cell protein and/or algae production), color removal, and production of calcium magnesium acetate. This study finds that sustainable and economically viable solutions are available for mitigating the environmental impacts which result from large-scale biomass-to-ethanol conversion facilities. However, further research in some areas is needed to facilitate successful implementation of appropriate technology options.

Keywords: Stillage; Anaerobic digestion; Ethanol production; Cellulosic feedstock; Sugar feedstock; Starch feedstock; By-product recovery; Vinasse; Distillery wastewater; Colour removal

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[☆] Florida Agricultural Experiment Station Journal Series No. R-07099.

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PII: S0961-9534(00)00017-9

Contents

1. Introduction

Stillage, also termed distillery wastewater, distillery pot ale, distillery slops, distillery spent wash, dunder, mosto, vinasse, and thin stillage, is the aqueous by-product from the distillation of ethanol following fermentation of carbohydrates. The production of ethanol from biomass, whether from sugar crops (sugar beets, sugar cane, molasses, etc.), starch crops (corn, wheat, rice, cassava, etc.), dairy products (whey) or cellulosic materials (crop residues, herbaceous energy crops, bagasse, wood, or municipal solid waste), results in the concurrent production of stillage which exhibits a considerable pollution potential [1,2]. Up to 20 liters of stillage may be generated for each liter of ethanol produced [3] and the pollution potential of stillage can exceed a chemical oxygen demand (COD) of 100 g/L [4]. A medium-sized ethanol facility producing 10^6 L ethanol/yr generates stillage with a pollution level equivalent to the sewage of a city with a population of 500,000 [5].

While large-scale ethanol production from sugar-based and starch-based crops has a considerable history, large-scale ethanol production from lignocellulosic biomass has been limited. However, efforts are underway to improve process economics and to bring cellulosics-to-ethanol conversion into production [6–19]. In contrast to sugar- and starch-based crops, the availability of significant resources of lignocellulosic biomass means that large-scale production of ethanol from lignocellulosic biomass has the potential to replace a major portion of imported liquid fuels [13]. Also, when conversion efficiencies are high, the production and use of fuel ethanol from all biomass sources can reduce greenhouse emissions of CO_2 which would otherwise result from the use of fossil fuels. However, for the production of ethanol to qualify as a sustainable "green energy" process, due consideration for treatment and utilization of the stillage by-product is essential.

An extensive review of the scientific literature was conducted to investigate methods to process and utilize the significant by-product streams associated with ethanol production from conventional and cellulosic feedstocks. A preliminary analysis of ethanol-production wastewater characteristics and treatment revealed a consensus toward anaerobic digestion as an economically viable and sustainable by-product recovery scheme. Therefore, much of this effort focused on examining those aspects of biomass-to-ethanol conversion and effluent characteristics which are expected to impact the technical feasibility of anaerobic treatment. To the extent practicable, an attempt was made to assess the roles of feedstock, hydrolysis method, in-plant recycling, microbial toxicity, by-product recovery (feed and nutrients), reactor type, biogas yield, phytotoxicity and sustainability, in by-product treatment and utilization options.

2. Feedstocks for ethanol production

Conventional feedstocks for the production of ethanol include both sugar-based and starch-based feedstocks, as well as whey from the dairy products industry. The sugar-based feedstocks include crops such as sugar beets and sugar cane, as well as fruit crops such as grapes, and are the most easily fermentable feedstocks. Fresh juices from beets and cane contain reducing sugars which are available to yeast with no pretreatment of the feedstock, other than size reduction and pressing. However, the relatively high market value of sugar has limited implementation of direct conversion to ethanol and, instead, ethanol is often a by-product of sugar production through the fermentation of molasses, also called blackstrap molasses, left over from concentration and precipitation of sugar from the juice [20].

There are several grades of blackstrap molasses depending on the sugar content, ash content, and color. Whereas blackstrap molasses is a by-product of sugar crystallization, high test molasses is a concentration of the virgin juice normally intended for use in food products [21]. High test molasses is often acidified to prevent crystallization of sugars during storage. Unless otherwise stated, we will use the term molasses to mean blackstrap molasses.

Beet molasses and cane molasses are the most common sugar crop-based feedstocks for ethanol production. One other sugar-based feedstock for ethanol production is whey [22], an aqueous by-product of cheese production that contains lactose as the principal sugar. In addition, sweet sorghum contains carbohydrates in fractions of both sugar and starch, and may be considered a sugar-based feedstock due to the sugar fraction.

Starch-based feedstocks include grains such as corn, wheat, rice, barley, and milo (grain sorghum), as well as root crops such as potatoes and cassava. In addition to milling, the conversion of starch-based feedstocks requires an enzymatic hydrolysis step, termed saccharification, to convert the starch to fermentable sugars [23]. Similar to the sugar industry, ethanol can also be produced as a by-product of large wet-milling operations which recover oils, proteins and gluten from grains for food and feed additives, and use the remaining purified starches to produce ethanol [23].

Cellulosic feedstocks for ethanol production include both herbaceous (e.g., grasses) and woody (softwoods and hardwoods) biomass, as well as industrial wastes (e.g., bagasse, rice hulls, and paper mill sludge) and municipal solid wastes (MSW) of organic origins. The organic fraction of MSW containing waste paper may be a suitable feedstock, as well as refuse derived fuel (RDF), which is a MSW fraction containing mostly paper and plastics. Cellulosic feedstocks typically contain a substantial amount of hemicellulose and lignin, which are bound up in the lignocellulose complex making up the plant fibers. These feedstocks require a more substantial pretreatment to convert the cellulose to fermentable sugars. After shredding, the cellulosic biomass must undergo acid, alkaline, or enzymatic hydrolysis to produce fermentable sugars. Since hemicellulose contains pentose sugars which cannot be utilized by the standard ethanol-producing yeast, *Saccharomyces cerevisiae*, novel organisms must be employed if utilization of these pentoses is desired [24].

3. Ethanol production processes

A successful ethanol production and conversion system that is both economically and environmentally sustainable requires the application of a host of component technologies in a holistic and integrated manner, such that economic risk for the investment is minimized. Fig. 1 displays one schematic representation of an ethanol production system which is classified into four dependent component systems — production, harvesting, storage, and conversion. This study concerns mainly the conversion process. However, conversion may be linked to the production system through the possibility of recovering and utilizing conversion by-products to enhance production efficiency, while providing an economically viable and necessary outlet for by-products which must leave the conversion facility. If the primary output of such a system is the production of liquid fuel ethanol, which leaves the facility in an almost pure state, then every other material input to the conversion facility besides the carbon precursor will eventually require some means of final disposition. Optimal sustainability will occur when each by-product generates maximum value and minimum environmental impact.

Not all of the inputs and losses for the component systems can be completely controlled through process design, although the goal is to minimize the cost of both controllable inputs and losses. For the conversion facility, while minimizing inputs is beneficial for economical ethanol production, there is also a significant incentive to minimize the wasting of "necessary" by-product outputs through treatment and conversion that permits their most valuable utilization.

A more detailed schematic of the unit process steps required to produce ethanol within the conversion facility is depicted in Fig. 2. While some differences exist in the processing of sugar, starch and lignocellulosic feedstocks, many aspects of the ethanol production process remain the same and detailed descriptions can be found elsewhere [25]. Since the total quantity (mass and volume) of the "whole" stillage leaving the distillation column is an order of magnitude larger than any of the other unit process "losses", the focus for minimizing waste at the conversion facility should target by-product recovery from this wastestream. However, since each of the preceding unit processes has a significant impact on the quantity and quality of this stillage wastewater stream, optimal utilization of stillage requires an understanding of how hydrolysis, fermentation and distillation affect the stillage by-product.

4. Pretreatment and hydrolysis

The effect of pretreatment process on stillage characteristics has not been documented. Pretreatment of a feedstock may include mechanical processes (milling and shredding), steam explosion [26,27], steam explosion in the presence of acid [28,29], super-critical explosion by carbon dioxide [30], ammonia freeze explosion (AFEX), solvent delignification (using ethanol, butanol, or acetic acid), and thermal–mechanical processes [18,31]. All of these processes serve to improve access to the substrate for further hydrolytic steps. In the AFEX process [32], the substrate is exposed to ammonia at elevated pressures and

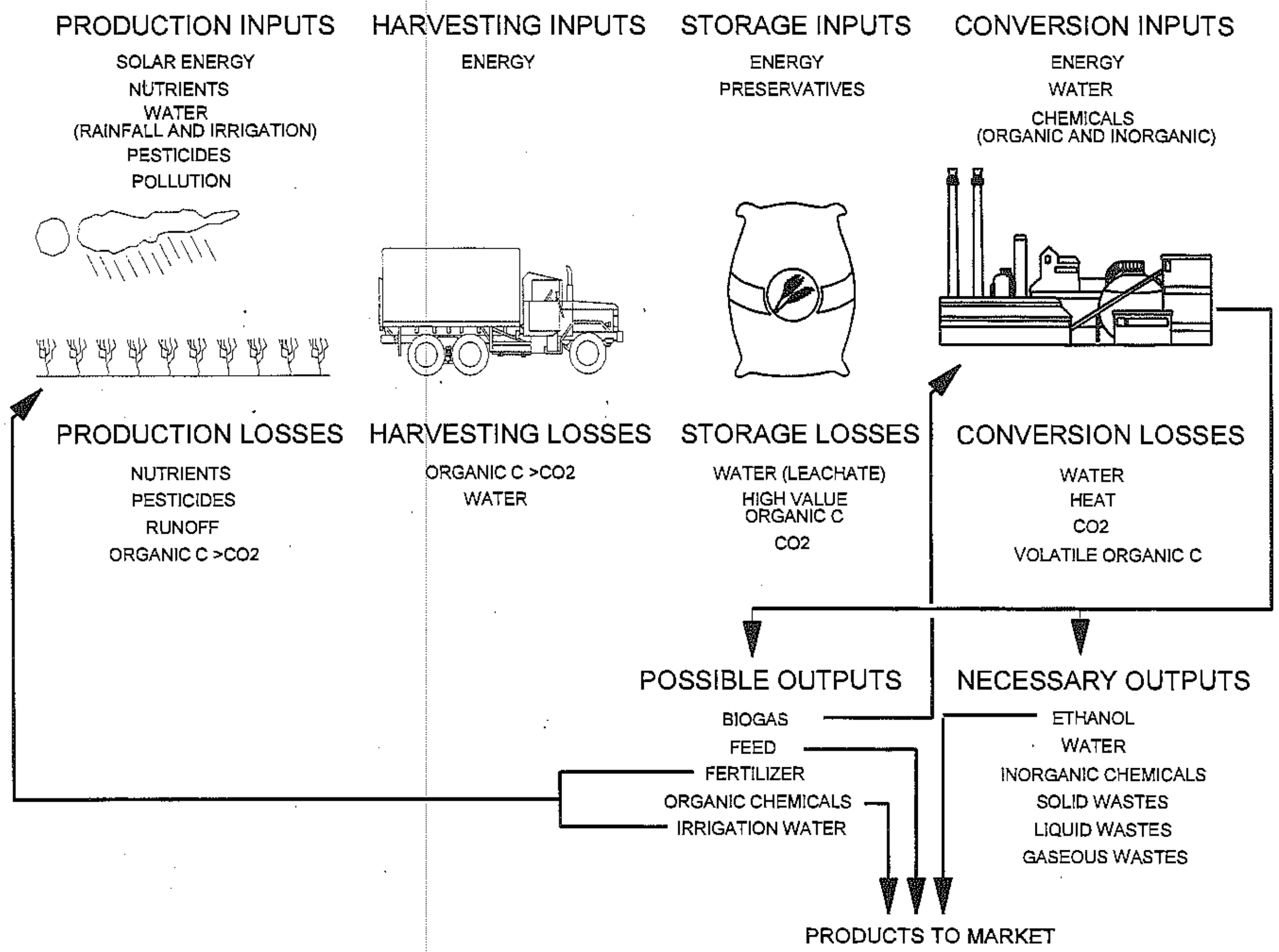

Fig. 1. Schematic representation of an ethanol production system.

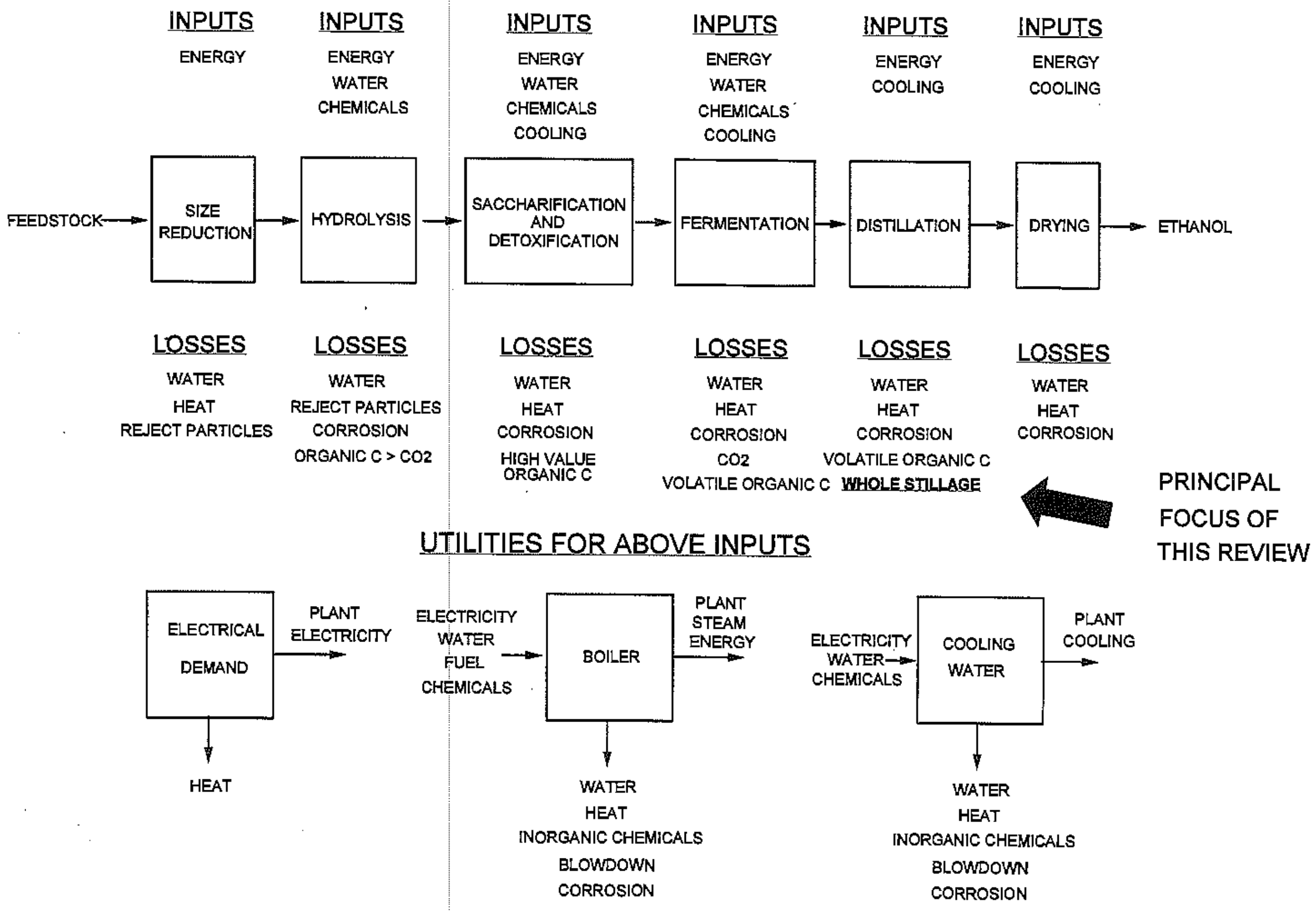

Fig. 2. Ethanol conversion facility: component processes, inputs and outputs.

flashed back to atmospheric pressure to open the cellulose fibers in order to improve enzymatic hydrolysis of the cellulose to fermentable sugars. Much of the ammonia can be recycled except for a fraction remaining on the fibers. Where pretreatments are effected to separate components of the biomass (e.g., bark or pith), it is plausible that such treatments will affect the composition of the fermentation media as well as the final stillage product.

As stated previously, sugar-based feedstocks do not require processing to convert carbohydrates into fermentable sugars. In starch-based feedstocks, a mashing and saccharification process is required to produce fermentable sugars [33]. After milling, the starch-based feedstocks are introduced into a cooker, with make-up water and α-amylase, and heated to 90°C. In this liquefaction process, α-amylase is employed to cleave long starch polymers to dextran. Alpha-amylase requires Ca^{++} for activation and has an optimal pH of 6.6. This is generally achieved by the addition of lime as the Ca^{++} source and additional alkali (usually NaOH) as required to reach the optimal pH, since the pH of most grain-mash is below this optimum. After liquefaction, the mash is cooled to below 60°C and gluco-amylase is added while the pH is lowered to the optimal value of 4.5 for this enzyme [25]. The gluco-amylase enzymes attack the ends of dextran and produce fermentable sugars. At this stage, nitrogen and phosphorous nutrients may be added where the nutrient content of feedstocks is expected to limit fermentation.

Since the pH optima of these two enzymes are different, the salinity of the mash and the final stillage is increased by the salts which are formed as a result of these pH adjustments. The composition of these salts is dependent on the acids and bases employed. The introduction of alkali and acid during mashing and saccharification is an important step for optimization and should receive careful consideration [33]. Minimizing the addition of alkali during mashing will lessen the requirement for acid during saccharification, leading to lower chemical consumption and a lower salinity of final effluent stillage. However, if the time period and pH achieved are insufficient in either step, the presence of unfermentable sugars may increase the COD of the final stillage and thereby impact stillage treatment requirements.

Hydrolysis of cellulosic feedstocks is accomplished through either enzymatic, concentrated acid [34], or dilute acid hydrolysis, or combinations thereof [9]. In enzymatic hydrolysis, extracts of cellulase enzymes obtained from cellulolytic organisms, such as *Trichoderma reesei*, are added to the feedstock, often along with β-glucosidase, to allow conversion of the cellulose to cellobiose and then to individual glucose units [35]. While enzymatic hydrolysis is considered expensive compared to acid hydrolysis, due to the cost of enzymes and the longer time required (days rather than minutes), it possesses the advantage that side reactions which convert some of the carbohydrates in cellulosic feedstocks to non-fermentable sugars are virtually absent.

In acid hydrolysis, the cellulosic feedstock is exposed to concentrated or dilute acids (usually H_2SO_4) at elevated temperatures and pressures for specific time periods to free the hemicellulose and lignin from the cellulose fibers and to hydrolyze the cellulose to glucose [36]. Acid hydrolysis may employ concentrated acids for short periods of exposure or dilute acids for longer periods [37]. A common scheme is to employ a two-stage dilute acid hydrolysis, where the hemicellulose is hydrolyzed to xylose and recovered in the first stage and a more vigorous second-stage hydrolysis is employed for conversion of cellulose to glucose [38]. The two streams may be combined or fermented separately [39]. A consequence of acid hydrolysis is the potential loss of glucose to hydroxymethyl furfural and xylose to furfural in side reactions [18]. In combinational hydrolysis processes, dilute acid hydrolysis or AFEX may be followed by enzymatic treatment to enhance the effect of costly enzyme additions [40]. More complete descriptions of these processes can be found elsewhere [9].

Finally, lignin solids remaining after hydrolysis may cause problems in fermentation when recycling of yeast is desirable. Alkaline (NaOH) or oxidant (H_2O_2) treatments may be employed in pretreatments to render the lignin to soluble forms [18]. Also, resinous acids and lignin degradation products resulting from acid hydrolysis may be inhibitory to fermentation [41,42], and over-liming prior to fermentation may be employed for detoxification of the mash [36]. The effect of hydrolysis method on stillage characteristics is not documented in the literature.

