NOSB NATIONAL LIST
FILE CHECKLIST

CROPS

MATERIAL NAME: **#4 Bleach/Chlorine**

✓ **NOSB Database Form**

✓ **References**

✓ **MSDS (or equivalent)**

✓ **TAP Reviews from:** **Marta Engel, Walter Jeffery, Chris Milne, Joe Montecalvo, and Rich Theuer**

NOSB/NATIONAL LIST
COMMENT FORM
CROPS

Material Name: #4 Bleach/Chlorine

Please use this page to write down comments, questions, and your anticipated vote(s).

COMMENTS/QUESTIONS:

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1. In my opinion, this material is:
_____ Synthetic _____ Non-synthetic.

2. This material should be placed on the proposed National List as:
_____Prohibited Natural _____Allowed Synthetic.

TAP REVIEWER COMMENT FORM for USDA/NOSB

Use this page or an equivalent to write down comments and summarize your evaluation regarding the data presented in the file of this potential National List material. Complete both sides of page. Attach additional sheets if you wish.

This file is due back to us by: Sept 5, 1995

Name of Material: Bleach | Chlorine

Reviewer Name: MARTA W. ENGEL, DVM.

Is this substance Synthetic or non-synthetic? Explain (if appropriate)

Synthetic

If synthetic, how is the material made? (please answer here if our database form is blank)

This material should be added to the National List as:

✓ **Synthetic Allowed** ____ **Prohibited Natural**

or, _____ **Non-synthetic (This material does not belong on National List)**

Are there any use restrictions or limitations that should be placed on this material on the National List?

YES. ONLY in small concentrations as a sanitizer for dairy equipment.

Please comment on the accuracy of the information in the file:

Looks very complete

Any additional comments? (attachments welcomed)

Alternatives to Chlorinated pipeline cleaners and Sanitizers for use in the dairy industry that can adequately prevent ↑ plate counts for bacteria would be very welcome.

Do you have a commercial interest in this material? ____ **Yes;** ✓ **No**

Signature Marta W. Engel DVM **Date** 9/11/95

These have all been adequately answered on your data sheet

Please address the 7 criteria in the Organic Foods Production Act:

(comment in those areas you feel are applicable)

(1) the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;

(2) the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment;

(3) the probability of environmental contamination during manufacture, use, misuse or disposal of such substance;

(4) the effect of the substance on human health;

(5) the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;

(6) the alternatives to using the substance in terms of practices or other available materials; and

(7) its compatibility with a system of sustainable agriculture.

Compatible only in a limited or restricted sense.

TAP REVIEWER COMMENT FORM for USDA/NOSB

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This file is due back to us by: Sept. 5, 1995

Name of Material: Bleach / Chlorine

Reviewer Name: WALTER JEFFERY

Is this substance Synthetic or non-synthetic? Explain (if appropriate) Synthetic

If synthetic, how is the material made? (please answer here if our database form is blank)

This material should be added to the National List as:

✓ **Synthetic Allowed** ____ **Prohibited Natural**

or, _____ Non-synthetic (This material does not belong on National List)

Are there any use restrictions or limitations that should be placed on this material on the National List?
Would allow sodium hypochlorite or Calcium hypochlorite but not ClO_2

Please comment on the accuracy of the information in the file:
I don't know what the first line of the properties section refers to - sodium hypochlorite only exists in solution where it is pale yellow. I think that ascribing a boiling point is misleading. I'd expect the stuff to decompose.

Any additional comments? (attachments welcomed)
The title is "bleach/chlorine" but there is no reference to chlorine. its manufacture or use. I doubt that much chlorine dioxide is used except in pulp bleaching & even there its use is declining. It's real nasty stuff generally produced by reduction of sodium chlorate.

Do you have a commercial interest in this material? ____ **Yes;** ✓ **No**

Signature Walter Jeffery **Date** 9/8/95

Please address the 7 criteria in the Organic Foods Production Act:
(comment in those areas you feel are applicable)

(1) **the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;**

(2) **the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment;**

(3) **the probability of environmental contamination during manufacture, use, misuse or disposal of such substance;**

(4) **the effect of the substance on human health;**

as noted in 2119(m)4: but refers to chlorine treatment of drinking water, not the use of NaOCl or $Ca(ClO)_2$.

(5) **the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;**

Will kill micro organisms besides germs, but if used properly other than on soils, the effects on other microorganisms should be minimal.

(6) **the alternatives to using the substance in terms of practices or other available materials; and**

The alternatives may not be practical or even work in some processing equipment.

(7) **its compatibility with a system of sustainable agriculture.**

TAP REVIEWER COMMENT FORM for USDA/NOSB

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This file is due back to us by: August 29, 1995

Name of Material: Bleach / Chlorine

Reviewer Name: CHRIS MILNE

Is this substance Synthetic or non-synthetic? Explain (if appropriate)

SYNTHETIC

If synthetic, how is the material made? (please answer here if our database form is blank)

This material should be added to the National List as:

X Synthetic Allowed ____ Prohibited Natural

or, _____ Non-synthetic (This material does not belong on National List)

Are there any use restrictions or limitations that should be placed on this material on the National List?

Review status in 5 yrs. (See attachment, OFPA CRITERIA #7)

Please comment on the accuracy of the information in the file:

OK

Any additional comments? (attachments welcomed)

See Attachment

Do you have a commercial interest in this material? ____ Yes; X No

Signature [signature] CHRIS MILNE **Date** 8/28/95

BLEACH/CHLORINE

OFPA CRITERIA

(1) The hypochlorites should not be mixed with ammonia, phenols or rust removers. Chlorine is incompatible with organic materials, heat, phosphorous, potassium hydroxide and sulfur.

(2) Chlorine dioxide is unstable and reactive.

(4) Chlorine dioxide is a more severe respiratory and eye irritant than chlorine. The hypochlorites are corrosive the skin and mucous membranes as well as irritants to the eyes, skin and mucous membranes. Severe reactions include esophageal strictures, toxic shock, circulatory collapse, pulmonary edema and coma. Lethality is more related to concentration than to dose with as little as 1 oz. being dangerous if the concentration is 15% or more. In 1992, there were approximately 50,000 poisonings reported to poison control centers requiring 12,000 individuals to be treated in health-care facilities due to hypochlorite bleach and disinfectant products as well as chlorine gases. Dioxins and furans from the manufacture and disposal of chlorine products are classified by as probable human carcinogens. The role of chlorine-containing compounds in the production of breast cancer by xenoestrogens is being studied.

(7) The use of chlorine products presents a dilemma for sustainable agriculture. Their use is compatible with the principles of sustainable agriculture so long as it is the only viable technology. Its continued viability should be determined by availability, cost, efficiency, toxicity, and practicality of the alternatives. Without such products, sustainable agricultural production is not currently cost-effective for the entire farming community. Nonetheless, their use entails significant ecological and health risks which would appear to be inconsistent with principles of organic farming and sustainable agriculture.The only way to reconcile their use is to allow it only so long as it is indispensable. By reviewing their status every five years, it will stimulate industry to decrease reliance on them and facilitate a phase-out of non-essential uses.

REFERENCES

Litovitz, Toby L., et al, *1992 Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System*, AMERICAN JOURNAL OF EMERGENCY MEDICINE, Vol. 11, No. 5, Sept. 1993.

Gosselin, Robert E. et al, CLINICAL TOXICOLOGY OF COMMERCIAL PRODUCTS, 5th Edition, 1984, Williams & Wilkins.

Manahan, Stanley E., TOXICOLOGICAL CHEMISTRY: A GUIDE TO TOXIC SUBSTANCES IN CHEMISTRY, 1989, Lewis Publishers, Inc.

Klaassen, Curtis D. et al, editors, CASARETT AND DOULL'S TOXICOLOGY, 3rd Edition, 1986, Macmillan Publishing Co.

NIOSH POCKET GUIDE TO CHEMICAL HAZARDS, U.S. Department of Health and Human Services, June 1990.

TAP REVIEWER COMMENT FORM for USDA/NOSB

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This file is due back to us by: August 29, 1995

Name of Material: Bleach/Chlorine

Reviewer Name: Dr. Joe Montecalvo

Is this substance Synthetic or non-synthetic? Explain (if appropriate)

Synthetic

If synthetic, how is the material made? (please answer here if our database form is blank) Produced on a large scale by electrolysis from fused elemental chlorides.

This material should be added to the National List as:

✓ Synthetic Allowed ____ Prohibited Natural

or, ____ Non-synthetic (This material does not belong on National List)

Are there any use restrictions or limitations that should be placed on this material on the National List?

Chlorine may be used only as a sanitizer/disinfectant in food processing. Residual free chlorine should not exceed 2ppm in washwaters.

Please comment on the accuracy of the information in the file:

Any additional comments? (attachments welcomed)

Good

Do you have a commercial interest in this material? ____ Yes; ✓ No

Signature Dr. Joh Montecalvo **Date** 7/31/95

Please address the 7 criteria in the Organic Foods Production Act:
(comment in those areas you feel are applicable)

(1) the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;

very great; Chlorine and all halogens are very reactive

(2) the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment;

very great; Chlorine can react with hydrocarbon residues and alkyl halides to form carcinogenic compds.

(3) the probability of environmental contamination during manufacture, use, misuse or disposal of such substance;

Low.

(4) the effect of the substance on human health;

① LD_{50} for Rats by inhalation = 137 ppm Cl
② Powerful irritant (gas)
③ Can cause fatal pulmonary edema (gas)

(5) the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;

Not Known?

(6) the alternatives to using the substance in terms of practices or other available materials; and

As a disinfectant for the food industry, no other compound has been shown to be as effective, with possibility of new information on ozone, FDA may approve ozone in a few years.

(7) its compatibility with a system of sustainable agriculture.

Only in limited, specific applications which can be controled.

TAP REVIEWER COMMENT FORM for USDA/NOSB

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This file is due back to us by: August 29, 1995

Name of Material: Bleach / Chlorine

Reviewer Name: R THELLER

Is this substance Synthetic or non-synthetic? Explain (if appropriate) SYNTHETIC

If synthetic, how is the material made? (please answer here if our database form is blank)

This material should be added to the National List as:

✓ Synthetic Allowed ____ Prohibited Natural

or, ____ Non-synthetic (This material does not belong on National List)

Are there any use restrictions or limitations that should be placed on this material on the National List?

ONLY AS AN EQUIPMENT CLEANER OR TO CREATE AN AVAILABLE CHLORINE LEVEL IN WASH WATER FOR ~~B~~ PUBLIC HEALTH AND SAFETY - PROCESSING AID

Please comment on the accuracy of the information in the file:

Very good

Any additional comments? (attachments welcomed)

Do you have a commercial interest in this material? ____ Yes; ✓ No

Signature RC Theuer **Date** 8/28/95

Please address the 7 criteria in the Organic Foods Production Act:
(comment in those areas you feel are applicable)

(1) the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;
CHLORINE (FREE AS IN BLEACH) OXIDIZES MATERIALS AND CAN CREATE TRACES OF CHLORINATED HYDROCARBONS IF LARGE QUANTITIES ARE USED INCORRECTLY

(2) the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment;
PERSISTANCE OF CHLORINATED SUBSTANCES SOME CREATED WHEN BLEACH OXIDIZES HYDROCARBON CONTAMINANTS.

(3) the probability of environmental contamination during manufacture, use, misuse or disposal of such substance;
SOME POSSIBILITY - LESS THAN GREENPEACE CLAIMS, MORE THAN INDUSTRY CLAIMS

(4) the effect of the substance on human health;
- NOT APPROPRIATE FOR DIRECT CONTACT
- IMPORTANT FOR SANITATION AND MAINTAINING PUBLIC HEALTH

(5) the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;
NO ISSUE

(6) the alternatives to using the substance in terms of practices or other available materials; and
FOR SMALL OPERATIONS, NO PRACTICAL ALTERNATIVES

(7) its compatibility with a system of sustainable agriculture.
REQUIRED FOR SMALL AND MEDIUM SCALE ON FARM PROCESSING, WASHING, ETC.

NOSB Materials Database

Identification

Common Name **Bleach/Chlorine**

Chemical Name Sodium Hypochlorite

Other Names Calcium Hypochlorite

Code #: CAS 7782-50-5 Cl; 7778-54-3 CaOCl;

Code #: Other 7681-52-9 NaOCl

N. L. Category Synthetic Allowed

MSDS yes

Chemistry

Family

Composition The main compounds of interest are sodium hypoclorite (NaOCl), calcium hypoclorite (CaOCl) and chlorine dioxide (ClO_2). There are a few minor bleaching compounds such as N-Chloro compounds and sodium chlorite which are used as sanitizers.

Properties Yellowish Liquid, slightly heavier than water with mild to penetrating chlorine odor. Boiling point 230 F. Sodium hypochlorite is an unstable liquid that decomposes in light. Calcium hypochlorite is a solid with 65% available chlorine. Both have a high oxidation potential and ready hydrolysis to the parent acid. Chlorine dioxide is a gas that condenses at about 11°C and is highly explosive.

How Made

In making sodium hypochlorite, chlorine gas is passed through a caustic soda solution containing less than 20.5% sodium hydroxide. The resulting mixture of hypochlorous acid and hypochlorite anion is in a ratio dependent on the pH. The residue of free caustic soda present in strong solutions acts as a stabilizer.

For calcium hypochlorite, hydrated lime is reacted with the chlorine gas. To make the calcium hypochlorite solid, steps are taken to remove the coproduct Calcium Chloride and then the product is air or vacuum dried. Solutions are employed in concentrations of 3-15% in bleaching and sanitizing applications. Sodium hypochlorite can also be prepared electrolytically using small diaphragmless or membrane cells, from seawater or brine. This method is mostly used for sewage and wastewater treatment, and aboard ships.

Chlorine dioxide must be manufactured where it is used because of its explosive character. End use of the chemical dictate the method of manufacture, which is either reduction of sodium chlorate in an acid solution, or the oxidation of chlorite.

Use/Action

Type of Use Crops/Processing/Livestock

Use(s) Disinfectant. Cleaning irrigation systems. (Not allowed as post-harvest dip.)
Sodium hypochlorite is used in food processing as a sanitizer and disinfectant, in households as bleach for laundry. Calcium hypochlorite is used in the dairy, wineries, and food industries as a sanitizer in a 50% product. It is also used to treat drinking water and in industrial cooling water to control slime and odors. Chlorine dioxide is primarily used in bleaching wood pulp, wastewater treatment, drinking water treatment, and in food processing flumes and cooling-tower water.