5. Fermentation

The fermentation process is normally operated as a batch, but the process may also be continuous or partially continuous [43]. In a conventional batch process, an inoculum of yeast culture often close to 10% of the fermenter volume is added to the cooled mash and allowed to ferment to completion, usually in less than 2 days [25]. The volume of stillage which results after distillation is inversely proportional to the concentration of ethanol at the end of the fermentation. Therefore, efforts to assure high ethanol content of the final beer will reduce stillage volume and improve distillation energy consumption and capacity [44]. Also, ensuring that fermentation has reached completion and that residual sugars in the beer are minimized can lower the COD of the resulting stillage. For every 1% of residual sugar (based on glucose), a stillage COD increment of 16 g/L can be expected.

Continuous fermentation with immobilized yeast [45] or recycled yeast [46] is advocated for potentially higher fermenter productivity and ethanol yield, mostly due to a decreased yield of yeast organisms. Any increase in ethanol yield should lower the organic strength of the final stillage, but this may depend on the final disposition of the product yeast. Where yeast is not recovered, continuous fermentation should lower stillage COD, since yeast yield is less than for batch fermentation. Conversely, where yeast is recovered for use in feed products, the impact of continuous fermentation on stillage COD can be expected to be minimal, since the lesser amount of yeast is removed from the stillage. However, continuous fermentation increases the susceptibility to contamination by microorganisms which produce fermentation products other than ethanol, most of which will remain in the stillage and increase stillage COD.

In a partially continuous fermentation, yeast may be partially recovered from the beer prior to distillation and returned to fermentation. The volume of stillage is reduced by the volume of returned yeast [47], but the soluble COD entrained with the yeast increases the COD of the stillage. In a similar manner, when properly used, back-set or stillage recycling (the use of stillage as make-up water for cooking and fermentation) will lower stillage volume [48] but not affect the total amount of COD produced since the stillage strength will be increased by the amount of back-set [49]. An analysis of beet molasses distilleries showed that the use of 30% back-set reduced stillage production from 15.9 to 12.6 L/L ethanol [50]. The use of back-set can reduce consumption of water, steam, and some chemicals, but the accumulation of fermentation products and non-fermentable sugars can inhibit the fermentation process. Therefore, a practical limit of 50% stillage recycling is considered a maximum [25,44,47,48,51–53]. Above this level of stillage recycling, inhibition of the yeast will lower ethanol yield and increase the COD concentration in the stillage beyond that contributed by the recycled stillage alone.

Several different organisms have been proposed for use in fermenting sugars to ethanol, with different strains of the yeast, *Saccharomyces cerevisiae*, being the most widely used due to its robust growth rate and high ethanol tolerance [54]. With proper nutrient and growth conditions, it has been shown that *S. cerevisiae* can tolerate ethanol concentrations up to 23% [54]. There is an interest in the use of thermotolerant yeast in thermophilic ethanol production [55,56], due to the potential for higher fermentation rates and ethanol yields, and the reduced requirements for cooling. Yet, to date, thermophilic fermenting organisms have suffered from low ethanol tolerance, presumably due to leaky cell membranes at the higher temperatures [56].

The bacterium, *Zymomonas mobilis*, has been shown to produce higher ethanol yields due to a lower cell yield, but its lower ethanol tolerance and lower feed by-product return has limited its widespread application [57]. Difficulty of separation, lower cell yield, and concern for pathogenic contamination in feed have limited the market for bacterial feed additives. In contrast, yeast are more easily separated, generally accepted as safe in feeds, and have an established market [58].

Since *S. cerevisiae* poorly ferments lactose, *Kluyveromyces marxianus* is often employed for fermentation of whey feedstocks [59]. For cellulosic feedstocks containing pentose sugars which are not fermentable by *S. cerevisiae*, the impact of organism selection on stillage COD could be significant since the pentose sugars can amount to 25% of the feedstock carbohydrates [60,61]. Genetically engineered *Escherichia coli, Zymomonas*, and yeast with extended substrate capabilities can utilize both 5-carbon and 6-carbon sugars to produce ethanol [24,62–65]. A significant decrease in stillage COD could be expected from utilizing pentose sugars in the fermentation of cellulosic feedstocks, but this has not been documented.

For cellulosic feedstocks employing enzymatic hydrolysis, saccharification may be aided by the addition of β-glucosidase to the mash to cleave the glucose dimer, cellobiose. Since the activity of β-glucosidase is inhibited by the presence of glucose, the use of saccharification during fermentation, called simultaneous saccharification and fermentation (SSF), is advocated since the fermenting organisms will lower inhibiting glucose concentrations [19,66]. Also, since higher ethanol yields have been achieved using SSF, the resulting stillage should have a lower organic content, although this has not been documented. A simple modification to SSF which was shown to be effective is the periodic application of ultrasound to the fermentation to enhance enzyme contact with the substrate [67].

6. Distillation and dehydration

After fermentation is complete, the beer containing typically 2–12% ethanol is pumped to a continuous distillation process where steam is used to heat the beer to its boiling point in the stripper column [25]. The ethanol-enriched vapors pass through a rectifying column and are condensed and removed from the top of the rectifier at around 95% ethanol. The ethanol-stripped stillage falls to the bottom of the stripper column and is pumped to a stillage tank. With efficient distillation, the stillage should contain less than 0.1–0.2% ethanol but, at times when distillation is not optimal, the stillage may contain a significant ethanol content. For each 1% ethanol left in the stillage, the COD of the stillage is incremented by more than 20 g/L. Due to the potential impact of residual ethanol content, therefore, proper control over distillation can greatly affect the COD of stillage.

The heating of stillage by steam can occur either by direct injection of steam into the bottom of the stripper column or indirectly through a "reboiler" heat exchanger at the bottom of the column [25]. Also true in the cooking process, the direct injection of steam impacts the stillage in two ways. First, the condensed steam adds to the stillage volume and dilutes the contents. In addition, loss of water from the boiler requires the addition of make-up water and increases the blow-down volume from the boiler required to avoid boiler scaling. More boiler feed water use and blow down increases the requirement for boiler chemicals and increases the amount of salts removed in the blow down [68]. Since the blow-down water is normally combined with the stillage, it dilutes the organic content of the stillage and increases the salinity. An analysis at a beet molasses distillery showed that stillage production decreased from 15.9 to 12.7 L/L ethanol when heating was switched from direct steam injection to the use of a reboiler [50].

In order to allow the blending of alcohol with gasoline, the water content must be reduced to less than 1% by volume. Higher water levels can result in the separation of an alcohol/water mixture below the gasoline phase, which may cause engine malfunction when a fuel tank empties. Unfortunately, separation of ethanol from water by distillation is limited to a purity of around 96% due to the azeotropic properties of ethanol/water mixtures. The removal of the water beyond the last 5% is called dehydration or drying. Traditionally, azeotropic distillation was employed to produce higher purity ethanol by adding a third component, such as benzene, cyclohexane or ether, to "break" the azeotrope and produce dry ethanol [69]. To avoid the illegal transfer of ethanol from the industrial market into the potable alcohol market, where it is highly regulated and taxed, dry alcohol usually requires the addition of denaturing agents which render it toxic for human consumption, and the azeotropic reagents conveniently met this requirement.

Except in the high purity reagent-grade ethanol market, azeotropic drying has been supplanted by molecular sieve drying technology, which is not only more energy efficient but also avoids the occupational hazards associated with the azeotropic chemical admixtures. In molecular sieve drying, the ethanol is passed through a bed of synthetic zeolite with uniform pore sizes which preferentially adsorb water molecules. After the bed becomes saturated, it must be regenerated by heating or evacuating the bed to drive off the adsorbed water. Either liquid or vaporous ethanol can be used, but the dominant and most efficient technology is the vapor-phase "pressure swing" adsorption molecular sieve process [69]. In this case, two molecular sieve beds are placed in parallel with one drying while the other is regenerating. During the regeneration phase a "side stream" of ethanol/water (often around 50%) is produced, which must be redistilled before it can be returned to the drying process. The "bottoms" from side stream distillation is often blended into the stillage, adding to the stillage volume.

7. Stillage production and characterization

The annual production of ethanol from various sugar- and starch-based feedstocks is significant. Production of ethanol in Brazil was 16.2 billion liters in 1997 [70], with 79% produced from fresh sugarcane juice and the balance produced from molasses by-product. In India, 250 distilleries were producing 1.5 billion liters of ethanol in 1995 [71] from sugarcane molasses, with at least 65% of the ethanol used as chemical feedstock. In the US, there were 57 facilities producing an estimated 6.9 billion liters of ethanol in 1999 [72]. Existing feedstocks may support some expansion of production capacity, but significant increases in ethanol production will require the utilization of cellulosic-based feedstocks. Since up to 20 liters of stillage may be generated for every liter of ethanol produced, substantial increases in ethanol production will also require effective solutions for stillage management.

The production and characteristics of stillage are highly variable and dependent on feedstocks and various aspects of the ethanol production process. Wash water used to clean the fermenters, cooling water blow down, and boiler water blow down may all be combined with the stillage and contribute to its variability. However, while the volume and COD concentration of stillage may vary considerably, the total amount of COD produced can be expected to be more consistent with the amounts of feedstock processed and ethanol produced. Table 1 shows yields of ethanol, stillage and COD on the basis of feedstock mass processed and indicates the impact of feedstock on COD produced. Feedstocks yielding higher amounts of ethanol appear to also produce higher amounts of stillage COD, but do not correlate with the COD concentration. Unfortunately, the number of studies which examine stillage production in this manner are limited.

Ignoring stillage production volumes, many studies have examined the characteristics of stillage in terms of its organic strength and nutrient content for various ethanol-producing feedstocks, as shown in Tables 2–6 for sugar beet molasses, for sugarcane juice, for sugarcane molasses, for some additional sugar and starch feedstocks, and for cellulosic feedstocks, respectively. A summary of the data from Tables 2, 3, 4, and 6 is presented in Table 7.

Upon analysis of these values, it is apparent that cane molasses stillage exhibits the highest levels of biochemical oxygen demand (BOD), COD, COD/BOD ratio, potassium, phosphorous and sulfate, while cane juice stillage exhibits the lowest levels of COD and BOD (Table 7). The concentration of sugars in molasses, through crystallization and evaporation of cane juice, increases the content of non-fermentable organics which remain in the stillage after fermentation, augmenting the COD and increasing the COD/BOD ratio. The high N-content of stillage from barley fermentation (Table 5) stands out and is presumably related to the high protein content in the grain. This level of N is sufficient to produce inhibitory levels of ammonia/ammonium in effluents from barley distilleries [73].

The high sulfate levels of molasses (Table 7) are also noteworthy, and are a result of the type of sulfiting process used in raw sugar production [20]. There is also an instance of high-sulfate cane juice stillage (Table 3) [74], which results from production of direct consumption sugar using a sulfitation process to produce a sugar straight from boiled juice without a second melting and refining step [75]. Such high levels of sulfate can impact further treatment and disposition of stillage.

Organic components of stillage have been studied by several researchers [76–78]. The principal low molecular weight components of cane molasses stillage were found to be lactic acid, glycerol, ethanol and acetic acid, while whey stillage also contained lactose, glucose, arabinitol, and ribitol [77]. Trace amounts of amino acids were found in all stillages tested, with corn stillage containing high levels of alanine and proline [77]. A comparison of barley- versus wheat-based stillage found higher levels of most amino acids in the crude protein of barley stillage but lower levels of crude protein on a stillage dry matter basis compared to wheat stillage [79]. Carbon-13 nuclear magnetic resonance and diffuse reflectance Fourier-transform infrared spectroscopy studies of cane molasses stillage suggested the presence of a fulvic acid (FA) component com-

Table 1
Stillage production from various feedstocks (values are calculated from data in literature sources)[a]

Feedstock	Ethanol production capacity 10^6L/yr	Ethanol yield L/kg feedstock	Stillage yield L/kg feedstock	BOD (COD) g/L	COD yield kg/kg feedstock	COD yield kg/L EtOH	References
Beets fresh and molasses	18.8	0.02	0.22	38 (65)	0.014	0.70	Holmes and Sane [199]
Cane molasses	nd	0.32	3.8	nd (nd)	nd	nd	Chamarro [44]
Cane molasses	50	0.21	2.52	45 (113)	0.28	1.33	Barnes and Halbert [102]
Cane juice	24	0.067	1.33	12 (25)	0.03	0.45	van Haandel and Catunda [3]
Corn	7–70	0.379	6.29	37 (56)	0.349	0.92	Loehr and Sengupta [95]
RDF/CA (dry wt basis)	nd	nd	5.5	37.7 (104)	0.572	nd	Broder [200]
RDF/DA (dry wt basis)	nd	nd	3.8	31.1 (110)	0.418	nd	Broder [200]
Softwood (*Pinus radiata*)	nd	0.25	20.4	13.2 (25.5)	0.52	2.05	Callander et al. [1], Mackie et al. [36]
Whey	2.0	0.012	0.02	5.4 (nd)	nd	nd	Barry [201]
Whey	nd	0.021	0.21	15 (nd)	nd	nd	Singh et al. [202]

[a] nd = no data; CA = Concentrated acid; DA = Dilute acid; RDF = Refuse derived fuel.

Table 2
Stillage characterization for sugar beet molasses feedstocks (values are calculated from data in literature sources)[a]

Feedstock	Stillage yield L/L EtOH	BOD (COD) g/L	N (total) mg/L	P (total) mg/L	K mg/L	Total S as SO_4 mg/L	pH	References
Beet molasses	11.8	27.5 (55.5)	4750	nd	5560	3500	4.3	Vlissidis and Zouboulis [203]
Beet molasses	nd	nd (115.8)	56	175	nd	1042	6.69	Boopathy and Tilche [204]
Beet molasses	nd	69.3 (147)	2700	222	14500	5800	5.5	Basu [205]
Beet molasses	11.8	nd (72)	7340	91	nd	4520	nd	Vlyssides et al. [162]
Beets fresh and molasses	11.3	38 (65)	3000	nd	nd	nd	4.9	Holmes and Sane [199]

[a] nd = no data.

parable to FA extracted from soils and sewage sludge, though exhibiting a higher C/N ratio [76].

Other important characteristics of stillage include color, heavy metals content and the presence of organic priority pollutants. Highly colored effluents can have negative environmental impacts if released into surface waters, where they may disrupt the growth of normal aquatic flora. Phenolics (tannic and humic acids) from the feedstock [80], melanoidins from Maillard reaction of sugars with proteins [75], caramels from overheated sugars [75], and furfurals from acid hydrolysis [81] can contribute to the color of the effluent. In addition, these compounds are known to be inhibitory to fermentation, to rumen microbes [82,83], as well as to biological treatment of the stillage [84–86]. Also, melanoidins are known to be mutagenic [87,88].

Heavy metals have been detected in effluents from ethanol production facilities [89]. Specifically, chromium, copper, nickel and zinc were found at levels significantly above detection limits in effluents from several ethanol facilities. Also, high levels of copper (> 150 mg/L) have been found in stillage from cherry/raspberry feedstocks due to the addition of $CuSO_4$ to the mash to bind cyanide in order to meet spirit standards [90]. While some heavy metals may be introduced from the feedstock and chemicals used, corrosion of piping, tanks, and heat exchangers is expected and may contribute to heavy metal levels in the effluent. Processing equipment used in acid hydrolysis is often made of corrosion-resistant alloys [38] to withstand the high temperature and acidic conditions of hydrolysis. Heavy metals contained in these alloys may leach into the feedstock during hydrolysis, resulting in detectable levels in the stillage. However, we found no studies addressing heavy metal levels in hydrolysis stillage.

Organic priority pollutants, including chloroform, methylene chloride, pentachlorophenol, and phenol, were found in wastewaters from at least 2 of 13 ethanol production facilities sampled [89], but no source for these compounds was identified. Since, in the US, large corn-processing plants may only produce ethanol when the demand for high-fructose corn syrup is low (in the winter months), idled ethanol-dehydrating equipment may be employed for drying other industrial chemicals, including organic priority pollutants [91]. Side streams from regenerating the molecular sieves must be redistilled and the chemical-based still bottoms is often combined with ethanol stillage, introducing priority pollutants into the stillage [91]. The presence of organic priority pollutants in stillage is atypical and is not expected when separation processes are not intermingled with other chemical processing.

Generally, the characteristics of stillage from cellulosic materials appear comparable to those of conventional feedstocks (Table 7) and, therefore, methods of stillage treatment and utilization applied to conventional feedstocks should also be applicable to cellulosic feedstocks. Two possible exceptions to the similarity of cellulosic and conventional stillage characteristics which deserve attention are the potential for higher levels of heavy metals from acid hydrolysis processes and the presence of unusual inhibitors, such as hardwood extractives [92], associated with phenolic compounds present in the feedstock.

8. Stillage treatment and utilization

Solutions for the treatment, utilization and disposal of stillage have been reviewed [2,48,93–95], but the role of anaerobic digestion in stillage treatment received minimal attention in these previous reviews. An early means of treatment and disposal included evaporation of the stillage, neutralization with alkali, followed by incorporation into road building materials [93]. While the fertilizer value of molasses stillage was well recognized, British Guiana banned field application to eliminate odor problems [93]. This led to a process of evaporation followed by incineration in the bagasse furnace, with the ash returned to the fields for fertilizer recovery [93]. From 1926 to 1942, more than 12 patents were issued in the US and UK on processes for treating stillage, including charcoal production, pyrolysis, and various means of fertilizer production [93].

8.1. Physical/mechanical separation

Fig. 3 illustrates the principal stillage treatment technology and utilization options. First, physical/mechanical separation can be applied to the stillage to recover and remove suspended solids containing yeast and other materials. For whole grains (corn), the separated solids can be dried and sold as a high-value animal feed called dried distillers grains (DDG) [96]. The presence of unfermented suspended materials facilitates this recovery process. For sugar crops and cellulosic crops, the separation of suspended solids proves more difficult. Following mechanical treatment, a host of technologies exists for further processing, including evaporation and/or membrane separation, single cell protein production, and anaerobic digestion.

8.2. Evaporation and membrane separation

With evaporation, the stillage is concentrated to a syrup in multi-effect evaporators with the

Table 3
Stillage characterization for sugar cane juice and mixed cane juice/cane molasses feedstocks (values are calculated from data in literature sources)[a]

Feedstock	Stillage yield L/L EtOH	BOD (COD) g/L	N (total) mg/L	P (total) mg/L	K mg/L	Total S as SO_4 mg/L	pH	References
Cane juice	20	12 (25)	400	200	800	nd	3.5	van Haandel and Catunda [3]
Cane juice	nd	15 (22)	400	58	nd	400	3.5	Driessen et al. [206]
Cane juice	nd	16.5 (33)	700	91	1742	760	3.7–4.6	Costa et al. [207]
Cane juice	nd	20 (nd)	nd	nd	nd	nd	3.7–5.9	Barnes and Halbert [102], Willington and Marten [208]
Cane juice	nd	nd (26.0)	1190	320	2100	1470	3.9	Callander and Barford [74]
Cane juice + molasses	nd	19.8 (45)	710	87	3817	3730	4.4–4.6	Costa et al. [207]
Cane juice + molasses	12.5	nd (31.5)	370	24	1300	420	3.9	Souza et al. [209]

[a] nd = no data.

co-production of evaporator condensate which is lower in organics (COD < 10 g/L) and almost devoid of inorganic salts. In whole grain-to-alcohol production, the syrup of concentrated stillage is mixed with DDG and further dried to a saleable product called dried distillers grains and solubles (DDGS) [97]. In the cane molasses ethanol industry, this syrup is sold as a low-value feed additive called "condensed molasses solubles" [20] which is typically high in potassium, limiting its use in feed formulations due to the laxative effect [98].