Action Hypochlorite ion acts as a chlorinating and oxidizing agent toward organic compounds. Germicidal activity is caused primarily by hypochlorous acid which forms in the breakdown of hypochlorite. Therefore the hypochlorite serves mainly as a reservoir for the hydrolysis to the unstable hypochlorous acid.

Combinations

Status

OFPA

N. L. Restriction Prohibited for direct application to crops. Chlorinated municipal drinking water is allowed. Flush water containing bleach from cleaning irrigation systems cannot be applied to crops or fields in concentrations greater than allowed in municipal drinking water standards or 2ppm, whichever is less.

EPA, FDA, etc

Safety Guidelines Use skin and eye protection and boots. **Directions**

Registration **State Differences**

Historical status allowed as a disinfectant.

Internationl status

OFPA Criteria

2119(m)1: chemical interactions

Chlorine ions are highly reactive with organic compounds and once chlorine and carbon join, some of the resulting compounds may be very resistant to breakdown. Others however, occur already widely in nature.

2119(m)2: toxicity & persistence

The hypochlorite itself breaks down very rapidly on exposure to light and air, but recombines with organic compounds into many breakdown products. The wide variety of compounds formed makes generalization about persistence of breakdown products difficult.

2119(m)3: manufacture & disposal consequences

Moist chlorine solutions are highly corrosive and special chemically resistant materials are necessary in manufacturing plants. Since the reaction producing hypoclorite is highly endothermic, much water is used in cooling. The main secondary products produced are salt and water, which must be disposed of in compliance with applicable regulations.

2119(m)4: effect on human health

The formation of carcinogenic chloroform and other trihalomethanes in drinking water can be prevented by treating with chlorine dioxide instead of chlorine.

2119(m)5: agroecosystem biology

The hypoclorous acid resulting from bleach degradation kills germs, but it also kills all bacteria and other microorganisms. The mechanism has not been fully explained, but scientific evidence points to penetration of the cell wall followed by reaction with the enzymatic system.

2119(m)6: alternatives to substance

steam sterilization, hydrogen peroxide, citric and other acids, sunlight, ozone (each of these is application specific)

2119(m)7: Is it compatible?

References

See attached

the CRUSADE TO BAN CHLORINE

By Ivan Amato
photographs by
DEBORAH SAMUEL

Environmentalists insist chlorine must be banned from use because chlorinated compounds are potentially dangerous to health and environment. Their "precautionary principle" is seductive, but an aggressive phaseout would change thousands of industrial processes and products, disrupting technology and society. Is the

. is it a veiled attempt to return to a pre-industrial Eden?

ONLY IN THE PAST YEAR OR TWO did the chemical industry realize a meteor was coming its way: a dead-serious proposal to eliminate or drastically curtail the industrial use of chlorine, skillfully brought to legis- ators and the public by Greenpeace nd other environmentalists known for nti-technology positions. "This is the nost significant threat to chemistry hat has ever been posed," says Brad ienhart, a longtime industry executive vho heads the Chemical Manufactur- rs Association's new $5 million cam- a) counter as much of that threat ssible, for as long as possible.

At issue is the industry's previ- usly unquestioned right to use massive mounts of chlorine, number 17 on the eriodic Table of Elements. Since the nd of World War II, chlorine, a pale reen gas in its elemental form, has be- ome central to the chemical industry, nd thus to thousands of processes and onsumer products. "It is the single nost important ingredient in modern ndustrial] chemistry," says W. Joseph tearns, director of chlorine issues for Dow Chemical Company, one of the rgest producers and users of chlorine.

"It is such a valuable and useful nolecule because it does so many things nd is involved in so many end prod- cts," remarks John Sesody, vice presi- ent and general manager of Elf Ato- hem North America's basic chemical usiness. Chemists and chemical engi- eers acknowledge that chlorine is dan- er) use and handle, but argue that y can manage these dangers well ough for society to safely enjoy chlo- ne's many benefits.

In fact, many in the chemical industry are passionate about the overall good they say chlorine chemistry does for society (as passionate as the anti-chlorine forces are about its potential for damage). With uses ranging from making pesticides to commodity polymers to synthesizing pharmaceuticals and disinfecting 98% of the nation's water supply, say defenders, chlorine is a substance society cannot do without.

Detractors couldn't disagree more. Polarizing the issue perfectly, "There are no uses of chlorine that we regard as safe," remarks Joe Thornton, a Greenpeace research analyst who in 1991 authored Greenpeace's case for a chlorine phaseout in a document titled "The Product is the Poison."

Among the documented "criminal actions" of some chlorine-containing chemicals: contaminating riverbeds and lush aquatic habitats such as the Great Lakes water basin; accumulating in the tissue of birds and other wildlife, where they contribute to reproductive disorders and increased incidence of disease; and causing a rare form of liver cancer in some plastics workers who were exposed to high amounts of vinyl chloride monomer (the building block of polyvinylchloride) during the 1960s, before the Occupational Safety and Health Administration imposed stringent exposure regulations.

Chlorinated organic molecules have been found in human tissues, and anti-chlorine advocates assert they may be responsible for some of the increase in breast-cancer rates over the past few decades. *No one can claim a causal link* between chlorine-containing chemicals and breast cancer, but the mere suggestion alarms the anti-chlorine camp enough for them to call for its phaseout. As alternatives are available for at least some chlorine-containing products and processes, activists conclude it's better to play it safe and simply banish the element from industry. For example, activists have claimed in all sincerity, we could return to metal piping instead of PVC.

Science isn't the name of the playing field

WHEN ASKED WHAT THEY THINK OF THE call to eliminate industrial use of chlorine, most chemists throw back a "yeah, right" look. Then they denounce it. "The idea of banning chlorine is patently ridiculous and scientifically indefensible," says Steven Safe, a Texas A&M toxicologist who for 20 years has studied such chlorinated compounds as dioxins and PCBs. Mario Molina, the atmospheric chemist now at M.I.T. who, with Sherwood Rowland, first identified the link between CFCs and ozone depletion, agrees. He told *Science* magazine last summer that banning chlorine "isn't taken seriously from a scientific point of view."

Industry may have been counting on science to throw out this challenge. Yet many participants and observers of the debate doubt that standard scientific study will play a decisive role in determining the fate of chlorine chemistry. Each side of the chlorine debate has corralled vast amounts of data (quite often the same data) to support their diametrically opposed arguments. But public perception can change much more quickly than science can unambiguously determine the real impact of chlorine on the environment and on human health.

The Rise of Industrial Chlorine

Chlorine, in its form as a negatively charged ion, combines with positively charged counterparts including sodium ions to form sodium chloride, commonly known as table salt. Chloride ions populate the sea and are found in copious amounts in blood and every other tissue. Flows of chloride ions are responsible for the conduction of nerve impulses. In this sense, life just couldn't be without chlorine.

Not so for elemental chlorine. Any kind of life caught in a cloud of chlorine gas is on the fast track toward death. It reacts readily with all manner of biological tissue. (Chlorine gas was the first chemical warfare agent to be deployed during World War I.) Elemental chlorine, which consists of two chlorine atoms bound together into an electrically neutral molecule, does not normally occur naturally on Earth. Industry derives it by passing an electrical current through brine, which converts the solution's sodium and chloride ions into chlorine gas and sodium hydroxide in roughly equal proportions. Each comprises the root of an enormous industrial tree whose branches are thousands of products and hundreds of industrial processes. (See the pull-out charts on the next pages.)

What makes chlorine so industrially useful is its chemical talent for attracting electrons. It readily reacts with electron-rich atoms such as carbon, making carbon and chlorine one of the century's most versatile combinations for synthesizing molecular structures. Because their atomic combinations are so robust, many of the resulting organochlorine molecules are extremely stable, a plus for many industrial applications. But that same stability also means that once some organochlorine chemicals end up in the environment, they tend not to break down. Also, some chlorinated compounds combine persistence with a tendency to accumulate in oily locations such as fat tissue. That is what makes chlorine a villain among the environmental advocacy community.

That point hit industry in the solar plexus this past February when EPA Administrator Carol Browner was quoted in the *New York Times*, the *Washington Post*, and other national media as saying that the agency's proposals for reauthorizing the Clean Water Act would include a "national strategy for substituting, reducing, or prohibiting the use of chlorine and chlorinated compounds." Ms. Browner's bombshell drew 2,000 angry letters from citizens and elected officials, and an additional 300 letters from industry, says an EPA source who asked not to be identified. "We quickly answered the ones from Congress, and now we are getting into the boxes [of letters.]"

The EPA's reply, which its public-affairs office has been busy delivering to reporters, is more in line with what most scientists would suggest. The Agency's prepared statement says it "will study chlorine and chlorinated compounds to determine whether actions may be necessary to protect aquatic resources from discharges of these compounds, and it is premature to draw any conclusions about EPA's final actions before the study is completed." Even if the study becomes part of a reauthorized Clean Water Act, it is extremely unlikely that any action would be in the form of a blanket ban on chlorine, say EPA insiders.

Despite that clarification, the potential fact of industrial life without elemental chlorine, which the coverage of Ms. Browner's statements displayed in neon, puts raw fear into the heart of chlorine's defenders.

The chemical industry has never been known as a master of public relations. Greenpeace, on the other hand, the most aggressive member of the anti-chlorine consortium, could have written the book. With their "Chlorine Free" campaign, Greenpeace and allies have used every outlet to make their case.

Realizing the court of public relations will likely adjudicate the chlorine debate, the Chemical Manufacturer's Association established and bankrolled the Chlorine Coordinating Council (since renamed the Chlorine Chemistry Council), with Brad Lienhart as its managing director. The group hopes to counter what it views as anti-chlorine prejudice fueled more by environmentalist hysteria than hard science and sober risk assessment. Chlorine compounds, they say, ought to be regulated like other compounds — based on determinations of their individual risks and benefits, not on the mere presence of chlorine atoms in their molecular anatomies.

As its first order of business, the CCC commissioned reports on chlorine which included a massive analysis — totaling 10 volumes and 4,000 pages — of the toxicological literature on chlorinated organic compounds. The Chlorine Institute, an older industry group devoted "to the safe production, handling, and use of chlorine," has even prepared packaged school lessons and a video that takes students on a tour of chlorine's role in everyday products. Big chemical companies including Dow have created new full-time positions such as Director of Chlorine Issues. The aim of this emerging infrastructure, says Lienhart, is to offer the public a different view of chlorine chemistry than the one anti-chlorine forces have been purveying unchallenged for years.

Industry remains the underdog. Last October 15, the anti-chlorine lobby got the likes of Bella Abzug, the fiery former New York congresswoman and a cancer survivor, to publicly endorse a Greenpeace document linking the rise of chlorine chemistry over the past few decades to rising rates of breast cancer. The Associated Press reported the event and sent the story over the wires. That sort of lachrymose (and toxicologically meaningless) coverage just isn't available to the CCC.

The strongest argument may be that, while substitutes for chlorine and chlorinated compounds may exist in some cases, the costs to switch are prohibitive and the substitutes not necessarily any less risky.

Elemental chlorine is a cornerstone of industrial chemistry

TO THE COMMUNITY OF MANUFACTURERS, chlorine remains a cornerstone of chemistry, playing a role in virtually every nook and cranny of modern society. By volume, chlorine is one of the largest chemical feedstocks, rivaling even petroleum. Global chlorine production now hovers around 38 million tons a year. In the United States, the number is more like 11 million tons of chlorine.

The Chlorine Institute reports that about 28% of the chlorine supply goes into making plastics, mostly polyvinylchloride (PVC), from which thousands of products are derived, among them wall coverings, floor tiles, siding, pipes, shoe soles, electrical insulation, automobile components, and medical equipment. Saran Wrap is made from another major chlorine-containing polymer — polyvinylidene chloride. Just over one-third of the chlorine supply is used for synthesizing an estimated 11,000 commercial chemicals. Among the lengthy list of chlorine-dependent products are most herbicides and pesticides, dyes, chlorosilanes for making semiconductor materials, carbon tetrachloride for making nonstick cookware and refrigerants, dichlorophenyl sulfone for making computer components and power-tool housings, propylene chlorohydrin that is used first to make propylene oxide, which in turn is used to make a range of products including lubricants, coatings, brake fluids, cleaners, adhesives, pharmaceuticals, and soft-drink syrups.

Just under one-fifth of the chlorine supply is consumed by chlorinated solvents such as methylene chloride, a degreaser and paint stripper, although demand for such solvents is declining as manufacturers switch to water-based and otherwise less environmentally troublesome materials and methods. Approximately 14% of the chlorine supply is used for bleaching pulp and paper; the pulp and paper industry is likewise undergoing a transition toward bleaching processes that use less chlorine or no chlorine at all. The remaining few percent of the chlorine supply goes mostly into agents for purifying drinking and waste water, and for manufacturing pharmaceuticals.

Although undisputed estimates are hard to come by, in one way or another chlorine use amounts to at least tens of billions of dollars of commerce each year in the United States alone. It employs directly or indirectly at least hundreds of thousands of people. The highest estimates, from a widely cited and much disputed economic analysis conducted for the Chlorine Institute by the Charles River Associates consulting firm in Boston, contends that chlorine accounts for $91 billion of economic input in the U.S. and, directly and indirectly, over 1.3 million jobs.

The seeds of controversy were planted in the 1960s

THE CONTROVERSY BEGAN WELL BEFORE Greenpeace focused its worldwide campaign on chlorine chemistry in the mid-1980s, following the lead of Germany's Green Party. Never mind the once undisputed public-health successes of chlorine use in disinfecting water, controlling insect-borne diseases, and manufacturing pharmaceuticals. Such benefits to society can easily be forgotten once the anti-chlorine alliance unleashes its ordnance.

Consider DDT, an insecticide so effective against malaria that the World Health Organization once considered shortages as threats to public health. DDT, which stands for dichloro-diphenyl-trichloro-ethane and includes five chlorine atoms in its molecular structure, became the rallying point of the then-nascent environmental movement when Rachel Carson documented its unanticipated effects on the environment and wildlife in her 1962 book *Silent Spring*. (Although DDT has never been proved to be a significant human hazard, it was banned from use in the U.S. because it was known to bioaccumulate or be deposited in body fat at relatively low levels of exposure.)