While evaporation serves to concentrate stillage components into a smaller volume, the significant energy required to evaporate the stillage (equivalent to 10% of the energy content of the ethanol) can negatively impact the energy balance of ethanol production [96]. Also, while the evaporator condensate is significantly lower in organic content than stillage, it still contains volatile organics including ethanol, acetic acid, and formaldehyde. The use of evaporator condensate for make-up water in the cooking process is possible. This can allow for higher levels of water recycling than achieved using 50% stillage back-set, but a build up of inhibitors prevents 100% water recycling [99]. Evaporator condensate has also been used for both boiler and cooling make-up water,

Table 4
Stillage characterization for cane molasses feedstocks (values are calculated from data in literature sources)[a]

Feedstock	Stillage yield L/L EtOH	BOD (COD) g/L	N (total) mg/L	P (total) mg/L	K mg/L	Total S as SO_4 mg/L	pH	References
Cane molasses	nd	25 (65)	1610	127	6497	6400	4.2–5.0	Costa et al. [207]
Cane molasses	16	25.8 (48)	820	157	nd	nd	4.4	de Menezes [48]
Cane molasses	nd	27 (88)	2000	nd	nd	4000	4.3–4.6	Shrihari and Tare [210]
Cane molasses	nd	30 (120)	1600	61	1920	4600	4.1	Harada et al. [211]
Cane molasses	nd	32 (nd)	205	6.8	nd	nd	4.6	Sahai et al. [212]
Cane molasses	nd	35.7 (77.7)	1780	168	8904	4360	4.2	Sheehan and Greenfield [2]
Cane molasses	13–15	39 (100)	1030	33	7000	9500	3.4–4.5	Driessen et al. [206]
Cane molasses	nd	40 (nd)	345	38.8	nd	69.5	4.4	Srivastava and Sahai [213]
Cane molasses	nd	40 (80)	nd	45	4013	nd	4.5–5.0	Silverio et al. [214]
Cane molasses	12	45 (113)	nd	nd	nd	nd	4.8	Barnes and Halbert [102], Willington and Marten [208]
Cane molasses	12	45 (130)	1000	130	nd	nd	4.5	Yeoh [4]
Cane molasses	nd	48 (nd)	382	10.4	nd	67	4.1	Sahai et al. [215]
Cane molasses	15	50 (108)	nd	nd	8298	4700	4.5	Lele et al. [5]
Cane molasses	20	60 (130)	2500	200	nd	3000	4.8	Halbert and Barnes [165]
Cane molasses	nd	60 (98)	1200	1500	1200	5000	3.8–4.4	Goyal et al. [216]
Cane molasses	nd	nd (68.9)	nd	nd	4484	1640	4.72	Espinosa et al. [217]
Cane molasses	nd	nd (66)	nd	nd	nd	nd	4.5	Calzada et al. [138]
Cane molasses	10	nd (75)	975	20	nd	nd	4.4	Garcia Garcia et al. [218]
Cane molasses	nd	nd (100)	2500	300	1750	700	4.6–5.1	Sanchez Riera et al. [219]
Cane molasses	13	nd (22.5)	1192	247	nd	nd	5.2	Cho [220]
Cane molasses	nd	27.5 (65)	750	nd	10370	nd	4.2–4.5	Sen and Bhaskaran [221]
Cane molasses	nd	41 (118)	1135	nd	5070	4200	3.5–3.7	Damodara Rao and Viraraghavan [190]
Cane molasses	nd	nd (24.6)	812	29	1980	607	4.17	Casarini et al. [222]
Cane molasses (rum)	nd	42 (105)	1450	100	nd	4000	4.0–5.0	Szendrey [223–225], Szendrey and Dorion [226]
Cane molasses (stored)	nd	27.5 (64.0)	1300	nd	nd	2800	4.5–5.5	de Bazua et al. [120]

[a] nd = no data.

but the acidity may cause problems in the boiler and the organics often result in excessive slime growth in the cooling system, which lowers heat exchanger efficiencies. Finally, the evaporator condensate can undergo aerobic or anaerobic biological treatment, if required nutrients and buffers are added [100].

Membrane separation has also been employed for concentration of stillage and recovery of permeate for recycling in cooking and mashing

Table 5
Stillage characterization for other sugar and starch feedstocks (values are calculated from data in literature sources)[a]

Feedstock	Stillage yield L/L EtOH	BOD (COD) g/L	N (total) mg/L	P (total) mg/L	K mg/L	Total S as SO_4 mg/L	pH	References
Agave tequilana (tequila)	10	nd (66.3)	nd	nd	290	880	3.4	Ilangovan et al. [227]
Apple/pear	nd	22 (48.9)	380	62	nd	nd	3.4	Robertiello [228]
Banana	nd	nd (53.7)	1530	150	3830	nd	nd	Hammond et al. [229]
Barley spirits (shochu)	1.5	83 (97)	6000	nd	nd	nd	3.7–4.1	Kitamura et al. [73]
Barley and sweet potato	nd	nd (29.5)	nd	9.1	nd	1370	4.2	Shin et al. [230]
Cassava	16	31.4 (81.1)	650	124	nd	nd	3.5	de Menezes [48]
Cherry (morello)	nd	nd (80.0)	nd	nd	nd	34	3.5–4.0	Stadlbauer et al. [90]
Cherry/raspberry	nd	nd (60.0)	nd	nd	nd	1975	2.7–2.9	Stadlbauer et al. [90]
Corn (thin stillage)	nd	26.9 (64.5)	755	1170	nd	nd	3.3–4.0	Ganapathi [231]
Corn (thin stillage)	nd	43.1 (59.4)	546	228	nd	299	nd	Dahab and Young [232]
Figs	nd	20.4 (35.4)	880	170	nd	900	3.6	Vlissidis and Zouboulis [203]
Grapes (cognac)	nd	nd (26)	nd	nd	800	nd	3.0–3.2	Henry et al. [233]
Grapes (wine)	nd	nd (30)	450	65	nd	250	3.5–4	Driessen et al. [206]
Grapes (wine)	nd	nd (40.0)	nd	130	nd	nd	3.8	Borja et al. [234]
Grapes (wine)	nd	16.3 (27.5)	650	nd	nd	120	4.2	Vlissidis and Zouboulis [203]
Pear	nd	nd (47.5)	nd	nd	nd	157	3.4–3.8	Stadlbauer et al. [90]
Potato	nd	nd (52.0)	2100	nd	nd	nd	4.8	Temper et al. [235]
Potato	nd	nd (39.0)	1000	430	4000	nd	nd	Wulfert and Weiland [236]
Milo (thin stillage)	nd	34.9 (75.7)	nd	1280	nd	nd	2.5–4.0	Stover et al. [237], Ganapathi [231]
Milo (thin stillage)	nd	40.4 (45.5)	nd	nd	nd	nd	4.1	Hunter [238]
Raisins	nd	30 (57.5)	750	220	nd	480	3.2	Vlissidis and Zouboulis [203]
Raisins (raki)	nd	nd (14.0)	250	50	nd	nd	3.9	Eremektar et al. [239]
Raspberry	nd	nd (70.0)	nd	nd	nd	37	2.9–3.8	Stadlbauer et al. [90]
Rice spirits (shochu)	nd	25 (50.9)	nd	129	nd	nd	3.5	Yang and Tung [240], Yang [241]
Rice spirits (shochu)	1.5	84 (nd)	nd	389	nd	nd	4.26	Kida et al. [118]
Sweet potato (shochu)	nd	14.2 (30.7)	1200	140	nd	nd	4.5	Nagano et al. [242]
Sweet sorghum	16	46.0 (79.9)	800	1990	nd	nd	4.5	de Menezes [48]
Wheat (shochu)	nd	25.9 (50.1)	1500	170	nd	nd	4.6	Nagano et al. [242]
Whey	1.7	5.4 (nd)	nd	nd	nd	nd	nd	Barry [201]
Whey	nd	15 (nd)	nd	nd	nd	nd	nd	Singh et al. [202]

[a] nd = no data.

[101]. While energy consumption is less than for evaporation, membrane fouling is problematic [102,103] and low molecular weight organics still pass through the membranes, eliminating the potential for 100% water recycling in the ethanol production process [104]. Membrane separation could also be applied to the evaporator condensate but, since this stream only contains low molecular weight organics, separation efficiencies would not be sufficient to remove fermentation inhibitors.

8.3. Single cell protein production

A potentially viable use of stillage is for single cell protein (SCP) production [99], where a second aerobic culture is employed to remove residual sugars and soluble proteins in the stillage and lower the COD and nutrient content [105]. Also, a portion of the stillage can be used to produce inoculum for ethanol production. Finally, the sludge from biological treatment of stillage could be processed into feed materials [106,107].

Five different filamentous fungi were grown on rum stillage, resulting in a COD reduction of up to 60% with *Gliocladium deliquescens* performing best [108]. Several species of *Candida* were grown on molasses stillage along with various additives and the best protein and biomass production occurred using *Candida krusei* with a phosphoric

Table 6
Stillage characterization for cellulosic feedstocks (values are calculated from data in literature sources)[a]

Feedstock/Process	Stillage yield L/L EtOH	BOD (COD) g/L	N (total) mg/L	P (total) mg/L	K mg/L	Total S as SO_4 mg/L	pH	References
Eucalyptus/DA	nd	nd (22.5)	200	40	nd	260–360	5.8–6.3	Good et al. [243]
Hardwood/TS-DA	nd	nd (19.1)	2800	74	nd	900	nd	Strickland et al. [244]
Hardwood (willow)/SE-Enz	nd	19.8 (33.3)	nd	nd	nd	nd	nd	Larsson et al. [12]
Mixed (herbaceous)/nd	nd	56.2 (140)	nd	nd	nd	602	nd	CH2M Hill [245][b]
Mixed (biomass)/nd	nd	46.8 (119)	nd	nd	nd	617	nd	CH2M Hill [245][b]
Mixed (softwood)/nd	nd	26.7 (72.0)	nd	nd	nd	589	nd	CH2M Hill [245][b]
MSW/TS-DA-SF	nd	32.1 (72.0)	140	nd	nd	nd	5.5	Broder [200]
MSW/nd	nd	20.9 (61)	nd	nd	nd	599	nd	Larsson et al. [12]
Pinus radiata/DA-SF	16.7	13.2 (25.5)	95.3	10.3	38.5	600	4.5–5.0	LFTB [246], Callander et al. [1]
RDF/CA	nd	37.7 (104)	13760	14.0	nd	nd	5.0	Broder [200]
RDF/DA	nd	31.1 (110)	2100	0.68	nd	nd	5.9	Broder [200]
RDF/TS-DA-SF	nd	nd (38.1)	nd	nd	nd	nd	5.5	Broder and Henson [247]
RDF/nd	6.7	6.5 (nd)	nd	nd	nd	nd	nd	DiNovo et al. [168]
Softwood (spruce and pine)/SE-Enz	nd	12.8 (26.5)	nd	nd	nd	nd	nd	Larsson et al. [12]
Timothy grass/SE	6–15	nd (50)	2100	nd	nd	nd	4.5–5.0	Belkacemi et al. [159]
Timothy grass/AFEX	6–15	nd (26)	1100	nd	nd	nd	nd	Belkacemi et al. [248]

[a] nd = no data; AFEX = Ammonia freeze explosion; CA = Concentrated acid; DA = Dilute acid; MSW = Municipal solid waste; RDF = Refuse derived fuel; SE = Steam explosion; SE-Enz = Steam explosion and enzymatic hydrolysis; SF = Saccharomyces fermentation; TS = Two stage.

[b] CH2M HILL (1991) values are predicted estimates.

acid addition [109]. A mixed culture of *Geotrichum candidum, C. krusei,* and *Hansenula anomala* was used to reduce the COD of whiskey stillage by 54.9%, which was higher than achieved by any of the organisms in pure culture [110]. Cultivation of pure and mixed cultures of *Aspergillus niger, Penicillium fellutanum,* and *Mucor hiemalis* on cane molasses resulted in an optimal process using a spore inoculum of 70% *A. niger* and 30% *P. fellutanum* [111]. Beet molasses stillage was used to propagate a mixed culture of both *Trichosporon* and *Candida* species in continuous culture, resulting in a 70% COD reduction at a loading of 66 g COD/L/day [112].

A two-staged culture of beet molasses, with *H. anomala* J 45-N-5 followed by an unknown soil yeast isolate I-44, resulted in an overall organic carbon reduction of 75% [113]. A two-staged culture of sugarcane molasses stillage, by *Candida utilis* followed by *Paecilomyces variotii,* resulted in a COD reduction of 92% [114]. Cane molasses stillage was also used to produce *C. utilis* var. major NRRL 1087, where large-scale production (7000 L) was prone to bacterial contamination which could be controlled by lowering the media pH [115]. A thermotolerant strain of *Candida rugosa* was found to achieve a higher rate of COD reduction at 40°C than at lower temperatures and this higher temperature also improved flocculation of the yeast, which would improve the economics of recovery [116,117]. Beet molasses stillage was also used in the cultivation of a *Hansenula* sp., isolated from stillage effluent, resulting in a 35.7% COD reduction and the amino acid profile of the biomass compared favorably with other food protein sources [118,119]. Shochu stillage was used to cultivate *Aspergillus awamori* var. *kawachi* which resulted in almost 50% reduction in organic carbon and improved the rate of anaerobic treatment of the resulting filtrate [120,121].

The use of SCP grown on malt whiskey stillage as an aquaculture feed has been studied [122]. A mixed culture of *G. candidum, C. krusei,* and *H. anomala* was substituted for casein protein in diets of rainbow trout and up to 50% of the protein could be replaced using the mixed culture without affecting growth. However, the N-utilization was less for the SCP-amended feed and amino acid supplementation did not improve N-uptake. In another study, *C. utilis* was found to be a suitable protein source for rainbow trout but the yeast was not grown on stillage wastes [123]. *C. utilis* grown on cane molasses stillage (rum) has also been used in laying hen diets and, though it proved to be inferior to soy protein, was found to give adequate performance at a 10% level in the feed [124]. Ultimately, the econ-

Table 7
Summary of stillage characterization for beet molasses, cane juice, cane molasses, and cellulosic feedstocks[a]

Feedstock		Stillage yield L/L EtOH	BOD g/L	COD g/L	COD/BOD	N (total) mg/L	P (total) mg/L	K mg/L	Total S as SO_4 mg/L	pH
Beet molasses	— Average	11.6	44.9	91.1	1.95	3569	163	10030	3716	5.35
	— std dev	0.3	21.7	38.9	0.21	2694	66	6322	2015	1.02
	— *n*	3	3	5	3	5	3	2	4	4
Cane juice	— Average	16.3	16.7	30.4	1.96	628	130	1952	1356	4.04
	— std dev	5.3	3.4	8.2	0.35	316	110	1151	1396	0.49
	— *n*	2	5	6	4	6	6	5	5	7
Cane molasses	— Average	14.0	39.0	84.9	2.49	1229	187	5124	3478	4.46
	— std dev	3.3	10.8	30.6	0.57	639	350	3102	2517	0.35
	— *n*	7	19	22	16	20	17	12	16	25
Cellulosics	— Average	11.1	27.6	61.3	2.49	2787	28	39	651	5.35
	— std dev	4.14	15.2	40.0	0.54	4554	30	nd	122	0.53
	— *n*	4	11	15	10	8	5	1	6	7

[a] nd = no data; std dev = standard deviation; *n* = number of literature values used.

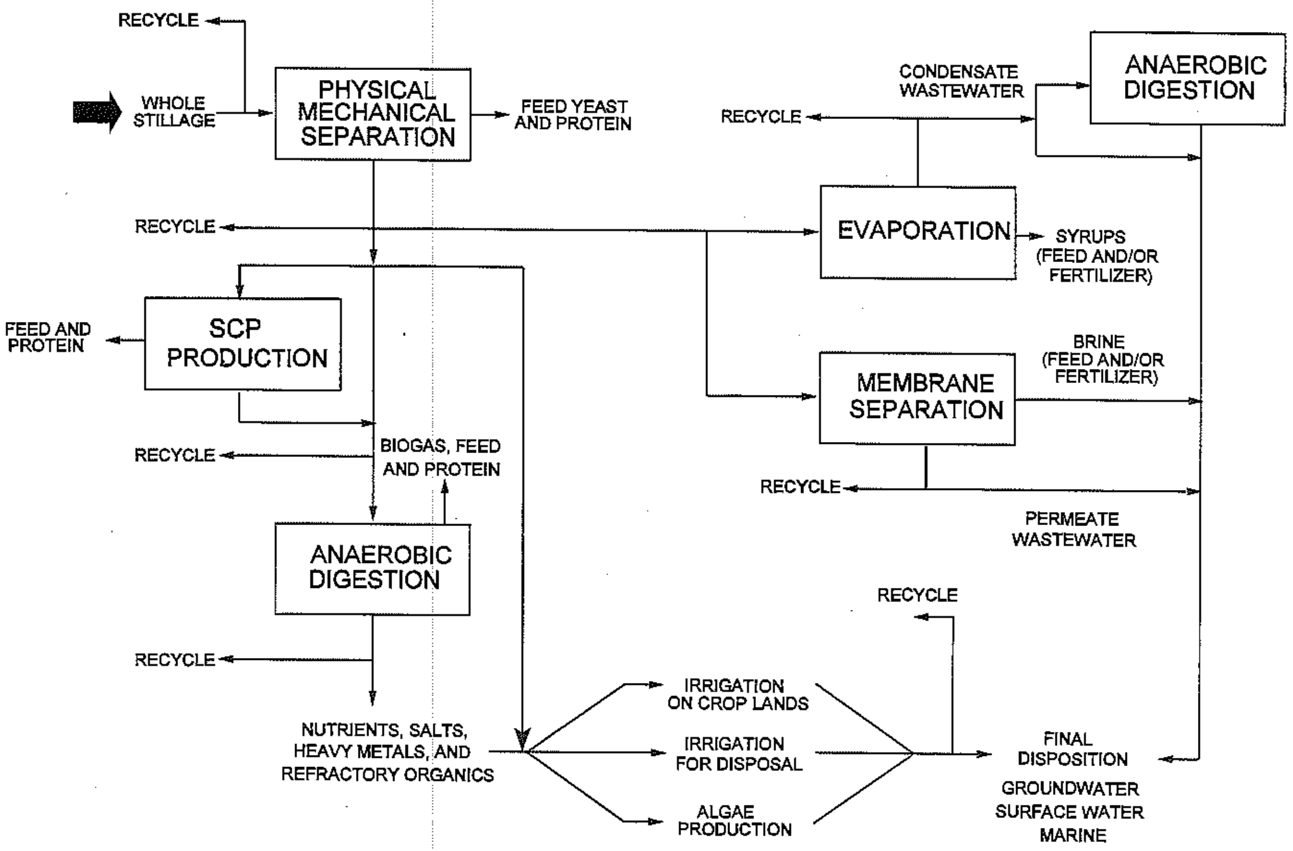

Fig. 3. Stillage treatment technology and utilization options.

omics of SCP production will be highly dependent on the market for SCP.

8.4. Calcium magnesium acetate

The production of organic acids from stillage for sale in the industrial chemical market has received recent attention [125]. In North America, the use of NaCl for winter time de-icing of roads and bridges is known to cause environmental degradation and to enhance corrosion rates of structures and vehicles, resulting in significant economic loss. Calcium magnesium acetate (CMA), as well as potassium acetate, are considered the most suitable substitutes for de-icing salt as they produce less environmental damage and are less corrosive. The market for CMA could grow significantly as restrictions on the use of road salt are mandated. One means of CMA production is through the fermentation of carbohydrates by *Clostridium thermoaceticum* followed by the precipitation and recovery of the organic acids, of which acetic acid is the major end-product. To lower the cost of nutrients required in the fermentation, the use of stillage has been investigated and found to be as effective as more expensive media additives [125–127].