Add the notoriety of chlorovillain PCBS, or polychlorinated biphenyls, a family of about 180 compounds that have anywhere from two to ten chlorine atoms in their molecular anatomies. PCBS' stability, low flammability, and insulating properties made them favorites for electrical and hydraulic equipment, but those same properties (along with their solubility in fat) likewise enabled them to accumulate to levels of concern in the cells and fat tissue of animals and people.

DDT and PCBS are not the only so-called organochlorine compounds that have a place among chemicals *non grata*. Even inorganic chlorine compounds that do not themselves persist in the environment, and presumably pose little long-term risk on their own, can break down into harmful molecules that do stick around. When the elemental chlorine used to bleach paper and the volatile chemicals used to make PVC plastic break down in the environment, they can spawn polychlorinated dibenzodioxins (PCDDS) and polychlorinated dibenzofurans (PCDFS). Both are suspected human carcinogens and both have documented adverse affects on wildlife in the Great Lakes region and elsewhere.

CFCS, or chlorofluorocarbons, whose nontoxicity, low cost, and physical and chemical properties had for decades made them just about perfect for large-scale cleaning and refrigeration uses, have become perhaps the best known and most vilified chlorinated compounds of all. CFCS' probable ozone-depleting properties, which never occurred to their originators in the 1930s, now overshadow all that's good about them. By the end of 1995, industry will halt the manufacture of CFCS in accordance with the international Montreal Protocol, a global response that anti-chlorine advocates view as an important precedent for their more ambitious goal of banning the industrial use of chlorine entirely.

"There are no uses of chlorine that we regard as safe," remarks Joe Thornton, a Greenpeace research analyst who in 1991 authored Greenpeace's case for a chlorine phaseout.

The above-noted "chemical black list" represents a tiny fraction of the chlorinated compounds in use. Even so, activists in Germany's Green Party and then at Greenpeace began, as Brad Lienhart puts it, "connecting the dots" between those few notorious chlorovillains and *all* chlorine-containing compounds. Even though the majority of chlorinated compounds have never been studied for their toxicological effects, Greenpeace views them as a single class of chemicals that should be considered unfit for commercial use until proven safe — a virtual impossibility, both scientifically and economically.

If Greenpeace were alone in its fight against chlorine, the Dows, Monsantos, and Du Ponts of the world might not have much to worry about. But the chemical industry decided that the call for a ban was more than environmentalist bravado when a normally conservative United States/Canadian commission, the International Joint Commission, officially announced comprehensive anti-chlorine recommendations to their respective governments in their biannual report of 1992.

The IJC's scientific panels and advisors convinced its six commissioners that chlorinated compounds are persistent enough in the Great Lakes region that a recommendation to phase them out is prudent. Although the Commission concedes that many of the synthetic chlorinated organic substances identified in the water, sediment, and biota of the region have not been identified as individually toxic, it concludes that many of these chemicals — because of their shared chemical characteristics — will be identified as persistent toxicants.

The IJC recommended in 1992 that the U.S. and Canada "develop timetables to sunset [phase out] the use of chlorine and chlorine-containing compounds as industrial feedstocks, and the means of reducing or eliminating other uses [such as water treatment and paper bleaching] be examined." Moreover, other "treaty" organizations

LARRY FORD

that oversee the use of international waters have articulated similar anti-chlorine positions.

"The IJC lit up our lives," says Nick Hinds, legislative director of Greenpeace's toxics campaign.

Despite rigorous lobbying by the CCC to stop lumping the entire menagerie of chlorine-containing compounds into one huge regulatory class, the IJC is standing firm. Its 1994 biannual report, issued following its most recent gathering in Windsor, Ontario, redoubled calls for sunsetting chlorine. Brad Lienhart, who participated in the IJC meeting, thinks that some gains were made despite the anti-chlorine message. The IJC's Virtual Elimination Task Force, which develops strategies to eventually eliminate all toxic inputs to the Great Lakes, agreed there is a need for "a thorough and complete analysis of chlorine chemistry before any schedule for sunsetting chlorine is implemented," Mr. Lienhart says. He believes such an analysis will vindicate much of chlorine chemistry as a sensible, environmentally responsible choice for manufacturers.

Following that mild concession by the IJC, though, another voice joined the anti-chlorine chorus. In early November, the American Public Health Association, which represents 50,000 public-health workers, registered some of the strongest anti-chlorine positions yet heard. A final draft of the APHA's position states "the only feasible and prudent approach to eliminating the release and discharge of chlorinated organic chemicals and consequent exposure is to avoid the use of chlorine and its compounds in manufacturing processes." The resolution concedes that not *all* uses of chlorine, especially such public-health uses as disinfecting drinking water and pharmaceutical production, have feasible alternatives — thereby implying that those uses of chlorine ought to be continued. But APHA calls for provisions to retrain workers displaced from a shrinking chlorine industry.

The cases for & against may rest on risk or benefit to society

LIKE LOOKING AT CLOUDS, BOTH SIDES CAN see what they want in existing data, or commission hand-picked scientists to do studies that lend credence to their respective interpretations.

Industry insider Brad Lienhart tirelessly points out that the many thousands of organochlorine compounds in use are chemically, physically, and biologically heterogeneous.

In lieu of objective scientific debate, methodological and philosophical issues are at the fore. One of the largest gulfs between the two camps centers on the unprecedented call to consider all chlorinated compounds in use as a single class subject to regulatory action. The case for banning all industrial uses of chlorine is easier to explain, which gives it a decided advantage over the more complicated argument of chlorine's defenders. The basic argument starts with reference to DDT, PCBS, dioxins, CFCS and a few other compounds that have documented effects. Next the argument points out that all of these compounds have one thing in common, namely, the presence of chlorine atoms in their molecular structures.

Finally, the argument takes an inferential step — and this is the precise point of contention. It concludes that, because of this commonality, all other chlorine compounds are suspected environmental and biological hazards. The concept of "reverse onus" would be applied to all chlorinated compounds: an assumption that they produce toxicity unless otherwise proved by the seller. Since chlorine detractors admit that most chlorine-dependent compounds have never been shown to have hazardous effects and have never even been studied, they refer to this conclusion as "the precautionary principle."

Another key component of the argument points to correlations between the presence of chlorinated organics in sediments, water basins, and tissues of animals and humans, on the one hand, and, on the other, incidences of wildlife population declines, reproductive and developmental anomalies in animals and people, and various diseases, including cancer. Theo Colborn, a Fellow at the World Wildlife Fund who chaired an often-cited gathering of toxicologists, ecologists, immunologists, and other scientists three years ago, said in an interview that "we have reached a point [of loading toxic synthetic chemicals in the environment and living tissue] that we ought to be con-

CHRISTOPHER HARTLOVE

cerned about releasing more."

The so-called "precautionary principle" is seductively simple. There are simply too many chlorinated compounds to study on a one-by-one basis to assess their safety. "There aren't enough rats in the world to assess individual compounds and what their combined effects might be," says Tufts University biologist Ana Soto, who is studying how compounds including PCBS can mimic the hormonal effects of estrogen.