8.5. Other bioproducts

The use of stillage for the production of potentially viable biological products including enzymes, chitosan, astaxanthin, plant hormones and the biopolymers, alternan and pullulan, has been studied. Shochu stillage was used to produce *A. awamori* var. *kawachi* for fodder, which also produced an effective saccharifying enzyme [128]. Shochu stillage was also employed in the production of both a protease, using *Aspergillus usami* mut. *shirousami* [129], and chitosan using *Gongronella butleri* which resulted in a 49% COD reduction [130]. Astaxanthin, a staining agent and quencher, has uses in both food processing and medical diagnostics, and its production by *Phaffia rhodozyma* was enhanced by supplementation of the media with molasses stillage [131]. A 1:4 dilution of stillage was found to enhance the production of the plant hormones, gibberellic acid, abscisic acid, indole acetic acid, and cytokinin by both *Funalia trogii* and *Trametes versicolor* [132]. Finally, condensed solubles from wet-milled corn stillage was used to supplement the media for *Leuconostoc mesenteroides* for the production of the biopolymer, alternan, which has uses in foods and cosmetics [133], and a similar substrate was also used for the production of pullulan by *Aureobasidium* [134].

8.6. Anaerobic digestion

Anaerobic digestion can serve as an effective means for removing COD from stillage and converting it to biogas, which is a readily usable fuel for the ethanol facility. This treatment option is examined in more detail in the next section. While sugar mills have bagasse in excess of fuel requirements [135], generation and sale of electricity can allow complete utilization of the bagasse by-product [136], as well as the biogas from anaerobic digestion of stillage. In addition, while sludge production from anaerobic digestion is low compared to that produced using aerobic treatment, the high COD of stillage will result in anaerobic sludge production which could be processed into feed materials [121,137]. The nutrients contained in the stillage are generally conserved through anaerobic digestion. After the majority of the organic content of the stillage has been removed by anaerobic digestion, only refractory organic compounds and inorganic compounds remain, including plant macro-nutrients (N, P, and K), plant micro-nutrients (Fe, Zn, Mn, Cu, and Mg), and nonessential metals. The application of anaerobic digester effluents to croplands returns these nutrients to a productive nutrient cycle. However, these nutrients may cause environmental degradation if over-applied to crops, or if the treated stillage is discharged into surface or marine waters [48].

8.7. Algae production

One potential means for removing the most environmentally detrimental of these nutrients (N and P) is via the growth of algae on the treated effluent [138,139]. *Spirulina platensis* is most often considered for nutrient polishing of effluents due to its high productivity, ease of harvesting, and potential market as an animal feed supplement. *Spirulina maxima* has been grown satisfactorily on dilutions of stillage while reducing the COD by 74% [140]. However, unless the final disposition is to marine waters, the high sodium requirements for Spirulina production could damage some soil and surface water ecosystems. *Chlorella vulgaris* has also been used for nutrient removal and to measure the stimulative effect of stillage on algae growth [141]. *Chlamydomonas reinhardii* growth was found to be stimulated by additions of 5% molasses stillage, with levels over 10% causing decreases in growth [142]. Also, algae may have potential in the removal of heavy metals from distillery effluents [143].

8.8. *Color removal*

Reducing the color of stillage, in addition to COD reduction and nutrient removal, may be required to allow the discharge of treated effluents into surface waters without degrading water quality. Highly colored wastewater can reduce the penetration of solar energy into shallow waters, which is required by aquatic plants for maintaining oxygen levels through photosynthesis. These colored effluents can cause death and decay of aquatic plants, which then contribute to oxygen demand and cause eutrophication. Color may be measured after removal of suspended solids and appropriate dilution and compared with a platinum–cobalt standard, but most of the work on color in stillage has relied merely on spectrophotometric absorption at a wavelength of 475 nm. While the removal of color may not be required for land application of stillage effluents, some facilities may not have adequate land area and must discharge effluents into surface waters.

Methods studied for color removal of stillage effluents include flocculation and coagulation, photocatalytic color removal, and microbial color removal by bacteria and fungi. A polymer of ferric-hydroxy-sulfate was used in the flocculation and coagulation of both fresh and anaerobically digested cane molasses stillage resulting in 32 and 87% reduction in absorbance at 475 nm, respectively [144]. In another study, alum, commercial inorganic flocculants, and commercial cationic polymers, were all capable of 86% color removal (absorbance at 475 nm) of anaerobic–aerobic treated molasses stillage, while less than 3% color removal was obtained for raw effluent [145]. Photocatalytic color removal after anaerobic treatment of stillage was shown to be effective [146], where digested cane molasses stillage (rum) exhibited a range of 75,000–100,000 Pt–Co color units (456 nm). A 10% dilution of this treated stillage was required to allow UV light penetration and, using a titanium dioxide catalyst, 99% color removal occurred within 1 day.

Microbial color removal has received considerable attention. An unknown bacterial soil isolate capable of agar liquefaction was found to remove, under anaerobic conditions, 71% of the color (absorbance at 475 nm) from anaerobically digested cane molasses stillage, while raw stillage underwent only 50% color removal [147]. An aerobic soil bacterial isolate from an Indian distillery resulted in a 36.5% color removal of digested cane molasses stillage in 8 days under aerobic conditions when nutrients and glucose were provided [148]. A culture of *Lactobacillus hilgardii* was capable of melanoidin conversion to lactic acid and produced 28% and 40% decolorization of cane and beet molasses, respectively [149]. *L. hilgardii* was also capable of continuous decolorization under anaerobic conditions [150]. An immobilized isolate of the bacteria *Lactobacillus casei* was found to achieve a decolorization of 52% and a COD reduction of 57%, and to simultaneously produce 11.3 mg/mL of lactic acid, when fermenting digested cane molasses stillage supplemented with nutrients and glucose [151].

Filamentous fungi have also shown promise. After 8 days, an isolate resembling *Mycelia sterilia*, with proper nutrient and glucose additions, resulted in 93% decolorization of a molasses pigment solution prepared from molasses stillage [152,153]. White-rot fungi have also been employed for decolorization, commonly using *Coriolus versicolor*. *C. versicolor* was found to achieve 71.5% color removal along with a 90%

Table 8
Mesophilic anaerobic treatment of stillage from beet and cane molasses feedstocks (values are calculated from data in literature sources)[a]

Feedstock	Reactor type (size — L)	Influent BOD (COD) g/L	HRT (days)	OLR (g COD/L/day)	Temp (°C)	Treatment efficiency % removed BOD (COD)	Methane yield (Prod) L/g COD (L/L/day)	References
Beet molasses	HABR (165)	nd (116)	5.78	20.0	37	nd (70)	0.08 (1.69)	Boopathy and Tilche [204]
Beet molasses	UASB (5 × 10³)	nd (10)	0.58	13.8	39	nd (55.4)	0.36 (4.95)	Pipyn and Verstraete [249]
Beet molasses	UFF (500)	nd (48)	1.3	36.0	42	nd (50)	0.36 (12.4)	Braun and Huss [250]
Beet molasses	DFF (5 × 10³)	30 (73)	9.1	8.0	37	nd (70)	nd (nd)	Athanasopoulos [251]
Cane molasses	UASB (11 × 10³)	nd (15.2)	0.83	18.3	nd	nd (76)	0.28 (5.2)	Costa et al. [207]
Cane molasses	UASB (42.5)	39 (100)	10	10	nd	87 (67)	nd (nd)	Driessen et al. [206]
Cane molasses	UASB (42.5)	43 (109)	6.8	16	nd	85 (67)	nd (nd)	Driessen et al. [206]
Cane molasses	2-GACF (5.25)	nd (70)	10	7	27	nd (81)	0.25 (1.77)	Goyal et al. [216]
Cane molasses	UASB (2.3)	nd (68.9)	3.2	21.5	35	nd (58)	0.17 (3.6)	Espinosa et al. [217]
Cane molasses	DFF (nd)	nd (50)	10	25.0	35	nd (78.1)	0.17 (nd)	Shrihari and Tare [210]
Cane molasses	ACR (20)	60 (130)	10	4.6	36	90 (85)	0.37 (nd)	Halbert and Barnes [165]
Cane molasses	2-CSTR (6.0)	13.7 (22.5)	4.1	5.4	37	89 (63)	0.20 (0.35)	Cho [220]
Cane molasses	UASB (100)	nd (46)	2	23.3	40	nd (71.3)	0.22 (5.1)	Sanchez Riera et al. [219]
Cane molasses	FB (300)	nd (67.7)	5	13.5	30–37	nd (66.3)	0.15 (2.04)	de Bazua et al. [120]
Cane molasses	2-CSTR (2.5 × 10⁶)	49 (132)	5.6	5.1	35–40	84.3 (63.2)	nd (nd)	Yeoh [4]
Cane molasses	HUASB (5)	40 (103)	0.25	36	30	nd (80)	0.4 (14.4)	Shivayogimath and Ramanujam [252]
Cane molasses	UASB (nd)	nd (88)	4.4	20	35	nd (61)	0.28 (nd)	Morris and Burgess [253]
Cane molasses	ACR (160 × 10³)	nd (80)	16	5	33	nd (80)	0.22 (0.74)	Karhadkar et al. [254]
Cane molasses (rum)	ACR (1890)	32.9 (74.8)	19	3.6	35	nd (67.8)	0.19 (0.70)	Shea et al. [255]
Cane molasses (rum)	ACR (30)	nd (54.6)	6.8	8.0	35	nd (78)	0.37 (2.96)	Roth and Lentz [256]
Cane molasses	UFF (5.25)	nd (66.1)	5.6	11.76	35	nd (71.8)	0.23 (2.7)	Seth et al. [257]
Cane molasses (rum)	DFF (1.7 × 10⁶)	20.5 (57.6)	3.8	15	35	60 (85)	0.22 (3.5)	Bories et al. [258]
Cane molasses (rum)	UFF (10 × 10³)	nd (55.0)	2.8	20	36	88 (70)	0.24 (4.8)	Arnoux et al. [259]
Cane molasses (rum)	DFF (13.2 × 10⁶)	42 (105)	8.2	12.8	38	85 (70)	0.21 (nd)	Szendrey [223–225], Szendrey and Dorion [226]

[a] nd = no data; ACR = Anaerobic contact reactor; 2-CSTR = 2-staged continuously stirred reactor; DFF = Downflow fixed film; FB = Fluidized-bed; 2-GACF = 2-phased granular activated carbon fixed film; HABR = Hybrid anaerobic baffled reactor; HUASB = Hybrid UASB; UASB = Upflow anaerobic sludge blanket; UFF = Upflow fixed film.

COD reduction in anaerobically digested cane molasses stillage when the effluent was amended with glucose [154]. The same organism achieved only 53% color removal when using fresh cane molasses stillage [155].

In all cases where decolorization was applied to anaerobically digested stillage compared to raw stillage, the level of decolorization was enhanced. In one case, *G. candidum* was grown on winery stillage to remove phenolic compounds prior to anaerobic digestion in order to improve anaerobic treatment performance [156]. Similarly, *Penicillium decumbens* was grown on beet molasses stillage to reduce phenolics which substantially improved digestion [157]. Most of these microbial decolorization studies required effluent dilution for optimal activity and, in cases where aerobic fermentation is required, the energy demand could be significant. Decolorization technology has not been applied at full-scale and cannot yet be considered a developed technology.

8.9. Other treatment processes

Several additional processes have been studied which hold potential for stillage processing and these include both thermal and electrochemical processes. First, thermal pretreatment using direct wet air oxidation of stillage followed by char recovery and incineration for steam production showed the potential for higher energy recovery than stillage evaporation followed by syrup incineration [5]. Also, supercritical water oxidation of stillage, using H_2O_2 at elevated temperatures of 673–773 K, has been shown to result in rapid reduction in organic strength [158]. Attempts at solid-catalyzed wet oxidation of stillage, using pure oxygen and MnO_2/CeO_2 mixed oxide catalyst at elevated temperatures (620 K) and pressures (20 MPa), were successful at reducing stillage strength, but resulted in inactivation of solid catalyst by carbonaceous fouling and reaction inhibition by stable intermediates [159]. Thermochemical liquefaction of stillage, using a sodium carbonate catalyst at elevated temperatures (300°C) and pressures (12 MPa), produced a maximum oil yield of 60% [160]. Finally, electrochemical treatment of stillage using NaCl, resulted in the production of chlorine and other oxidants which destructively oxidized stillage COD [161,162]. None of these processes have been attempted at large scale and they cannot be considered as proven or economical stillage treatment methods at this time.

8.10. Final disposition

Nutrients contained in ethanol feedstocks are drawn from the soils on which these crops are grown and, therefore, should be returned to these soils for the ethanol production system to be truly sustainable. Thus, land application is the most appropriate method for final disposition of ethanol stillage. In Brazil, much effort has been focused on the proper utilization of stillage nutrients [48] and methods for land application of untreated stillage onto sugar cane fields prior to planting have been developed. Experience has shown that application of untreated stillage to standing pasture can result in phytotoxicity [91], presumably due to N-immobilization. This was overcome by amending the untreated stillage with ammonia, but this increased the land area required and the cost of disposal. The use of surface and marine waters for final disposition should be discouraged but there may be site-specific circumstances in which these options have to be considered. Where surface water discharge is required, methods for tertiary treatment [163] (nutrient removal) should be considered, along with decolorization.

Odor control alone is sufficient incentive to consider appropriate treatment for stillage prior to discharge. Finally, the long-term impact of Na salts in stillage effluents on agronomic properties of soils has not been adequately studied and the replacement of sodium-based chemicals in plant operations should be investigated. The final disposition of stillage and treated stillage effluents will be considered in depth in a subsequent review [164].

9. Anaerobic treatment of stillage

Anaerobic treatment of ethanol stillage has

Table 9
Mesophilic anaerobic treatment of stillage from other conventional feedstocks (values are calculated from data in literature sources)[a]

Feedstock	Reactor type (size — L)	Influent BOD (COD) g/L	HRT (days)	OLR (g COD/L/day)	Temp (°C)	Treatment efficiency % removed BOD (COD)	Methane yield (Prod) L/g COD (L/L/day)	References
Agave tequilana (tequila)	UASB (2.3)	nd (66.3)	3	25	32	nd (80)	nd (nd)	Ilangovan et al. [227]
Barley and sweet potato	2-UASB (4.7)	nd (29.5)	1.2	25	37	nd (90)	0.28 (7.0)	Shin et al. [230]
Cherry (morello)	2-PAF (1200)	nd (80)	8	10	32	nd (80)	nd (nd)	Stadlbauer et al. [90]
Corn (thin stillage)	ACR (11.2)	8.8 (16)	5	3.2	35–38	nd (97.3)	nd (3.6)	Stover et al. [237], Ganapathi [231]
Evaporator condensate (corn)	UASB (2×10^6)	nd (5.7)	0.46	12.3	35	nd (89)	0.25 (3.1)	Lanting and Gross [100], Gross and Lanting [260]
Evaporator condensate (sugar beet)	UASB (145×10^3)	nd (2.6)	0.17	15	nd	nd (85)	nd (nd)	Driessen et al. [206]
Grape (cognac)	DFF (140)	nd (26)	2.2	16	35	nd (91)	nd (5.48)	Henry et al. [233]
Grape (brandy)	UASB (127×10^3)	25 (30)	2.2	15	35	nd (82)	nd (nd)	Cheng et al. [261]
Grapes (wine)	UASB (42.5)	nd (30)	1.4	22	nd	nd (92)	nd (nd)	Driessen et al. [206]
Grapes (wine)	DFF (15×10^3)	nd (25)	1.7	15	36	nd (89)	0.34 (5.2)	Arnoux et al. [259]
Grapes (wine)	ITR (2.9)	nd (25)	2.4	10.7	36	nd (nd)	0.22 (2.35)	Buhlert et al. [262]
Grapes (wine)	UASB (10.5)	nd (31)	3.4	9	30	nd (90)	0.08 (0.72)	Moosbrugger et al. [263]
Grapes (red wine)	AFB (8.0)	10.2 (17)	1.13	15	37	nd (80)	nd (nd)	Ehlinger et al. [84]
Grapes (red wine)	DFB (5.0)	nd (15)	1.3	15	35	nd (85)	0.30 (4.48)	Garcia-Calderon et al. [264]
Malt whiskey (pot ale)	UASB (1.05)	nd (43)	2.8	15.3	35	nd (90)	nd (nd)	Goodwin and Stuart [265]
Mixed (wheat and sweet potato shochu)	MCR (5500)	20 (40)	5.7	7	37	nd (98)	0.28 (2.3)	Nagano et al. [242]
Mixed (potato, beets, wheat, and corn)	UFF (1.8×10^6)	nd (20–55)	5	10	37	nd (75–95)	0.3 (3.25)	Weiland and Thomsen [266]
Potato and beet	UFF (1400)	nd (40)	4	10	36	nd (90)	nd (nd)	Weiland and Wulfert [267]
Whey	ACR (26×10^6)	17 (27)	3.7	7.3	35	nd (nd)	0.08 (0.63)	Mawson [59]
Whey	ACR (nd)	nd (7)	nd	nd	36	nd (85)	0.37 (nd)	Reesen and Strube [268]
Whey	CSTR (3×10^6)	nd (nd)	nd	20	35	nd (85)	nd (nd)	Stafford [170]

[a] nd = no data; ACR = Anaerobic contact reactor; AFB = Anaerobic fluidized bed reactor; CSTR = Continuously stirred reactor; DFB = Downflow fluidized bed; DFF = Downflow fixed film; ITR = Inclined tube reactor; MCR = Membrane contact reactor; UASB = Upflow anaerobic sludge blanket; UFF = Upflow fixed film; 2-PAF = 2-staged pulsed anaerobic filter; 2-UASB = 2-staged UASB.

Table 10
Thermophilic anaerobic treatment of stillage from conventional feedstocks (values are calculated from data in literature sources)[a]

Feedstock	Reactor type (size — L)	Influent BOD (COD) g/L	HRT (days)	OLR (g COD/L/day)	Temp (°C)	Treatment efficiency % removed BOD (COD)	Methane yield (Prod) L/g COD (L/L/day)	References
Barley (shochu)	UFB (0.45)	12.6 (21.4)	0.18	115	53	nd (78.0)	0.27 (31.6)	Kida and Sonoda [269]
Beet molasses	UASB (2×10^6)	35 (43.2)	10.5	6.57	52.7	88.0 (86.0)	0.43 (0.81)	Vlissidis and Zouboulis [203]
Beet molasses	UASB (5.75)	nd (15.4)	0.18	83.6	55	nd (59.6)	0.26 (22.1)	Wiegant et al. [270]
Cane molasses	UASB (140)	2.5 (10)	0.43	23.5	55	88.2 (40)	0.12 (3)	Harada et al. [211]
Cane molasses	UASB (5.8)	nd (3.8)	0.16	24.0	55	nd (66)	nd (nd)	Harada et al. [211]
Cane molasses	2-CSTR (8.6)	45 (130)	5.6	20.0	55	90.2 (65.2)	0.17 (1.23)	Rintala [271]
Cane juice + molasses	UASB (70×10^3)	nd (31.5)	0.45	26.5	56	nd (71.7)	0.22 (5.88)	Souza et al. [209]
Grapes (wine)	AFB (0.25)	nd (15)	0.46	32.3	55	nd (82.5)	0.33 (5.8)	Perez et al. [272]
Grapes (wine)	UFF (2.0)	nd (15)	0.82	19.6	55	nd (47.9)	0.18 (3.55)	Perez et al. [273]
Grapes (wine)	CSTR (1.8)	11.7 (16.6)	4	4.15	55	nd (88)	0.25 (1.04)	Romero et al. [274]

[a] nd = no data; AFB = Anaerobic fluidized bed reactor; CSTR = Continuously stirred reactor; 2-CSTR = 2-staged continuously stirred reactor; UASB = Upflow anaerobic sludge blanket; UFB = Upflow-fluidized bed; UFF = Upflow fixed film.

often been cited as an effective and economic treatment option [2,3,48,102,165,166]. However, some studies [8,9,89,167,168] overlooked the potential of anaerobic digestion and considered the application of aerobic treatment for ethanol wastewaters. The high COD of stillage means that significant aeration power would be required for aerobic treatment and that about 50% of the COD would be converted to sludge requiring further disposal [99,169]. Anaerobic digestion can convert a significant portion (>50%) of the COD to biogas, which may be used as an in-plant fuel, and also saves the energy that would be required for aeration using aerobic treatment. In addition, anaerobic digestion has about 10% of the sludge yield and lower nutrient requirements compared to aerobic treatment [170].

A considerable amount of research has been conducted on anaerobic digestion of ethanol stillage from conventional feedstocks, especially cane molasses. Cane molasses stillage with a COD of over 100 g/L has been found to inhibit stable digestion and this may be overcome by dilution to a COD of around 50 g/L [171] using other waste streams at the plant. High potassium levels [172], high levels of metals [173], high stillage sulfate levels [174], and the presence of phenolic compounds [156,157,175] have been implicated in molasses stillage digestion deficiencies.

The effects of wastewater sulfate levels on anaerobic treatment have received considerable attention [176,177]. In anaerobic treatment, wastewater sulfate is converted to more toxic sulfide at the expense of methane production and leaves the reactor as either sulfide in the effluent or hydrogen sulfide in the biogas. Effluent sulfide levels contribute to odors, corrosiveness and effluent oxygen demand, while hydrogen sulfide in the biogas causes corrosion problems in engines and boilers. In general, sulfide inhibition is not encountered in anaerobic treatment when the wastewater COD/SO_4 ratio is above 10 g/g, while inhibition is severe when the ratio is below 0.5 g/g [177]. This is caused by the stripping effect of higher biogas production rates which rapidly remove sulfide as it is formed. Digestion of wastewater with an intermediate COD/SO_4

Table 11
Anaerobic treatment of stillage from cellulosic feedstocks (values are calculated from data in literature sources)[a]

Feedstock/ process	Reactor type (size — L)	Influent BOD (COD) g/L	HRT (days)	OLR (g COD/L/day)	Temp (°C)	Treatment efficiency % removed BOD (COD)	Methane yield (Prod) L/g COD (L/L/ day)	References
Eucalyptus/DA	UFF (2.0)	nd (22.5)	2.1	10.7	35	nd (86.6)	0.4 (2.7)	Good et al. [243]
Eucalyptus/DA	UFF (2.0)	nd (22.5)	2.25	10.0	55	nd (84.4)	0.38 (2.4)	Good et al. [243]
Eucalyptus/DA	CSTR (2.0)	nd (22.5)	9.5	2.4	35	nd (85.5)	0.4 (0.6)	Good et al. [243]
Hardwoods/TS-DA-SF	CSTR (1.0)	nd (19.1)	nd	nd	35	nd (nd)	nd (nd)	Strickland et al. [244]
Pinus radiata/ DA-SF	CSTR (8.0)	nd (25.5)	6.4	4.0	37	nd (92)	0.28 (1.2)	LFTB [246], Callander et al. [275]
Pinus radiata/ DA-SF	UASB (10)	13.2 (25.5)	1.6	16.0	37	93 (86)	0.21 (3.3)	LFTB [246], Callander et al. [276]
Pinus radiata/ DA-SF	UASB (8.0)	13.9 (27.5)	2.0	13.8	37	92 (82)	nd (4.0)	LFTB [246]
RDF/CA	BMP (0.125)	37.7 (104)	2–5	nd	35	96.3 (67)	0.16 (nd)	Broder [200]
RDF/DA	BMP (0.125)	31.1 (110)	2–5	nd	35	93.6 (85)	0.27 (nd)	Broder [200]

[a] nd = no data; BMP = Batch assay; CA = Concentrated acid; CSTR = Continuously stirred reactor; DA = Dilute acid; RDF = Refuse derived fuel; SF = Saccharomyces fermentation; TS = Two stage; UASB = Upflow anaerobic sludge blanket; UFF = Upflow fixed film.

ratio may be handled by diluting the wastestream to a COD of 15 g/L so that the sulfide is removed in the effluent at the higher flow rate that dilution allows [177]. Finally, high reactor sulfide levels can also be mitigated by adding soluble Fe^{3+}, which promotes precipitation of ferrous sulfide.

Table 8 lists treatment parameters for mesophilic anaerobic digestion of stillage from beet and cane molasses. Table 9 lists treatment parameters for mesophilic anaerobic digestion of stillage from some other conventional feedstocks. Table 10 lists treatment parameters for thermophilic anaerobic digestion of stillage from beet and cane molasses. Table 11 lists treatment parameters for anaerobic digestion of stillage from cellulosic feedstocks. Finally, Table 12 summarizes the anaerobic treatment parameters from Tables 8–11.

For the mesophilic studies, the average organic loading rate (OLR) applied is 9–12 g COD/L/day, with an average COD treatment efficiency greater than 70% and average methane yield greater than 0.25 L/g COD added (Table 12). Thus, the treatment efficiencies and loading rates for mesophilic anaerobic treatment are quite high and indicate that anaerobic digestion is a suitable method for biological treatment of the waste. Since stillage leaves the distillation process at about 90°C, cooling is required to bring the waste down to mesophilic temperatures (<42°C).

Application of thermophilic digestion would only require cooling the stillage to under 60°C, which occurs naturally during temporary stillage storage. Table 12 shows that thermophilic treatment of molasses stillage achieves similar BOD treatment efficiencies at almost twice the OLR of mesophilic systems. While the average COD treatment efficiency for thermophilic molasses stillage digestion appears lower than that for mesophilic, this difference is most likely due to variations in the refractory COD of the molasses stillage and the lower thermophilic methane yields tend to confirm this. The higher thermophilic OLRs indicate that smaller digesters are required which should improve process economics. It is interesting to note that, in 1932, Boruff and Buswell advocated thermophilic an-

Table 12
Summary of anaerobic treatment of stillage from conventional and cellulosic feedstocks. Statistics are compiled from studies using reactors larger than 1000 L, except for thermophilic and cellulosic studies where data was limited[a]

Temperature/Feedstock		OLR (g COD/ L/day)	Treatment efficiency % removed BOD	Treatment efficiency % removed COD	Methane yield (L/g COD)	Methane productivity (L/L/day)
Mesophilic/molasses	— Average	12.25	79.33	71.20	0.26	3.84
	— Std dev	5.72	12.98	9.33	0.06	1.85
	— *n*	8	4	8	6	5
Mesophilic/other	— Average	12.16	nd	87.25	0.25	2.90
	— Std dev	4.08	nd	5.60	0.10	1.66
	— *n*	10	nd	8	5	5
Thermophilic[b]/molasses	— Average	23.50	89.20	60.73	0.17	3.37
	— Std dev	2.68	1.41	14.12	0.05	2.35
	— *n*	4	2	4	3	3
Mixed/cellulosic	— Average	9.48	93.73	83.56	0.30	2.37
	— Std dev	5.35	1.84	7.27	0.10	1.28
	— *n*	6	4	8	7	6

[a] nd = no data; std dev = standard deviation; n = number of literature values used.

[b] Data from Vlissidis and Zouboulis [203] excluded due to impacts of P and SO_4 precipitation on process; Data from Wiegant et al. [270] excluded as outlier.

aerobic digestion of stillage [178], and yet the literature indicates that only two full-scale thermophilic digesters have been built (Table 10).

The failure to implement thermophilic stillage digestion is caused by a number of factors, including: (1) a lack of availability of thermophilic inocula; (2) a perceived higher sensitivity of thermophilic digestion compared to mesophilic digestion; (3) concern about restart of intermittently operated thermophilic digesters; and (4) perceived higher COD levels in thermophilic effluent compared to mesophilic effluent. A number of studies have shown that the use of mesophilic inocula does not limit the development of thermophilic biomass [179–183]. Likewise, some studies have shown that thermophilic digestion is more tolerant to organic overloads than mesophilic digestion when immobilized reactor designs are used [184,185]. In tropical climates between sugarcane harvests, the temperature in an idled thermophilic digester would drop to an ambient temperature of 25–35°C. At the start of the next cane harvesting season, the reactor must be brought to design operating temperature and loading rate within a reasonable period. There is no indication that this restart period is longer for thermophilic digesters [186] than for mesophilic digesters [187,188]. Finally, a comparison of effluent COD from thermophilic versus mesophilic digestion of cane molasses stillage in Brazil concluded that higher effluent COD was a disadvantage of the thermophilic process [189]. However, the thermophilic reactor was only installed to provide biogas for yeast drying and the bulk of the stillage was land applied without treatment, so there was no incentive to limit effluent COD from the reactor [189]. If appropriate loading rates and nutrient supplementation are maintained, there is no reason for effluent COD levels from thermophilic reactors to exceed those of mesophilic reactors treating the same wastewater [184]. Thus, lower cooling demand and increased loading rates should make thermophilic anaerobic stillage treatment preferable in future installations.

Table 13 lists some of the full-scale anaerobic digesters currently treating stillage by supplier, reactor type, country and range of OLR. This list indicates that at least 149 facilities have been built, and that 87 of these are in India. While most of these digesters are of the upflow anaerobic sludge-blanket (UASB) or expanded granular sludge-bed (EGSB) design (78 UASB; 3 EGSB), a significant number (27) of bulk volume fermenters (BVF) have been commissioned as well. There are also 22 downflow fixed film (DFF) digesters, 10 anaerobic contact (AC) digesters, six hybrid (Hybr) digesters, and three upflow fixed film (UFF) digesters. The immobilized sludge reactors (UASB, EGSB, DFF, UFF and Hybr systems) have significantly higher OLRs, with a trend of higher OLRs in developed countries. In contrast, the BVF have much lower OLRs, with a trend of higher OLRs in developing countries. This may suggest that a higher level of control in developed countries allows high OLRs in the immobilized sludge type digesters, while less stringent discharge requirements may allow higher OLRs for BVF in developing countries. In India, the BVF is regarded as being the most inexpensive and stable design which is applicable where land area is not restrictive [190]. The number of full-scale anaerobic digesters operating on stillage wastes is a valid testament to the feasibility of this treatment technology.

Finally, the limited data regarding anaerobic treatment of stillage from cellulosic feedstocks (Table 11) are comparable with treatment parameters from other feedstocks (Table 12). The OLR applied and treatment efficiencies achieved indicate that cellulosic stillage is amenable to anaerobic treatment. However, the limited number of studies on stillage from different cellulosic feedstocks and hydrolysis methods means that predictions of treatment performance are prone to error. Improved predictions could be made if a larger data set of cellulosic stillage characteristics and treatment parameters were developed.

10. Summary and conclusions

This technical review was developed from research conducted at the University of Florida

Table 13
Full-scale anaerobic digester facilities treating distillery wastes worldwide by supplier [203, 209, 277–284], reactor type, country and effluent type[a]

Supplier	Reactor type	Country	Effluent type	No. of plants	OLR (g COD/L/day)
ADI	BVF	India	Cane molasses	20	0.9–3.6
ADI	BVF	Kenya	Cane molasses	1	3.00
ADI	BVF	USA	Evaporator condensate	3	0.26–0.58
ADI	BVF	Colombia	Cane molasses	1	2.30
ADI	BVF	Pakistan	Cane molasses	1	0.9–3.6
ADI	BVF	Nepal	Cane molasses	1	3.50
Bacardi	DFF	Puerto Rico	Cane molasses	1	12.8–14.4
Bacardi	DFF	Dominican Republic	Cane molasses	1	nd
Bacardi/Lars Enviro	DFF	India	Cane molasses	2	8.65–9.5
Biometano Consultoria	UASB thermophilic	Brazil	Cane juice and molasses	1	26.5
Biothane	EGSB	Germany	Evaporator condensate	1	11.20
Biothane	EGSB	USA	Evaporator condensate	2	15.6–15.9
Biothane	UASB	Canada	Evaporator condensate	1	15.40
Biothane	UASB	India	Evaporator condensate	1	12.60
Biothane	UASB	Slovakia	Evaporator condensate	1	10.50
Biothane	UASB	USA	Evaporator condensate	2	8.3–10
Biothane	UASB	Thailand	nd	1	15.00
Biothane	UASB	Germany	Evaporator condensate	1	9.00
Biothane	UASB	Netherlands	Evaporator condensate	1	19.40
Biotim	AC	Germany	Wheat starch	1	3–4.7
Biotim	Hybr	Thailand	Cane molasses	1	nd
Biotim	Hybr	Belgium	Beet and cane molasses	1	9
Biotim	Hybr	Korea	Barley, sweet potatoes and tapioca	1	8
Biotim	Hybr	Indonesia	Cane molasses	1	16.5
Biotim	UASB	India	Cane molasses	2	15
Biotim	AC	Korea	Barley, sweet potatoes and tapioca	2	3.3
Biotim	Hybr	India	Cane molasses	1	9.2
Biotim	Hybr	Portugal	Wine	1	13
Degremont	AC	France	Grape wine	1	4.42
Degremont	AC	Germany	Cereals	2	13–15
Degremont	UFF	Germany	Cereals	1	12.11
Degremont	UASB	India	Cane molasses	23	12–19.5
Degremont	AC	Paraguay	Cane juice	1	nd
Degremont	UFF	Spain	Grape wine	2	10.36
Degremont	AC	Switzerland	Mixed	1	1.05
Degremont	AC	USA	Corn	1	nd
Degremont	AC	Venezuela	Cane molasses	1	8.61
Lars Enviro	DFF	India	Cane molasses	13	8.65–12.3

Table 13 (*continued*)

Supplier	Reactor type	Country	Effluent type	No. of plants	OLR (g COD/L/day)
Paques	UASB	Japan	Distillery	1	28.6
Paques	UASB	Japan	Sweet potato	1	30
Paques	UASB	Turkey	Grape wine	4	11.2–12.6
Paques	UASB	India	Molasses	25	9.9–15.2
Paques	UASB	S. Africa	Grape wine	1	13.95
Paques	UASB	Germany	Grape wine	1	12.00
Paques	UASB	Taiwan	Chinese wine	1	10.67
Paques	UASB	Switzerland	Grape wine	1	13.16
Paques	UASB	Guatemala	Cane juice	1	17.50
Paques	UASB	Netherlands	Beet molasses	1	14.48
Paques	UASB	Venezuela	Cane juice	2	16.2–18.5
Paques	UASB	Brazil	Cane juice	2	15.00
SGN	DFF	France	Grape wine	2	11.0–11.8
SGN	DFF	Spain	Grape wine	2	15
SGN	DFF	Guadeloupe	Cane molasses (rum)	1	14.1
Vlissidis	UASB thermophilic	Greece	Beet molasses	3	7
			Total installations	149	

[a] AC = anaerobic contact; BVF = bulk volume fermenter; DFF = downflow fixed-film; EGSB = expanded granular sludge bed; UFF = fixed-film; Hybr = hybrid reactor; UASB = Upflow anaerobic sludge blanket.

Table 14
Commercial full-scale cellulosics-to-ethanol projects under development in North America [198][a]

Feedstock	Location	Process technology	Annual production L/yr	Company
Cellulosics	Ottawa, Canada	Enzymatic	3.8×10^6	Iogen
Bagasse	Jennings, LA	2-stage dilute acid	38×10^6	BCI
MSW	Middletown, NY	Concentrated acid	38×10^6	Masada [285]
Rice straw	Sacramento, CA	Concentrated acid	45×10^6	Arkenol
Rice straw	Gridley, CA	Enzymatic	76×10^6	BCI/Gridley LLC
Softwood wastes	SE Alaska	nd	$23–30 \times 10^6$	Sealaska
Softwood wastes	Chester, CA	Enzymatic	76×10^6	BCI/Colling Pine

[a] nd = no data.

to assess the feasibility of an integrated biomass-to-energy system in Central Florida which resulted in several related publications [16,191–197]. Table 14 lists some cellulosic-to-ethanol conversion projects currently under development in North America [198]. Large-scale production of ethanol from lignocellulosic biomass has considerable potential due to the availability of significant resources of lignocellulosic biomass. However, substantial increases in ethanol production also require effective solutions for stillage management. This effort has contributed to an appreciation of the potential impacts of the biomass-to-ethanol production process on cellulosic stillage characteristics and utilization. It can be concluded from this study that existing research supports the application of anaerobic digestion for cellulosics-to-ethanol stillage treatment and biogas recovery. However, there is a need for further information on the characteristics and treatment of cellulosic-based stillage.

The results of some of the research currently underway, both in the US and in other countries at the forefront of commercially viable biomass-to-ethanol technology development (e.g., Canada, Brazil, New Zealand, etc.), are not widely available and not immediately accessible to the authors. Specific research efforts resulting in greater information dissemination would facilitate government and industry progress toward economically and environmentally sustainable biomass-to-ethanol energy production systems. Areas of research apparent to the authors which merit further investigation include:

1. hydrolysis stillage characterization data should be obtained for pertinent feedstocks, hydrolysis methods, and fermentation schemes, and these results should be considered during feedstock and process selection/optimization;
2. as final selection of feedstock/process is approached, corresponding hydrolysis stillage treatability studies should be performed prior to preliminary process design and cost estimation.

Thermophilic anaerobic digestion of ethanol stillage achieves similar BOD treatment efficiencies and methane yields, at almost twice the organic loading rate, compared to mesophilic treatment. Therefore, application of thermophilic anaerobic digestion would improve process economics, since smaller digesters and less stillage cooling are required. Downstream processes for stillage utilization and by-product recovery considered worthy of continued investigation include the production of feed (from single cell protein and/or algae production), color removal, and production of calcium magnesium acetate. The results of this study suggest that sustainable and economically viable solutions for mitigating environmental impacts which result from large-scale biomass-to-ethanol conversion facilities are available. However, further research in some areas is needed to facilitate successful implementation of appropriate technology options.

Acknowledgements

This work was a component of the "Economic Development Through Biomass Systems Integration in Central Florida" project, which was funded by a grant from the National Renewable Energy Laboratory to the Center for Biomass at the University of Florida.

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Resources and Conservation, 8 (1982) 111—129
Elsevier Scientific Publishing Company, Amsterdam — Printed in The Netherlands

OPTIONS FOR HANDLING STILLAGE WASTE FROM SUGAR-BASED FUEL ETHANOL PRODUCTION

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(Received 26th May 1981; accepted in revised form 28th December 1981)

ABSTRACT

While the stillage waste from ethanol fuel production can be a serious source of water pollution, it can also be a valuable resource from which to recover useful products such as fertilizer, animal feed, or methane gas. Selecting the most appropriate stillage management is a matter of trade-offs between energy, economic, and environmental considerations. There is a need for an information clearing-house on commercial stillage handling processes to assist ethanol fuel developers in matching processes to their needs.

INTRODUCTION

Many countries throughout the world are seriously looking for ways to reduce their petroleum imports because of recent spirals in petroleum prices. They are looking toward alternative sources of energy that can be produced locally. Many of the new liquid fuel technologies, however, will require massive capital investments and long lead times before they are in large-scale production. In contrast, fermentation distilleries for ethanol can go into immediate production. With the technology already well proven, the distilleries can use a variety of feedstocks (sugars and starches) that can be produced almost anywhere in the world.