Nevertheless, the pro-chlorine advocates assert that the only scientifically defensible way to ascertain chlorine's health and environmental effects is to do toxicological, epidemiological, and other studies of specific organochlorine chemicals. They point out that the scientific data simply does not exist to implicate any but a very few organochlorine compounds, such as DDT and PCBS — which have been studied for many years. Brad Lienhart tirelessly points out that the many thousands of organochlorine compounds in use cannot legitimately be thought of as a single class because they are chemically, physically, and biologically heterogeneous. Adds W. Joseph Stearns, Dow's director of chlorine issues: "The substantive part of this issue is that *some* organochlorines are persistent toxics, not that all organochlorines contain chlorine."

Indeed, many organochlorine compounds have short lifespans in the natural world. Mr. Stearns argues that to condemn any compound because it contains chlorine in its molecular structure will lead to a whole host of environmental regulations that the actual risks do not call for. And depriving society of thousands of useful, chlorine-based products without ascertaining if the risks are unacceptable, says the pro-chlorine camp, is a misguided formula that will greatly damage the nation's economic strength and standard of living.

Greenpeace's insistence that "substitutes exist" is misleading

CHLORINE'S DEFENDERS CAN POINT OUT the importance of its use in modern industrial chemistry, and try to explain the complex toxicological reasons why tens of thousands of compounds having nothing in common but chlorine should not be treated as a single class of chemicals. But their strongest argument may be that, while substitutes for chlorine and chlorinated compounds may exist in many cases, the costs to switch are prohibitive and the substitutes not necessarily any less risky.

Susan Sieber, a toxicologist and Deputy Director of the Division of Cancer Etiology at the National Cancer Institute, warns that hasty blanket bans can have the unwanted effect of pushing alternatives that are worse. "You need to assess the risks and benefits," she says.

Attempts at sober assessment that would fall between the two camps have begun in earnest. One example is a 180-page report that the M.I.T. Program in Technology, Business and Environment prepared for the Norwegian government and European industry groups. The report begins the daunting task of assessing the economic, social, and environmental costs and gains of non-chlorine substitutes, focusing on several areas including cleaning solvents in the electronics industry, polyvinylchloride (PVC) plastic, chlorinated pesticides, and chlorine-based bleaching agents.

The report notes that a trend toward chlorine-free bleaching technologies in the paper industry shows that major categories of chlorine use are *not* absolutely necessary for the industries that have been heavy chlorine users. "This suggests that concerns over the unavailability of such alternatives in other cases of chlorine use may be overblown," concludes the summary of the report's findings.

Availability of substitutes, however, is only part of the story. Among the big caveats:

✦ Substitutes carry their own environmental and health effects. For example, water-based substitutes for CFCS in the electronics industry add a new source of water pollution. The return of hydrocarbon coolants and insulating fluids for electrical transformers has brought back the fire hazards that PCBS had virtually eliminated.

✦ Chlorine-based technologies themselves may have been less hazardous replacements for nastier technologies. A

LETTER TO THE EDITOR

Natural Source of Organochlorides

IMMENSE QUANTITIES OF ORGANOCHLORINES and other organohalogen chemicals occur naturally in our biosphere — nearly 2,000 different compounds at last count, 700 of which were discovered in the last 10 years alone — with new examples being isolated and identified regularly ("Organochlorines lace Inuit breast milk," SN: 2/12/94, p. 111).

For example, nearly 100 different natural halogen compounds are present in one species of edible Hawaiian seaweed, and one species of Florida Gulf acorn worm produces 20 different organohalogen compounds. Some 5 million tons of natural methyl chloride are produced by the biomass annually, dwarfing the 26,000 tons of emissions produced by humans. Tetrachloroethylene, chloroform, carbon tetrachloride, methylene chloride, and several natural CFCS have been detected in the emissions of the Santiaguito volcano of Guatemala and the Kamchatka volcanoes of Siberia. Previously unknown PCB isomers were discovered in Mount St. Helens' volcanic ash.

Obviously, not all of these halogen sources add significantly to the total halogen content of the biosphere, but many do. In any event, chlorine is as natural to our world as carbon, oxygen, and hydrogen.

— *Gordon W. Gribble*
Professor of Chemistry
Dartmouth College, Hanover, N.H.

chlorine-dependent route to titanium dioxide, a widely used pigment in white paint, replaced the dangerous lead-based pigments that contributed to a public-health calamity. The chlorine-dependent process produces one-sixth the hazardous waste of an alternative process that relies on sulfuric acid.

✦ Affordable alternatives that can perform as well as the chlorine-dependent product may not exist. In these cases, technological innovation and development can take a long time, at great cost. The report cites the absence of any drop-in replacements for CFCs that automakers could use for air conditioning systems of cars after the CFC ban goes into effect.

Few see the whole picture, but legislators and user groups have begun to react

GREENPEACE BELIEVES IT HAS INDUSTRY on the run. "The writing is on the wall," says Jay Palter, Toronto director of the group's Chlorine Free campaign. "A chlorine phase-out is inevitable and industry is just stalling for time."

Industry representatives don't see it that way. "Greenpeace is not fundamentally changing the way we do business," says Michael W. Berezo, director of environmental strategy for Monsanto. At the moment, neither EPA nor its Canadian counterpart, Environment Canada, has accepted the notion that all chlorine compounds ought to be regulated or phased out as a class. Berezo does concede that the ascent of the chlorine issue is pushing Monsanto and other companies to look more aggressively at alternatives to chlorine-containing chemicals. But industry's dilemmas lack easy answers.

Specific user groups have begun to wrestle with the chlorine issue as it affects them. The Jan/Feb '94 issue of the newsletter *Environment Building News* ran a 10-page article titled "Should We Phase Out PVC?" The report makes a Herculean effort to integrate the available information on PVC's benefits and the dangers stemming from its manufacture into a picture that might guide its readers. After concluding that its account left more questions than answers, the article counseled the 1,200 builders and architects who subscribe to the newsletter to "seek out better, safer, and more environmentally responsible alternatives" to polyvinylchloride — without actually suggesting that readers completely avoid vinyl materials. PVC accounts for more than a quarter of worldwide chlorine use, so such recommendations can have far-reaching effects.

Perhaps the most newsworthy feature of the chlorine controversy is that it has progressed to the point where a ban is being taken seriously by governments and industry. And even if the meteor of a ban is deflected by pragmatic concerns, chlorine chemistry may be forever changed by an asteroid shower of legislation. In October, Rep. Bill Richardson (D-NM) delighted environmentalists by reintroducing a bill that would legislate chlorine out of the pulp and paper industry within five years. In October, the Clinton administration nearly issued an executive order that would have mandated government to buy paper made without chlorine. (The requirement didn't make it into the final order.)

Even a year ago, engineering professor David Marks, who is coordinating M.I.T.'s $1.8 million cross-disciplinary study of chlorine, thought the anti-chlorine movement couldn't box its way out of an unbleached paper bag. Now he wonders. "The chlorine industry could wake up one day and see many anti-chlorine bills on the table in Congress," he warns. "Things are moving so fast, it's hard to tell how it will end up."

Industry is well aware how quickly a few Bella Abzugs can alter public perception. Despite the difficulties in switching to chlorine-free production, progressive companies are eyeing such strategies as pollution prevention and substitution to preempt future, more costly adjustments. Truly farsighted companies aim to turn anti-chlorine sentiment into a market. Dow has created a new business entity called Advanced Cleaning Systems, which provides water-based cleaning technology and support services for green industrial niches. And Louisiana Pacific, one of the country's largest paper manufacturers, is trumpeting its new chlorine-free bleaching process at a plant in Samoa, California.

Should there be a chlorine phaseout, it would probably occur in a piecemeal fashion, hopping from product category to product category. Both sides will continue to debate the data on what effects chlorinated compounds have on the environment and human health. But it seems quite possible that even without government-imposed limits, public perception and the market forces that follow from it will dictate the future of chlorine's role in industry and society.

The editors wish to thank Dr. Steven Safe of Texas A&M University, and organic chemist Dr. Albert Dittman, for providing technical review of this article.

LETTER TO THE EDITOR

Let's Ban Oxygen, Too

I READ THAT GREENPEACE AND OTHER ENVIRONMENTAL organizations propose the banning of all compounds that contain the element chlorine. In the same spirit, I believe all compounds containing the element oxygen should also be banned, because such well-known components of smog as ozone, carbon monoxide, and nitrogen oxides all contain oxygen. I am starting a new grassroots campaign to support this worthy cause. It will be called No Oxygen (NO), and our slogan will be "Just Say NO."

— *T.S. Benedict Yen, Dept. of Pathology Univ. of California, San Francisco*

Chlorine Chemistry and Products

The Chlorine Tree*

Industry makes elemental chlorine by passing an electrical current through brine, converting the solution's sodium and chloride ions into chlorine gas and sodium hydroxide (see other side).

Chlorine defenders point to the tree as an almost self-explanatory argument against any blanket ban. Anti-chlorine advocates counter that substitutes for much of chlorine's uses are available.

CHLORINE

- Vinyl chloride → Polyvinyl chloride
- Vinylidene chloride → Polyvinylidene chloride
- Dichloroethyl ether → High-grade lubrication oils; Vinyl ether; Paints, varnishes, and lacquers → Plastic (clear plastic bottles); Anesthetic
- Methyl chloride
  - → Chlorosilanes → Semiconductors
  - → Methylcellulose
  - → Silicones → Medical devices, surgical membranes; Polishes, waxes; Encapsulation of electronic parts; Water repellent coatings; Various home use caulking and sealing compounds; Cosmetics and pharmaceuticals
- Ethyl chloride → Ethylcellulose
- Ethylene dichloride → Ethylene Diamine → Paper chemicals; Softeners; Additives for oil, detergents
- Methylene chloride; Chloroform; Carbon tetrachloride
- Water treatment → Sanitizing and disinfecting agent for municipal water supplies; Water and sewage treatment
- Allyl chloride → Epichlorohydrin → Epoxy resins; Polymers - water treatment, wet strength resins; Glycerin
- Paper and pulp
- Benzoyl chloride; Chlorotoluenes, chlorophenol; Benzotrichloride; Parachlorobenzotrifluoride; Dichlorobenzene → Plastics; Pharmaceuticals; Perfume bases; Sunscreen; Dyes; Initiators and stabilizers for plastics; Crop protection chemicals; Cosmetics; Food bleaches
- Chloroprene → Neoprene
- Dichlorophenyl sulfone → Polysulfone → Computer components; Power tool housings; Appliance housings; Electronic parts; Pipe and sheets
- Phosgene → Polyurethane
- Propylene chlorohydrin
  - → Propylene oxide → Polyurethane
  - → Propylene glycols
  - → Hydroxypropylacrylate → Coatings
  - → Polypropylene glycols → Lubricants; Metal working fluids; Rubber; Plastics
  - → Propylene glycol ethers → Lubricants; Metal working fluids; Rubber; Plastics
  - → Isopropanolamines

SOURCE: Charles River Associates, 1993.

* Compounds on the far right are not derived directly from elemental chlorine — chlorine plays a role in their manufacture.

Luggage, handbags, and umbrellas
Watch straps and billfolds
Shoes and belts
Textile fabric coatings and paper coating
Raincoats, rainsuits, and parkas
Magnetic recording tape
Golf bags and recreational equipment, toys
Exercise equipment pad coverings
Inflatable boats and water floats
Baby strollers, bibs, crib bumper pads, and mattress covers
Card tables and chairs
Woodgrain vinyl coating for stereo cabinets, radio and TV cabinets, TV carts, bookshelves, table tops, and counters
Cases for cosmetics, cameras, binoculars, hunting rifles, and musical instruments
Container for food products, cosmetics, toiletries, and household chemicals
Swimming pool liners and covers
Garden hoses and lawn furniture
School and office supplies such as ring binder covers, pencil cases, book totes
Floor coverings and decorative molding strips
Wallpaper
Siding, gutters, and gutter leaf guards
Window and door frames
Pipe and fittings; domestic, commercial, industrial
Film and sheeting
Solar reflective film
Electrical insulation for wire and cable
Adhesive and bonding agent base for synthetic turf
Automobile vinyl tops, upholstery, floor mats
Seat coverings
Electrical and decorative vinyl tapes

Pipe and fittings for sewer service
Packaging for food products, especially meats and poultry
Multiwall bags
Seat covers and upholstery
Fibers and bristles
Latex coatings

Thickening agent for foods and nonfoods

Time-release pharmaceuticals
Water treatment
Inks
Coatings

Topical anesthetic
Nonstick cookware
Plastic processing
Photographic chemicals
Pharmaceuticals, cosmetics
Paint removers, process solvents
Dry cleaning
Adhesives
Corrosion resistant plastics
Refrigerants
Aerosols

Coatings for aluminum cans
Surface coatings on autos, appliances, equipment
P.C. boards, composites
Household adhesives and glue for metals, glass, and ceramics

..rmaceuticals
..oisturizing compounds

Newspaper, copy paper, writing paper
Coffee filters
Tissue
Paper towels
Computer paper
Printing paper (books, magazines, reports, calendars, etc.)

Oil resistant auto components
Carpet backing and seat cushions
Wire coating and electrical components
Shoe soles

Pharmaceuticals
Crop protection chemicals
Intermediates

Polycarbonates

Bulletproof "glass"
Windows on buses, trains, subways, aircraft, buildings
Household appliance housings
Compact discs
Protective helmets and face shields
Containers
Automotive and electrical components

Shoe uppers and heels
Auto bumpers and fenders
Insulation
Brush bristles and spandex fibers
Adhesives
Sealants and caulking agents
Paints, varnishes, and coatings
Foam cushions, mattresses

Plastics
Solvents
Coatings, paint
Food additives
Plasticizers
Antifreeze and coolants
Flavoring extracts
Soft-drink syrups
Lotions/creams, suntan lotions
Brake fluids
Pharmaceuticals
Crop protection chemicals
Natural gas treatment

Coatings
Paints
Solvents
Cleaners
Intermediates
Brake fluids
Mining chemicals

Adhesives
Coatings
Corrosion inhibitors
Cosmetics/personal care products
Crop protection chemicals
Neutralizing agents
Plastics
Surfactants