Figure 1 shows some of the issues concerning large-scale alcohol fuel development [1]. The basic policy question at the top of the diagram is entwined with issues and management questions that arise proceeding downward in the diagram. Many of the issues revolve around the question of what land will be used to grow the feedstock, economic competitiveness of alcohol with petroleum, or the need for an assured domestic source of liquid fuel even if it is not fully competitive. There is, however, also the issue of liquid stillage waste produced as a by-product of the fermentation—distillation process and what should be done with it.

A distillery produces about 13 liters of stillage for every liter of alcohol [2]. A typical large distillery, which produces 150 m^3/day of ethanol, there-

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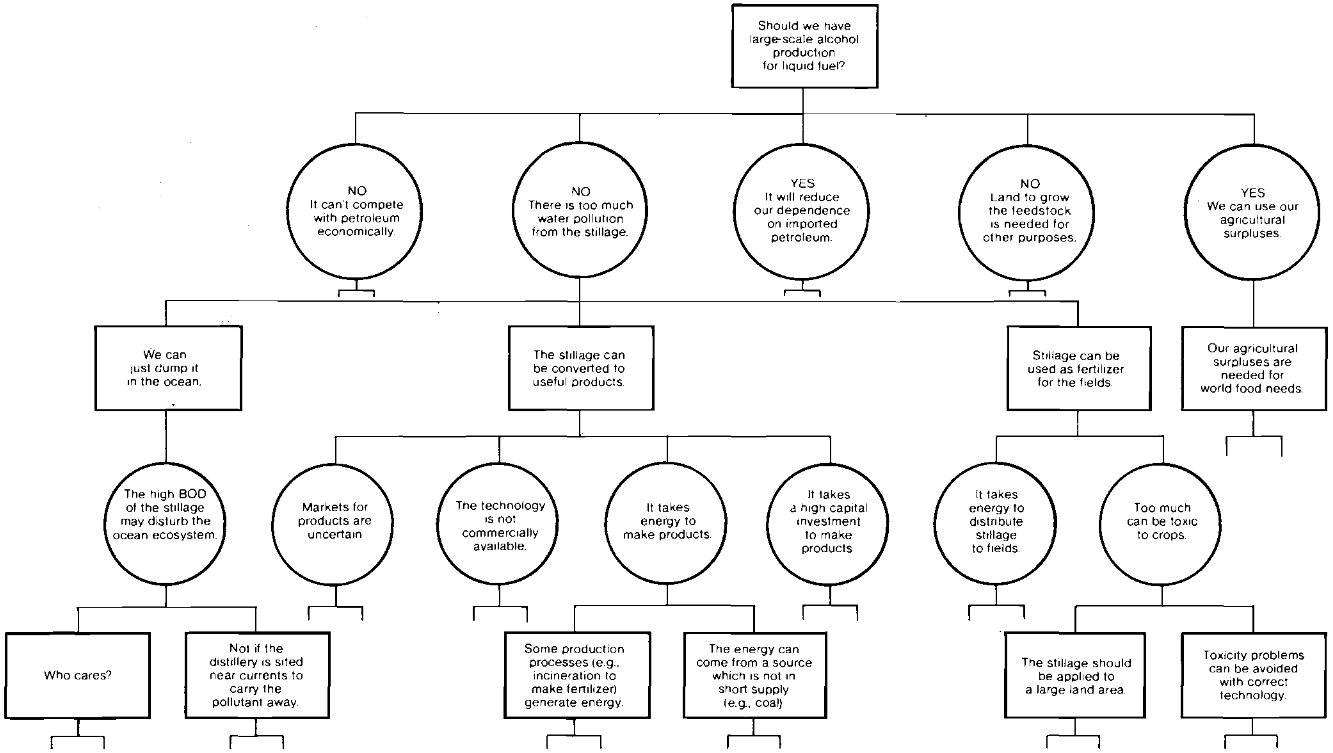

Fig. 1. Examples of issues associated with alcohol fuel development.

fore produces an additional 2000 m^3 of stillage. This volume is not excessive compared with typical volumes of industrial effluents or the hydraulic capacity of conventional waste water treatment, but when the volume of the stillage is multiplied by the concentration of biological oxygen demand (BOD), which is much greater than for sewage, the scale of the water treatment problem becomes enormous. It is possible to gain a perspective by expressing the BOD load in terms of population equivalents. Table 1 shows that a 150 m^3/day molasses distillery produces as much BOD as the sewage from a city of about 1.2 million inhabitants.

TABLE 1

Approximate population equivalents for stillage from a molasses distillery, assuming daily sewage production to be 75 g BOD per capita[a]

Ethanol production (m^3/day)	Population equivalent[b]
30	250,000
60	500,000
120	1,000,000
150	1,200,000
200	1,600,000
250	2,000,000

[a] Personal communication, Metropolitan Water, Sewerage and Drainage Board, Sydney, Australia.

[b] Distilleries using only cane juice would have population equivalents somewhat less than half of those for molasses distilleries.

Options for stillage handling

All forms of stillage contain everything that was added to the fermenter less fermentable sugars plus yeast metabolites and yeast cell contents. The exact composition of stillage depends on the raw material and distillery operating techniques. Some typical analyses of Australian stillage are in Table 2. All sugar-based stillages are low in pH and high in organic content, which gives them their high BOD. The ash content of molasses and cane-juice stillage is composed primarily of the inorganic components of the cane plant sap and is rich in potassium and magnesium. Calcium is introduced during sugar processing. The principal anions present are sulphate and chloride, and there are small amounts of phosphate and nitrogen. Molasses stillage generally has a higher organic and salt loading than other stillages.

Stillage might be handled several ways [1,3,4]:

1. Discharge to an adjacent waterway or land area.
2. Marine outfall (discharge a substantial distance from shore).
3. Return to agricultural fields.
4. Conventional sewage treatment.

TABLE 2

Typical composition of ethanol stillage

	Feedstock	
	Molasses	Cane juice
pH	4.8	3.7—5.9
Specific gravity	1.05	
Temperature (°C)	90	
BOD	45,000 mg/ℓ	20,000 mg/ℓ
COD	113,000 mg/ℓ	
Dissolved solids	10%	
Suspended solids	11%	6—11%
Ash	3%	2—3%
Organic matter	8%	5—8%

5. Lagoon treatment.
6. Anaerobic digestion (and production of methane).
7. Incineration to an ash which can be used as fertiliser.
8. Evaporation to an animal feed (or use as an aquaculture feed).

Some important characteristics of these stillage handling options are summarized in Table 3.

Brazil has employed discharge to waterways (sometimes with lagoon treatment) and return to agricultural fields [5]. Japan has incinerated stillage to a fertilizer ash, and Australia has used conventional sewage treatment, land disposal, and marine outfalls [3]. Grain alcohol stillage in the United States has been evaporated and marketed as an animal feed [6].

These options vary enormously in their environmental characteristics and the degree to which they are commercially proven, consume or produce energy, lead to useful by-products, and cost or generate money (Table 3). For example, conventional sewage treatment of stillage would result in an environmentally clean discharge, but is very expensive. It would require substantial expansion of existing treatment facilities and could add as much as 20% to the production cost of the alcohol.

Stillage handling options which require the smallest capital investment involve discharge of one sort or another. Of these, the least expensive is discharging directly from the factory, but this may have serious environmental consequences. Somewhat more expensive is discharge from an ocean outfall, which may or may not have damaging effects, depending upon local conditions. The more expensive redistribution of the stillage to agricultural fields has the advantage of utilizing plant nutrients and soil conditioners in the stillage but has the hazard of toxic effects ("overfertilization") from excessive application. Toxicity effects from field application can be minimized by distributing the stillage over a large area, but this means more expense in the distribution system.

TABLE 3

Characteristics of alcohol stillage handling options

	Stream discharge	Marine outfall	Land disposal	Sewage treatment	Lagoon treatment	Anaerobic digestion	Incineration	Industrial evaporation	Solar evaporation (open ponds)
Energy									
Net energy	0	–	–	—	0	+	+[b]	–	0
Economic									
Capital cost	L	L–M	L–M	H[a]	M	H	H	H	L–M
Operating cost	L	L	M–H	H	L	M	M	M	L
Further treatment	N	N	N	N	Y	Y	N	N	N
Useful product	N	N	Y	N	N	Y	Y	Y	Y
Environmental impact									
Land use effect	0	0	H	L	M	L	0	0	M
Water quality impact	H	M–H	L–M	L	L	0–L	0	0	0
Air quality impact	0	0	L–M	0	0	L	L	L	L–M
Odor potential	M–H	L–M	L–M	L	L–M	L–M	0	L	L–M
Flora–fauna	M–H	L–M	L–M	L	L	L	0	0	L

0 Nil
– Negative
+ Positive
L Low
M Moderate
H High
N No
Y Yes

[a] Capital cost to the distillery is low if it takes advantage of municipal sewage facilities.

[b] Varies with feedstock.

Four major products which can be derived from stillage are stock feed, fodder yeast, fertilizer, and biogas. The concept of stillage utilization implies the production and sale of marketable by-products or use by the distillery itself. The revenue from by-product sales may cover the cost of by-product recovery or even produce a profitable cash flow. However, the capital cost of recovering useful by-products is considerably greater than costs of simple disposal, often as much as the distilation itself. If markets (or internal use) cannot be found, the by-products can be of negative value to the distillery.

There are numerous trade-offs to consider in stillage handling options. A review of some of the available and potential options follows in more detail, but it must be stressed that there is no simple solution to distillery waste water problems. The choice of a stillage treatment method depends upon a number of factors:

1. The waste water characteristics.
2. Applicable ambient and emission standards.
3. Energy requirements of the distillery.
4. Economics.
5. Availability and cost of land.
6. The location of the distillery relative to receiving waters and by-product markets.

DISPOSAL OPTIONS

Marine and river discharge

The simplest method of stillage disposal is dumping it into a conveniently located body of water such as a river or ocean. Depending on the proximity of the water body, this might also be the cheapest available method in terms of capital and operating costs, including energy costs. Therefore, this method is expected to have considerable use. Although aquatic disposal of stillage can be viewed as "throwing away" a valuable resource and can lead to water pollution if carried out in excess, it can nonetheless be an attractive interim measure until a product recovery system is in place.

Environmental considerations

Table 4 lists some of the effects of stillage on water quality. When stillage is added to a body of water, the dissolved oxygen content of that water is rapidly reduced. The extent of reduction will depend on the relative volumes of stillage and water, the original oxygen content of the water, and the natural replenishment of dissolved oxygen in such forms as inflow of fresh water and surface aeration. Depletion of dissolved oxygen may proceed to a point where aerobic organism (from aerobic bacteria to fish) can no longer survive. When anaerobic conditions prevail, the waterway may become unpleasant, as foul-smelling reduced sulphur compounds are produced.

TABLE 4

Environmental impacts of alcohol stillage upon water quality and the aquatic ecosystem

***Depletion of dissolved oxygen**
***Discoloration**
***Odors**
Eutrophication
Salinization (in fresh water)
Acidification
Increase in water temperature (locally)
***Changes in species composition of aquatic flora and fauna**
Fish kills (in extreme cases)

***Most significant impacts.**

Natural reoxygenation can generally replenish the depleted oxygen content of a body of water if the stillage is sufficiently diluted. The amount of dilution necessary varies with environmental conditions, but the quantities of water involved can be appreciated by considering an example in which it is assumed that the stillage should be allowed to increase the BOD by no more than 20 mg/ℓ. A 150 m^3 ethanol/day molasses distillery producing about 2000 m^3/day of stillage at 45,000 mg/ℓ BOD would require a dilution of 2250 to 1 to achieve a final concentration of 20 mg BOD/ℓ. 4.5 Mm^3/day of water would be required for dilution, a volume of water that would only be available in the ocean or a large river. Even with this dilution, the color of the final mixture would be about 30 Hazen Units, rather dark and possibly unacceptable to the public.

Effects on fisheries depend on the relative volumes of stillage and water flow. The social significance of these effects depends on the importance of fishing to the subsistence and livelihood of the communities involved. The significance for recreation likewise depends on the current and potential recreational use of the water course and its surroundings. The effects can range from destruction of fishing to aesthetic problems, such as odor or coloring of the water.

It is unlikely that the 150 m^3/day molasses distillery in the preceding discussion could discharge into anything but the largest river without an excessive effect on the ecosystem. The smaller the distillery the greater the chance that discharge to a stream could be a reasonably satisfactory disposal option. However, even a relatively small (30 m^3/day) cane juice distillery would require a stream flow of 900,000 m^3/day so as not to exceed a 20 mg/ℓ BOD increase. This flow might be available in larger river basins, but the effects on other uses of the water would have to be carefully considered.

Effects on potable water can range from minor changes in increased color and salt content to massive oxygen depletion leading to the death of fish and other organisms. Minor changes may be acceptable with current water treatment, but more drastic changes may only be correctable with increased water treatment costs. If the stream into which the stillage is discharged is used as a source of irrigation water, then stillage may actually impart some benefit to the irrigated crop. This will be site-specific, however, and depend on relative volumes of irrigation water and the nutrient requirements of the crop. In some areas, irrigation and subsequent higher water table levels are increasing stream salinity and affecting downstream users. Stillage would exacerbate this problem.

The ocean has long been considered a large, assimilative receiving body for the acceptance of discharged wastes. With sufficient dispersion, sea waters should easily accommodate the high BOD, the salt content, and the low pH of stillage.

Stillage may enter the ocean indirectly by way of discharge to an estuary or nearby stream. This would be the least-cost option for a distillery not located adjacent to the ocean. Unless the stream is large, there may not be sufficient dilution and discharged stillage may affect estuarine ecosystems. Negative effects may take the form of oxygen depletion, oversupply of nutrients upsetting nutrient balances, and color and turbidity decreasing availability of light to photosynthetic organisms. If dispersion is sufficient, the effects may be positive, with organic matter and nutrients in stillage stimulating productivity through the food chain. Because of the significance of estuaries on total marine ecosystems and their importance as breeding grounds for commercial and subsistence fisheries, an adequate assessment of potential effects is imperative.

Distilleries located close to the sea have a fairly low-cost option of piping stillage to the coast and discharging off the shore. The best chances of achieving sufficient dispersion of stillage are by deep-water discharge or carefully designed offshore diffuser systems. Barging and deep-water dumping are possibilities, but because of high capital and operating costs and dependence on weather, selection of such a system is unlikely. There could be barging of stillage that has been concentrated by evaporation, but evaporation involves an increase in factory capital and operating costs and consumes more energy.

Offshore diffuser systems are more promising. The design and location of a diffuser depends on the dilution required and on local tidal conditions, currents, and the sea floor, which can be assessed by hydrological surveys. Environmental impacts to be considered are those on the adjacent shoreline and estuarine ecosystems as well as coral reefs, which are particularly sensitive to minor changes in nutrient loadings. Ecological considerations should influence siting decisions and, in the case of coral reef systems, may dictate that a diffuser be located outside fringing reefs. Some locations are emminently suited to ocean discharge due to extremely deep water or strong coastal currents. The laying of offshore pipelines is possible but can be expensive because of sea-floor terrain. Pumping and environmental monitoring are additional costs.

Stillage as an irrigant and crop fertilizer

The use of stillage as an irrigant and crop fertilizer for sugar cane appears attractive. Sugar cane requires large amounts of water and inorganic nutrients, both of which stillage can supply. It seems sensible to return this material to the fields, substituting for purchased fertilizer inputs and supplementing irrigation.

Operational considerations

The following questions address a number of issues raised when assessing the feasibility of stillage as an irrigant or fertilizer for sugar cane:

1. What is the fertilizer requirement of the crop?
2. What is the water requirement of the crop? How much of that requirement is met by rainfall and existing irrigation? Is there a need for supplementary irrigation?

3. What is the fertilizer content and balance of the stillage? What is the volume of stillage available?

4. During what seasons are irrigation water and fertilizer required by the crop? When is stillage available?

5. How far is the crop located from the distillery? How far can stillage be transported economically?

6. How will stillage be applied? What will be the consequences of over-application of stillage?

7. Who controls the crop? How will this affect the management of stillage distribution?

8. What standards and regulations cover such an application of effluent? Who is responsible for water pollution liability subsequent to the application of stillage to a crop?

9. What is to be done with stillage or other waste water not required for the crop (because of excess volume, excess fertilizer, or seasonal reasons)?

A molasses distillery will probably operate year round, but a cane juice distillery will operate only when cane is available. A molasses distillery may be at a disadvantage for land applications of its stillage because it may produce stillage at times when the crop does not require irrigation. A cane juice distillery is usually located near its supply of cane, but a molasses distillery may be located centrally to the supply of molasses from a number of sugar mills. The salts in the stillage have, therefore, come from a large area and must be redistributed to a large area if over-application is to be avoided.

Stillage could be blended with irrigation water to deliver it to the crop, or a special distribution system such as pipelines could be installed for crops close to the distillery, but more distant sites might only be serviced by tanker, which consumes liquid fuel. The organization of stillage distribution and application is facilitated if distillery operators also control the crop to be treated. The cane for a juice distillery or integrated sugar mill/distillery complex may come from production organizations ranging from highly organized estates managed by the distillery operator to a large number of small holdings operated by small producers.

Environmental considerations

In traditional fertilizer treatment, the management question is: "How little fertilizer can be added and still achieve worthwhile increases in yield?" With stillage as the fertilizer, the objective is to minimize distribution costs. Because stillage contains considerably more potassium than nitrogen or phosphorous, the management question also becomes: "How much potassium can be added in the form of stillage before yields decline?" Effects of over-application of potassium may be short-term changes in cane quality and increases in the ash content of sugar produced from it [7].

The most important issue, however, is long-term productivity of the cane land. Experience with intensive land application of stillage in Australia (the distillery operated by CSR Limited in Sarina, Queensland) has indicated that salts can accumulate in the soil until vegetation is no longer supported [8]. Although this is reversible, the interim effects on the viability of the industry could be serious.

A significant issue is the liability for pollution and other problems caused by misuse or accidents in stillage handling. A spill of the concentrated material or heavy rainfall shortly after application to a cane field could lead to serious contamination of a waterway. If the spill, run-off, or wash-off occurs on or from a grower's property, is the distillery operator liable? Does his liability end at the distillery gate or the farm gate? Who is responsible during transport?

Another significant problem with stillage is odor, particularly in aqueous solutions, which rapidly become anaerobic. This may occur in cane fields when rain follows stillage application. Rainfall may also cause salts and color to appear in leachates from the cane fields and may affect downstream water quality. Fly breeding, which has occurred in intensively treated land disposal sites, may also be a problem in cane lands.

Stock feed (evaporation or yeast)

Stillage can be used as a feedstock for production of yeast as a high protein additive for animal feeds. It can also be concentrated to molasses consistency and added to stock feed, serving as a binding agent and providing nutrients. Stillage from corn-based fermentation has high value as a stock feed, but stillage from molasses fermentation has a significantly lower market value as a stock feed, primarily because of the large amount of potassium it contains.

Market considerations

Because molasses has long been used for stock feed, molasses stillage may find a stock feed market by replacing the molasses that has been diverted from stock feed to distilleries. Such may be the case in Hawaii, where the bulk of molasses produced is currently exported to the continental United States for use as stock feed. Many other nations do not have intensified cattle feedlot operations, so the domestic demand for stillage stock feed could be doubtful and at best seasonal. The potential for export markets may improve if more molasses is removed from the world market and large quantities of surplus grain are directed from animal feed to fermentation.

Developers of new distilleries would have to be confident of the viability of the stock feed market before committing themselves to concentration of stillage. A collapse of the market could have disastrous effects on the economics of ethanol production and leave the distillery with a stillage disposal problem. The large corn fermentation capacity under development or projected for the United States includes, in many cases, plans for the production of feeds from corn stillage. There may therefore be a large supply of feed in North America available for export. Whether sugar-based stillage could achieve an adequate price in this competitive market is debatable. Because the stillage from cane juice and cassava distilleries has significantly less nutrient value than that from a molasses distillery, it is doubtful that the capital cost involved in producing a concentrate from cane juice or cassava stillage could be justified.

The likely seasonal or export demand for stillage-based stock feed may require further concentration of the material to avoid spoilage in shipment or storage, adding to the energy costs of production.

Production methods

Evaporation of water from stillage in open solar ponds has been proposed as one method to produce a dried sludge for stock feed or fertilizer. However, large areas of land could be required, depending on factory output and net evaporation rates; and concentrated stillage is an excellent breeding medium for flies. This method could be a viable, low capital cost proposition in areas with abundant, low-cost land and an excess of evaporation over rainfall. Ponds would have to be designed and managed to minimize or control insect breeding and prevent overflow during heavy rainfall to avoid pollution of nearby waterways. Suitable methods of sludge removal, handling, and utilization would have to be developed.

The main method for producing stock feed is to remove the water by heat evaporation. Molasses stillage, however, has proven difficult to concentrate using multiple-effect evaporators, and scaling of heat transfer surfaces is a recurring problem. Stock feeds produced by an evaporation plant will be costly and require significant energy input, adding to the distillery's overall net energy requirements. Solutions to scaling problems may require complex cleaning systems, adding to capital cost and introducing another effluent requiring treatment and disposal.

Candida utilis can produce significant quantities of high quality yeast for animal feed when cultured in well aerated stillage. The stillage BOD is only reduced by about 50% in yeast production, so a substantial residue still remains. There would also be a substantial power requirement for aeration, and more complex control than is needed for the production of ethanol. Nutrients may be required to achieve yeast growth. Additional fermenter capacity (about equal to that used for ethanol production) would be required, as well as yeast recovery equipment (such as centrifuges) and dewatering equipment (such as drum rollers). Capital costs and operating costs are high, and the risks to be satisfied by a market return for the yeast are, therefore, substantial. Establishment of secure markets for yeast is essential before making a commitment to this option.

Fertilizer (incineration)

Market considerations

To the extent that potassium and other salts in stillage can replace purchased fertilizer inputs for farming, stillage or isolates from it will have a market value. The value at the farm gate will depend on the value of the replaced fertilizer, the compatibility of the stillage material with existing application practice, and the possible need for purchases of other materials to supplement nutrient imbalances in the stillage fertilizer. The market value will have to be sufficient to cover the recovery and distribution costs of the stillage fertilizer, including capital costs. In 1978 stillage from the Sarina, Queensland distillery in Australia (50,000 m^3/yr capacity) had a value of about US$6.5 million when expressed in terms of the commercial fertilizer it might replace [8]. The stillage stream contained approximately 1100 Mg nitrogen, 100 Mg phosphorous, 6300 Mg potassium, 1200 Mg calcium, and 800 Mg magnesium. Such a high potential value is sufficient to generate an interest in recovery and distribution, but the potential can only be realized if the material can be delivered to the farm in a usable form at a price competitive with conventional alternatives.

Production methods

Concentration of stillage nutrients could be effected if the organic components were retained by a membrane allowing passage of salts only. Because a significant proportion of low-molecular-weight organic matter is present, a membrane with a cutoff at molecular weight 1000 would be required. Some laboratory work has been done, and there is a great deal of potential for improving the technology in this area. Electrodialysis techniques have also been proposed but much work remains before such systems can be applied on a commercial scale.

Incinerators can be designed to produce a soluble ash product with excellent potential for use as fertilizer. This has the advantage of facilitating transport and distribution because of the low volume of the material. Because the ash has a relatively high quantity of potassium, however, and farmers are accustomed to using a balanced fertilizer, it may be necessary to upgrade the ash by adding nitrogen and phosphorus.

In addition to the ash, stillage incineration produces heat that can be used for process steam and electricity generation, improving the net energy balance of a distillery. Stillage incineration is not yet well established but is under development. Incineration facilities, with their attendant evaporation plants, heat recovery, and ash handling systems, involve high capital costs. (Estimates are about US$25 million for a 50,000 m^3/yr molasses distillery.) Advantages of incinerators are complete removal of BOD and excellent heat recovery. To prevent air pollution, fly ash recovery must be an integral part of the incinerator plant.

It is logical for operators of molasses distilleries to look to adapting the incinerator technology of other industries. The incineration of aqueous liquid organic wastes has been established for some years, especially in the pulp and paper industry.

Japanese industry built a number of stillage incinerators in the early

1970s. These first generation incinerators were characterized by high capital and operating costs. The plants were large, sometimes as big as the distillery itself and, therefore, difficult to install in cramped industrial estates. Stillage was evaporated to about 40% solids in multiple-effect evaporators and then introduced to the incinerator's combustion chamber with atomizing steam. A supplemental fuel (oil or natural gas) was often required to sustain combustion, and steam generated in the boiler was usually sufficient only for the stillage evaporation plant. Problems associated with the operation of evaporator-incineration plants include scaling of evaporators and maintaining combustion temperatures to prevent overheating, which can cause fusion of the ash to an insoluble glass with no fertilizer value.

The potential for energy recovery from stillage depends on the feedstock. The low solids content of cane juice stillage and its lower potassium concentration means that it will require more energy for evaporation, and the product ash will be of lower value than that from molasses, although most cane juice distilleries will have bagasse available for fuel. It may be difficult to justify the high capital expenditure of incineration for a cane juice distillery.

Stillage from Australian molasses is characterized by high solids content and high calorific value. A feasibility study of incineration for one Australian distillery has indicated that steam can be produced for all the electrical and process steam requirements of the distillery. This would replace dependence on imported oil. The company that operates the distillery is investigating detailed designs for a commercial plant.

In summary, the incineration of stillage is attractive for operators of molasses distilleries. It makes possible virtual independence from external energy sources, demand for water is significantly reduced because of condensate recycling, and potassium can be returned to cane farms. The problems are:

1. there is no new-generation incinerator yet in commercial operation for stillage;
2. capital costs are high, probably of the same order as the cost of the distillery itself;
3. incineration is probably not a viable option for a cane juice distillery.

Methane (anaerobic digestion)

Market considerations

Because of the high organic content of stillage, anaerobic digestion offers a prospect of financial return from methane production. Given adequate time in the digester, up to 95% of the BOD can be removed, producing a gas that could supply all of a molasses distillery's fuel requirements (and perhaps 30% of the requirements of distilleries operating on cassava or cane juice). In the case of a molasses distillery, the potential fuel saving is significant. If that saving is sufficient to cover the capital cost of the digester and the further treatment and disposal of its effluent, methane production should be seriously considered.

In the case of a cane juice distillery, the methane may have little value if the distillery's fuel requirements are already met by bagasse. If the bagasse is used in the manufacture of paper or as a source of cellulose for hydrolysis and subsequent fermentation, there will be a fuel requirement that could be met by methane. Methane in excess of a distillery's fuel requirements may find a market in other industrial or domestic uses. This could require decisions on such issues as sharing of reticulation costs and pricing policies, but it may be feasible in regional industrial developments.

Use of anaerobic digestion for stillage treatment has until recently been considered uneconomic because of the long residence times (and hence large digester capacity) required to achieve a reasonable degree of BOD conversion to methane. However, the high costs of energy have prompted new research into the application of anaerobic digestion to distillery wastes.

Production methods

Current research is aimed at increasing the rate of microbial breakdown of BOD. One potential method is to use thermophilic bacteria (functioning between 50° and 60°C) rather than the normal mesophilic groups (30° to 40°C). This method is suited to a distillery operation because of the high temperature of stillage. Other research is aimed at optimizing sludge return rates and gas recycling and quantifying the requirements for nutrient supplements. The sludge produced in the digestion process has considerable potential as a fertilizer, but sludge handling, dewatering, and distribution systems will have to be identified to capitalize on this potential.

Even at 95% BOD reduction, the residual BOD of the digester effluent is still high, and much of the coloring material and dissolved inorganic salts will still be present. The digester effluent could be discharged into an ocean or river or returned to crop fields as is, but the environmental complications of direct discharge and land application then apply. Local conditions and environmental regulations may dictate further treatment of the digester effluent to reduce BOD and color. This might entail aerobic treatment, settling, or flocculation and color removal by carbon treatment or ozonation. These additional treatment requirements may consume a large amount of the energy generated by the methane, so the overall net energy balance of the system could be significantly less than first expected. The salt loading remains, and this will influence the final disposal method of the treated effluent.

Stillage from molasses usually has a high sulphate concentration, and under anaerobic conditions sulphate is reduced to sulphide, either hydrogen sulphide gas or dissolved sulphides. Hydrogen sulphide in product gas can cause air pollution problems when it is burned. Research is under way to reduce sulphides by gas stripping and recycling [9].

Even if anaerobic processes can reduce 95% of stillage BOD in short periods (e.g. 5 days), considerable problems remain. At 5 days residence time, the anaerobic digester will require a capacity at least three to four times the distillery's fermenters. Large digesters could have high capital costs if tanks are used. Lower-cost, in-ground digesters could be built but would require novel gas recovery and sludge removal systems. Investigation for a molasses distillery in Australia has shown that for anaerobic digestion, aerobic secondary treatment, and color removal by ozonolysis, the required capital cost is at least as great as that for an evaporator/incinerator complex for the same size distillery. There still remain operating costs and management problems of hydraulic loading of the treated effluent.

Application of anaerobic systems to cane juice distilleries is complicated by the seasonal nature of the availability of cane. Anaerobic digesters, like most other biological systems, are difficult to start up and would be slow to attain stable operating conditions at the start of each cane season. There would be fewer problems for a multiple feedstock distillery that can operate on cassava or molasses when cane is not available.

IMPLICATIONS FOR ENERGY DEVELOPMENT POLICY

Costs

Stillage disposal is a cost of production dependent on environmental standards and returns from any stillage by-products or recoverables. Some stillage options can replace or supplement purchased fuel and reduce energy inputs which are a significant component of production costs. Energy-producing options like incineration and anaerobic digestion, however, involve such high capital costs that the capital component of production costs rises accordingly.

The fact that very little of the energy-producing technology has achieved commercial status with stillage treatment may make the risks of so large a capital investment unacceptable. The absolute supply of capital may also preclude expenditures on high technology options, when it is considered that the capital cost of a molasses stillage incinerator may be the same as the cost of the molasses distillery itself.

Other stillage utilization technologies which produce potentially saleable by-products may also involve appreciable capital investment. A distillery developer will want to be assured of the commercial status of the technology and the existence and viability of the market for the by-product before capital is outlayed for its recovery. The viability of markets can be expected to be country- or region-specific.

A distillery developer can be expected to select a stillage disposal option that involves the least net cost of operation and the lowest capital cost, consistent with prevailing environmental standards. He cannot be expected to build one molasses distillery complete with stillage incinerator instead of two similarly sized distilleries with less sophisticated stillage treatment and the same capital outlay, unless pressures from environmental policies outweigh simple cost effectiveness for energy production.

Environmental standards and distillery siting

The unique disposal considerations for stillage suggest that environmental agencies should reassess conventional water quality standards before applying them to stillage discharges. Standards based on best practicable or best available means will have to recognize the high cost and high risk of these stillage treatment options. The fact that they are available on a pilot scale does not mean they will be easily applied at a commercial scale. Arguments that the value of the stillage by-products will justify the expense for their recovery fail to recognize the non-commercial status and potentially high costs of these recovery methods and the uncertain market value of many of the by-products.

National emission standards alone are not appropriate for regulating stillage discharges, because emission standards for aquatic discharges should be tailored to each body of water. Ambient standards are more meaningful but still have operational problems unless a distance from the point of discharge is specified and an appropriate and achievable standard assigned. This means appropriate and achievable in terms of the assimilative properties of the body of water and the ecological and socioeconomic consequences of exceeding a certain level of water quality degradation.

In discussions about high-technology stillage utilization systems, it must be recognized that a low technology disposal option might be not only most appropriate economically for a distillery but also satisfactory environmentally, depending on the site. The siting of a new distillery depends on several considerations. For a distillery using an existing molasses resource, the location might be a compromise between feedstock availability, access to the market for ethanol, and socioeconomic considerations such as availability of labor or competition for use of water. For a new cane juice distillery, the key factors are the availability of land for cane agriculture, the social infrastructure, and the availability of water for the crop and the factory. It is important for effluent disposal to receive equal attention with these other considerations in distillery site selection. Governments need to devise policy measures to ensure that this happens so that the potential for environmental conflicts is minimized at an early stage.

Government policy

The stillage problem of each distillery needs to be assessed individually in view of its specific site, scale of operation, and feedstock. As environmental regulatory agencies work with distillery operators to develop appropriate standards for each distillery's operation, the agencies need guidance from government policy on how to weight trade-offs between energy production and environmental quality. Some governments may see their current energy and trade deficit problems as superceding the need for maintenance of environmental standards, at least in the short term. In making such decisions, governments need to assure themselves that they are as fully informed of the consequences as possible.

There are strong arguments for the need to "get it right" the first time. Once established, a distillery will not only be part of the national fuel economy, but it will also be entrenched as a key element in the regional economy, with the incomes of many people depending on the distillery and the government having invested in the infrastructure to aid its development. The costs of retrofitting may be beyond the resources of a distillery's operation, and arguments about its regional significance may sway the government to accept unsatisfactory environmental performance. Alternatively, the government may find it has to increase ethanol market prices to stimulate an improved environmental performance, or it may have to spend more to remedy the problems caused by the distillery.

If a government depends on private industry as the source of investment capital for distillery developments, then clearly defined government policies are required on matters such as tax policies and the market price of ethanol. Government requirements concerning environmental performance will keep investors away unless their income will be sufficient to cover the capital and operating costs of facilities required to achieve that performance. Investors need to see consistency in the government's position on both environmental standards and pricing policies before capital is committed.

Distillery developers might contend that the costs and market uncertainties of more complex stillage treatment technology do not justify the initial capital outlay. It could be argued that a premature commitment of large amounts of capital to inadequately developed technology is a poor choice, and environmental quality might suffer if the operation fails commercially. Developers may, therefore, suggest that they be allowed to choose a low-cost disposal option such as aquatic discharge, and after generating a cash flow and accumulating some profits, later install more costly product recovery.

There appears to be room for compromise in the early stages of distillery development. The duration and extent of compromise needs to be clearly defined by a stated government policy on environmental quality. Compromise implies an on-going assessment of developments in stillage handling technology by both distillery operators and environmental regulatory agencies, accompanied by an evaluation of the performance of the initially installed technology and a constructive dialogue between the parties.

The achievement of a balance between energy production and the maintenance of acceptable environmental quality is a major goal of all nations. Standards should not be so unrealistically stringent as to discourage development, but they should not be so lenient that major environmental disruption and increased social costs ensue. Many less-developed countries suffer from a shortage of capital that limits their available options, and in the urgency of their energy situations they lack the professional manpower to do a thorough job on the assessments, standards, and policies appropriate to their needs and aspirations.

A proposed clearing-house for stillage processing information

Serious consideration should be given to the way in which stillage will be managed, from the earliest stages of planning a new distillery, including decisions on where the distillery will be located. A distillery planner might ask the following questions:

1. What are the markets for by-products such as methane, fertilizer, or animal feed?
2. What is the risk of a process which is not commercially proven?
3. How much capital is available?
4. Is it necessary that the process pay for itself?
5. Must the process be self-sufficient in energy?
6. Will the distillery serve a large area or a small area?
7. Can the distillery be located near the ocean?

Although the answers to these questions should suggest which stillage option is most appropriate, there will not necessarily be a simple solution. It may be necessary to return to the questions and decide where compromises will be made among the kinds of considerations shown in Table 3. Compromises are matters of policy, and a realistic policy can be shaped only to the extent that the practical possibilities for stillage handling are dealt with explicitly and realistically in the fuel alcohol development process.

It is essential that both distillery developers and environmental agencies be fully aware of the potential environmental significance of stillage. They should be well informed on past and present commercial experiences with stillage handling so they can relate environmental quality aspirations to the practicability of achievement. There are numerous commercial systems for processing alcohol stillage which are now under development in different parts of the world. Many have been adapted from processes already in use for other industrial effluents with similar properties. Some are already in use, others are only in the pilot stage, and still others are in laboratory development. The manufacturers and developers of these systems make varying claims about them, some valid, others not.

It is difficult for anyone deciding on stillage management to know what systems are available and which is appropriate for the circumstances. It is likely that decisions will often be made on the basis of partial information because a comprehensive survey of stillage systems would be excessively costly for a single distillery. This would be particularly true in a crash program where there is little time to assemble information and insufficient professional manpower.

There is, therefore, a need for a clearing-house of information on stillage management technology. This information should include specific equipment and processing systems available or under development. Each system should be documented with respect to the capital costs of the equipment, the kinds of stillage (with respect to distillery feedstock) that the process handles, the energy budget of the process and the characteristics of its products. It should allow someone who is setting up a new distillery to evaluate different stillage handling systems with respect to the particular circumstances of the distillery, matching candidate systems to the sources of energy available, calculating costs in terms of energy inputs and other requirements of the system, evaluating by-products with respect to local markets, and evaluating emissions with respect to local standards. At a national level this information could be used to evaluate the feasibility of establishing alcohol distilleries on a large scale.

Although there is not now any established clearing-house for this sort of information, a study conducted by the Hawaiian Sugar Planters Association [4] represents a significant first step in this direction. As there are numerous systems that have not yet been catalogued and described in a manner most useful for planning and developing large-scale alcohol production, there is an opportunity to do so in a way that could have a significant impact on liquid fuel development.

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Production of Isoamyl Acetate from Sugar Beet Molasses by *Williopsis saturnus* var. *saturnus*

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ABSTRACT

J. Inst. Brew. 114(1), 34–38, 2008

Three strains of *Williopsis saturnus* var. *saturnus* were employed for the production of natural isoamyl acetate (the character impact compound of banana flavour) using sugar beet molasses as the carbon source and batch cultivation at 25°C under anaerobic conditions. Of the three strains, strain HUT 7087 was the best producer of isoamyl acetate, producing 20.7 mg/L. Sugar beet molasses was deemed to be an acceptable carbon source for the production of this flavour compound.

Key words: Isoamyl acetate, sugar beet molasses, *Williopsis saturnus* var. *saturnus*.

INTRODUCTION

The increasing demand for natural products over the past decade has led to research on the use of biocatalysts for the production of natural flavour compounds. Products produced with bioprocesses, starting with natural substrates, are in principle defined as 'natural' if they are already found in plants or other natural sources[18]. Consumers prefer foods containing such natural flavours because of possible health issues as well as the possible environmental damage caused by synthetic chemicals and the production thereof[20].

Esters of short-chain fatty acids are important flavour and fragrance compounds that are widely used in the food and beverage industries. Isoamyl acetate, also called isopentyl acetate, is the character impact compound of banana flavour and pear drops. It is one of the most highly employed compounds in the food industries with a production of 74 tonnes per annum[22]. The extracts of natural flavour esters from plant materials are often in short supply. Enzymatic synthesis processes can be attractive, however they are very selective and are carried out at moderate temperatures[17].

A wide range of microorganisms are known to produce flavour compounds from simple nutrients via de novo synthesis (e.g. sugars and alcohols)[16]. Some yeasts can produce large amounts of fruity esters. If the levels produced were high enough to make a commercial product, it would offer an alternative way to obtain natural banana flavour. Natural flavours have a higher value in the market than those of chemically produced flavour compounds.

The genus *Williopsis* was originally introduced to accommodate the saturn-shaped ascospore-forming, nitrate-assimilating species *Williopsis saturnus* (formerly *Hansenula saturnus*). Since the genus was first defined in 1925 by Zender, further species have been accommodated within this genus[15]. It has been reported that *Hansenula* yeasts are a potent producer of esters[13]. *Williopsis* species synthesize important levels of volatile esters, e.g. isoamyl acetate at a concentration of 12-73 mg/L[14].

Sugar beet molasses, a by-product of the sugar manufacturing process, is among the most important raw materials for industrial cultivations; especially for the production of baker's yeast, citric acid, organic acids, amino acids, antibiotics, and enzymes. It generally contains sucrose (47-50%, wt/wt), proteins, vitamins, amino acids, organic acids and heavy metals[5,18]. Because of the high sucrose content, a substantial portion of the molasses produced is used for the production of industrially value-added products.

The aim of this study was to investigate production of isoamyl acetate from sugar beet molasses using three strains of *W. saturnus*. As far as known, there is no report on the production of isoamyl acetate from sugar beet molasses by the *Williopsis* genus.

MATERIALS AND METHODS

Microorganisms and medium

W. saturnus HUT 7087, *W. saturnus* IAM 12217 and *W. saturnus* NCYC 22 were obtained from the HUT (Japan), IAM (Japan) and NCYC (United Kingdom) culture collections, respectively. Yeasts were maintained on Malt Extract Agar (15 g/L) slants and re-cultured monthly. Sugar beet molasses was obtained from the Ozmaya Co. (Adana, Turkey). Molasses was diluted with deionized water to obtain a 10 ºBrix molasses solution and adjusted to pH 3.0 with 1 N H_2SO_4. This was to remove heavy metals that would affect cultivation. The molasses solution was allowed to stand for 24 h and then centrifuged at 5000 × *g* for 15 min. The supernatant was collected, adjusted to pH 5.0 with 10 N NaOH[18] and used as both a preculture and cultivation medium.

Batch cultivation

Batch cultivations were carried out in duplicate 3 L laboratory bioreactors (New Brunswick, BioFlo 110, USA) containing 2 L of cultivation medium. The temper-

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Publication no. G-2008-0303-545

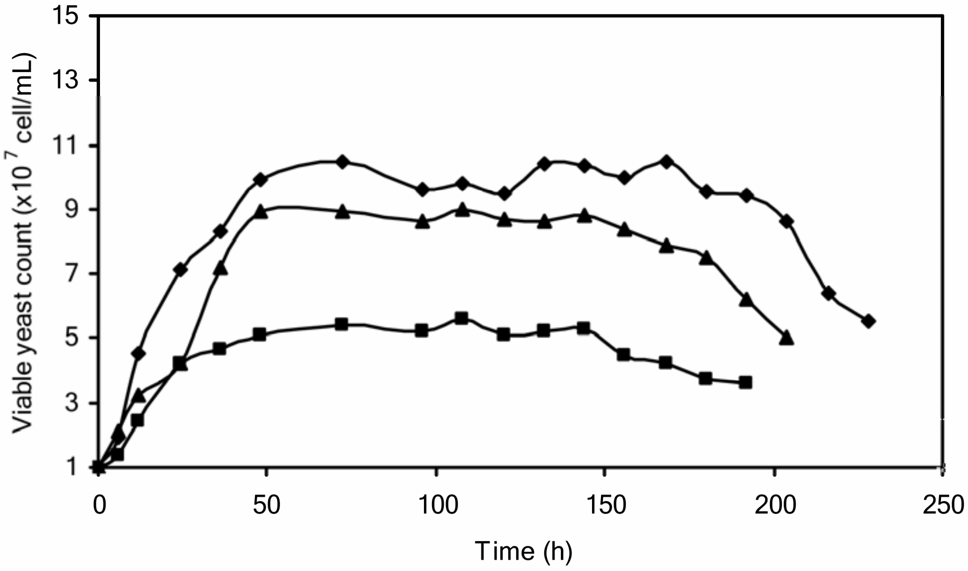

Fig. 1. Growth kinetics of *W. saturnus* strains: (♦) *W. saturnus* HUT 7087, (■) *W. saturnus* IAM 12217, and (▲) *W. saturnus* NCYC 22.

ature and agitation speed were maintained at 25°C and 100 rpm, respectively. The yeast was harvested from a 48 h preculture by centrifugation and used to inoculate the bioreactors at 1×10^7 cells/mL. The density of the cultivation medium and cell numbers were monitored throughout cultivation[8].

Analytical procedures

The number of viable cells was counted under a light microscope in a Thoma chamber using methylene blue[1]. The supernatant of the cultivation medium was used to determine the density by a density meter (Mettler, Toledo).

Analyses of ethyl alcohol, 2-methylbutanol (active amyl alcohol), 3-methylbutanol (isoamyl alcohol), isoamyl acetate and ethyl acetate were performed in duplicate using a gas chromatograph (Shimadzu GC-14B, Japan) equipped with a split/splitless injector and a flame ionization detector and a 60 m × 0.25 mm i.d. × 0.4 µm Chrompack CP-WAX-57CB capillary column. The temperature programme was as follows: 40°C for 4 min, then raised by 1.8°C/min up to 94°C and by 30°C/min from 94°C to 180°C and held at 180°C for 4 min. The carrier gas was He at 1.30 mL/min. Injection: 1 µL in split mode. Split ratio was 1:50. The FID was kept at 180°C. Samples containing the internal standard (3-pentanol) were injected directly into the column. For ethyl alcohol analysis samples were diluted accurately to not more than 1% (v/v) alcohol. The internal standard used for ethyl alcohol was 1% pure n-butanol. The oven temperature was stable at 70°C. The results given represent the means for two independent cultivations with their standard deviations[9].

RESULTS AND DISCUSSION

The aerobic yeasts, including *Brettanomyces, Debaryomyces, Dekkara, Lipomyces, Pichia, Rhodotorula* and *Williopsis* (yeasts also known as non-*Saccharomyces*), ferment sugars only weakly, or not at all. They utilize sugars oxidatively for cell growth with the production of desirable flavour compounds[9].

Yeast growth, sugar consumption and ethyl alcohol production

Fig. 1 shows the growth kinetics of three strains of *W. saturnus*. Growth of all strains reached stationary phase after 48 h of cultivation. At 72 h, *W. saturnus* HUT 7087 exhibited a high concentration of cells in the medium and reached 1.1×10^8 cells/mL; by contrast, both *W. saturnus* IAM 12217 and *W. saturnus* NCYC 22 at 108 h reached concentrations of 5.6×10^7 cells/mL and 9×10^7 cells/mL, respectively. At the end of cultivation *W. saturnus* HUT 7087 showed a population of 5.6×10^7 cells/mL. *W. saturnus* IAM 12217 and *W. saturnus* NCYC 22 grew to a lesser extent, reaching populations of 3.6×10^7 cells/mL and 5×10^7 cells/mL, respectively.

Several studies have confirmed that non-*Saccharomyces* yeasts can survive longer than previously thought in wine production[10,12,23], growing up to 10^6-10^7 cells/mL. Anaerobic conditions alone were not reported to result in any loss of viability in pure cultures of *Debaryomyces, Hansenula* or *Pichia*[3].

Fig. 2 shows a drop in the density of the medium as monitored throughout cultivation as a criterion of sugar consumption. All the sugar was not utilized by the yeasts as the cultivation had not progressed after 228 h, 204 h, 192 h by HUT 7087, NCYC 22 and IAM 12217, respectively. The density was around 1.0160 g/cm^3 for all strains at the end of cultivation. All yeasts strains left residual sugar in the growth medium. Residual unfermented sugars have been reported with species of *Candida, Hanseniaspora, Pichia* and *Hansenula* by Drysdale and Fleet[6], Forster[11], Ciani and Picciotti[4], Erten[8] and Erten and Campbell[9].

Fig. 3 shows the ethyl alcohol content during cultivation. There was a rapid increase in ethyl alcohol content for all strains during the first 150 h of cultivation. The

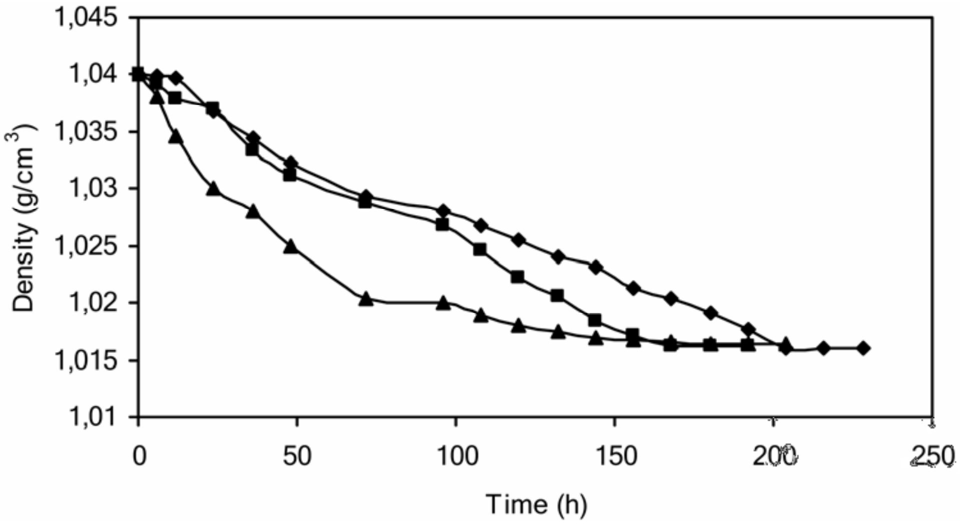

Fig. 2. Density of medium monitored throughout cultivation as a criteria of sugar consumption: (♦) *W. saturnus* HUT 7087, (■) *W. saturnus* IAM 12217, and (▲) *W. saturnus* NCYC 22.

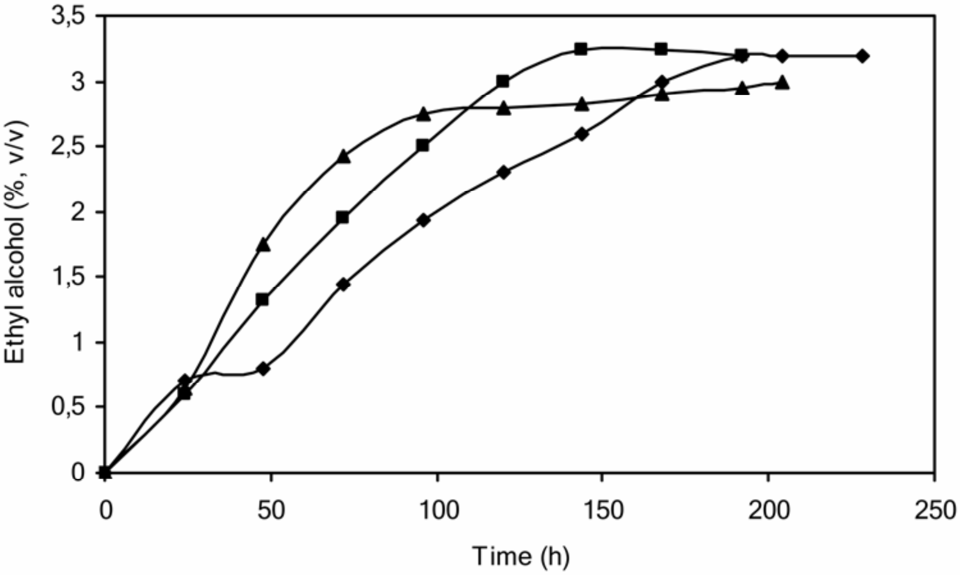

Fig. 3. Ethyl alcohol produced by *W. saturnus* strains: (♦) *W. saturnus* HUT 7087, (■) *W. saturnus* IAM 12217, and (▲) *W. saturnus* NCYC 22.

ethyl alcohol content was around 3% (v/v) with all strains. The yeast species employed in this study oxidise sugars, mainly to CO_2 and H_2O, producing only low levels of ethyl alcohol, but they also generate esters, higher alcohols and other compounds[2,12]. According to Foster[11], Erten[8] and Erten and Campbell[9], *W. saturnus* can produce 2.8-7.8% (v/v) ethyl alcohol.

Production of amyl alcohols and isoamyl acetate

Figs. 4 and 5 show the amounts of 2-methylbutanol and 3-methylbutanol formed during cultivation, respectively. The levels of 2-methylbutanol and 3-methylbutanol reached an optimum towards the end of the active growth phase for all strains. Two of three strains produced similar amounts of 2-methylbutanol (23.8-24.6 mg/L) and 3-methylbutanol (20-24.6 mg/L) during cultivation. It has been reported that most amyl alcohol synthesis occurs during the growth phase, with only 10-15% additional being synthesised during the later stage of industrial cultivation[7].

Fig. 6 shows the amounts of isoamyl acetate produced during cultivation. The synthesis of isoamyl acetate already starts during the active growth phase. Highest isoamyl acetate (20.7 mg/L) production was found using the culture *W. saturnus* HUT 7087. This strain also produced higher levels of ethyl acetate (59.9 mg/L) compared to *W. saturnus* IAM 12217 (38.7 mg/L) and *W. saturnus* NCYC 22 (36.9 mg/L). Synthesis of isoamyl acetate by yeast is performed by the action of alcohol acetyltransferase (*AATFase*) in the presence of isoamyl alcohol and acetyl-CoA. It has been reported that in sake brewing , the bottle neck of isoamyl acetate production is the amount of isoamyl alcohol in the sake mash. Since the K_m value of

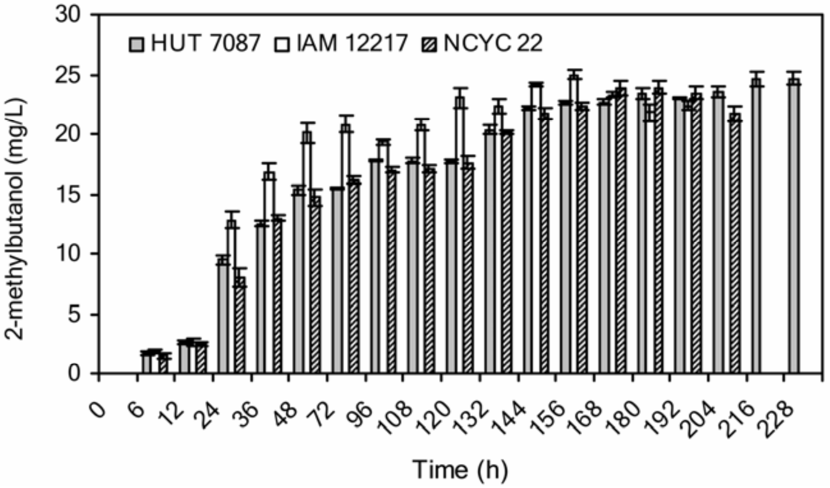

Fig. 4. 2-Methylbutanol produced by *W. saturnus* strains.

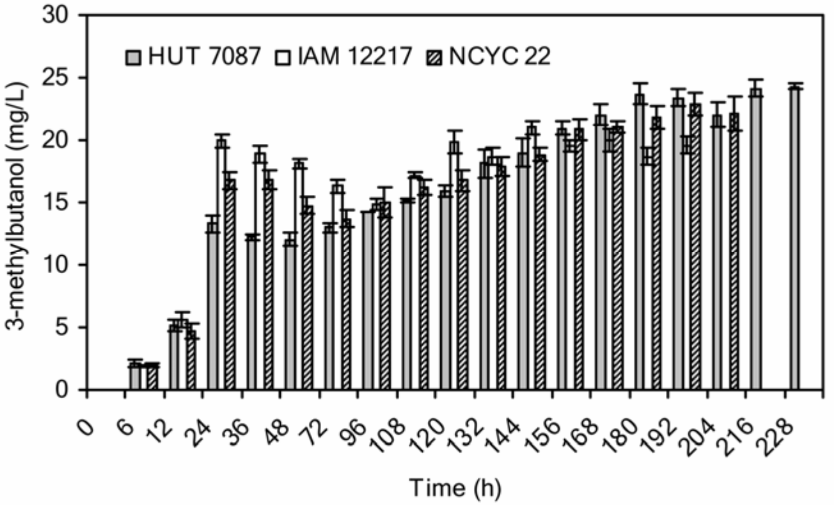

Fig. 5. 3-Methylbutanol produced by *W. saturnus* strains.

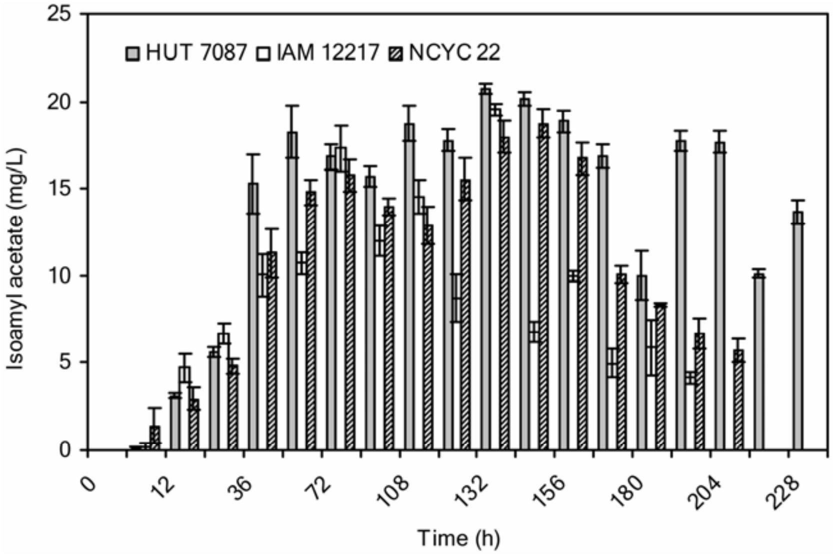

Fig. 6. Isoamyl acetate produced by *W. saturnus* strains.

Table I. Isoamyl acetate/total amyl alcohol ratios of *W. saturnus* strains.

Yeast strain	Isoamyl acetate/ total amyl alcohol ratio
W. saturnus HUT 7087	4.66
W. saturnus IAM 12217	1.48
W. saturnus NCYC 22	4.48

AATFase for isoamyl alcohol is high (meaning that the affinity of *AATFase* to isoamyl alcohol is low), a large amount of isoamyl alcohol is required for the production of isoamyl acetate[13].

The ratio of the esters to higher alcohols is known to influence the sensory properties of fermented beverages. Particularly, an increased content of esters gives an enhanced fruity flavour, and this can improve when higher alcohol content decreases[14,21]. Inoue et al.[13] showed that the ratio of isoamyl acetate to isoamyl alcohol in a culture of *Hansenula mrakii* was 1.33, while that of *Saccharomyces cerevisiae* was 0.0054. Table I lists the (isoamyl acetate/total isoamyl alcohol) ratios calculated for the media fermented with the three strains of *W. saturnus* in this study. As can be seen, the best ratio was with strain *W. saturnus* HUT 7087.

CONCLUSIONS

There is a growing demand for naturally obtained flavour compounds. The employment of enzymes and whole cells as biocatalysts to produce natural flavour compounds is a production process that is frequently utilized. With the aid of *Williopsis saturnus* strains, it was possible to produce isoamyl acetate, which has the character impact compound of banana. The production of 20.7 mg/L isoamyl acetate from sugar beet molasses appears to be an encouraging result as this type of production has not been reported previously but further investigations will be needed to increase this level for industrial production.

ACKNOWLEDGEMENTS

This work was supported by grants from The Scientific and Technical Research Council of Turkey (Project No: TUBITAK-TOVAG 3393) and The Academic Research Projects Unit of Cukurova University (Project No: ZF2004BAP13). We also thank the HUT, IAM and NCYC Culture Collections for providing the yeast strains and the Özmaya Co. (Adana, Turkey) for the sugar beet molasses.

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(Manuscript accepted for publication February 2008)