Hydroch

Methyl cl
Chloroac

Trichlor

Tetrachl
anhydrid

Chlorina
paraffins

Sulfur di
Sulfur m
Thionyl c
Sulfuryl c

Pl
Phosphor
Phosphor

Ferric ch

Stannous

Zinc chlo

Other m

Chlorina

Sodium

Calcium

1, 1, 1 Tr
Perchlor
Methylen
Trichloro

Titanium

- **Hydrochloric acid**
  - Food processing
    - Sugar refining
    - Corn syrup
    - Gelatin
    - Monosodium glutamate
    - Brewing
  - Desulfurization agent for petroleum
  - Production of alkyl chlorides
    - Electronic silicone
  - Oil well acidizing
  - Production of metallic chlorides
    - Catalysts
    - Photoflash bulbs
    - Refractories
    - Alloys
    - Pyrotechnics
  - Pickling in steel manufacture
  - Water treatment
  - Production of hydrochlorides
    - Rubber accelerator
    - Plastics stabilizer
    - Rocket propellants
    - Pharmaceuticals
  - Latex coagulating agent
- **Methyl chloroacetate, Chloroacetic acid**
  - Polymers, ion exchange resins
  - Permanent wave solutions, hair care products
  - Crop protection chemicals
  - Synthetic caffeine, vitamins
  - Vinyl stabilizer
  - Pharmaceuticals
  - Thickeners, food additives
- **Trichloroacetaldehyde**
  - Liniments
  - Pharmaceuticals
- **Tetrachlorophthalic anhydride**
  - Flame retardants
- **Chlorinated olefins and paraffins**
  - Cable insulation
  - Highway stripe paint
  - High-pressure lubricants
  - Flame retardants
  - Plasticizers for polyvinyl chloride
  - Detergents
- **Sulfur dichloride, Sulfur monochloride, Thionyl chloride, Sulfuryl chloride**
  - Photographic chemicals, dyes
  - Intermediates
  - Rubber antioxidants
  - Purifying sugar juices
  - Bandaids
  - Erasers
  - Oil additives
  - Pacemaker batteries
  - Crop protection chemicals
- **Phosphorus trichloride, Phosphorus pentachloride, Phosphorus oxychloride**
  - Gasoline additives, hydraulic fluids
  - Intermediates
  - Semiconductor manufacture
  - Fire-retarding agents
  - Crop protection chemicals
- **Ferric chloride**
  - Photography, etching and engraving
  - Water treatment
  - Printed circuitry
  - Pharmaceuticals
- **Stannous chloride**
  - Silvering mirrors
  - Stabilizer for perfume in soaps
- **Zinc chloride**
  - Soldering fluxes
  - Deodorant preparations
  - Dental cements and dentifrices
- **Other metal chlorides**
  - Catalysts
- **Chlorinated isocyanurates**
  - Sanitizers for swimming pools
  - Household and commercial bleaches
  - Detergents for automatic dishwashers
  - Scouring powders
- **Sodium hypochlorite**
  - Bleaching pulp, paper, and textiles
  - Water purification
  - Pharmaceuticals
  - Household bleach
  - Disinfectant for swimming pools
- **Calcium hypochlorite**
  - Algaecide, bactericide
  - Deodorant
  - Potable water purification
  - Disinfectant for swimming pools
- **1, 1, 1 Trichloroethane, Perchloronethylene, Methylene chloride, Trichloroethylene**
  - Paper de-inker
  - Transformer fluid
  - Circuit boards
  - Drain cleaners
  - Textile manufacture
  - Leather finishing
  - Pigments
  - Dyes
  - Refrigerants
  - Spot remover
  - Crop protection chemicals
  - Solvents
  - Adhesives
  - Degreaser
  - Dry cleaning agents
- **Titanium dioxide**
  - Electrical components
  - Semiconductors
  - Corrosion-resistant paint
  - Synthetic gemstones
  - Catalyst
  - Paint pigment, opacifiers
  - Titanium metal

MATERIAL SAFETY DATA SHEET
ALL PURE BLEACH

SECTION I - Product Identification

MANUFACTURERS NAME : ALL PURE CHEMICAL COMPANY
EMERGENCY TEL. NO. : (209)835-5343
PREPARATION DATE : 04/29/86
INFORMATION TEL. NO. : (209)835-5343
PRODUCT NUMBER : 00464
PRODUCT NAME : ALL PURE BLEACH
PRODUCT CLASS : NONE

SECTION II - Hazardous Components

SODIUM HYPOCHLORITE

SECTION III - Physical Data

BOILING RANGE : 230F   VAPOUR DENSITY(AIR=1) : NA
EVAPORATION RATE: 1   VOLATILE VOLUME : 95.0   WT/GAL: NA
OTHER PROPERTIES :
YELLOWISH LIQUID,SLIGHTLY HEAVIER THAN WATER W/MILD CHLORINE ODOR

SECTION IV - Fire and Explosion Hazard Data

SPECIAL PRECAUTIONS :
CLOSED CONT;AWAY FROM CLOTH&COMBUST MATL;EMPTY CONT HAZ RESIDUES

SECTION V - Health Hazard Data

DISPOSAL PROCEDURE :
FLUSH IN SAN SEWER/NOT IN LAKES,ETC; AWAY FROM FOOD OR FEED
OTHER PRECAUTIONS : NONE

SECTION VI - Reactivity Data

RESPIRATORY PROTECTION : NONE UNLESS FIRE
VENTILATION : NDA
SKIN PROTECTION :
POLYVINYL CHLORIDE-ALCOHOL/HEOPRENE/BUTYL-NATURAL RUBBER/POLYETHYLENE
EYE PROTECTION :
SAFETY GLASSES/FACE SHIELD/GOGGLES
OTHER PROTECTIVE EQUIPMENT :
RUBBER BOOTS/APRON-WEAR PROT CLOTH WHEN DISPERSING LG SPILL
HYGIENIC PRACTICES : NONE

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SECTION VII - Spill and Disposal Procedures

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FLAMMABILITY CLASSIFICATION : NONE
FLASH POINT : NA
FLAMMABLE LIMITS UPPER - NA LOWER - NA
EXTINGUISHING MEDIA : NA
UNUSUAL FIRE AND EXPLOSION HAZARDS :
HEAT=TOXIC FUMES;REACTS W/ACIDS;REMOVE CONTAINERS FROM FIRE AREA IF POSS
SPECIAL FIRE-FIGHTING PROCEDURES : NA

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SECTION VIII - Protective Equipment

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STABILITY : UNSTABLE
HAZARDOUS POLYMERIZATION : WILL NOT OCCUR
HAZARDOUS DECOMPOSITION PRODUCTS :
CHLORINE AND OTHER HAZARDOUS GASES
CONDITIONS TO AVOID : HEAT
INCOMPATIBILITY (MATERIALS TO AVOID) : STRONG
ACIDS/OXIDIZERS/AMMONIA/FECES/URINE/PAINT/KEROSENE/THINNERS/SHELLAC...

==

SECTION IX - Storage and Handling Precautions

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EFFECTS OF OVEREXPOSURE :
EYE/SEVERE IRR;SKIN/IRR
MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE :
NONE
PRIMARY ROUTE(S) OF ENTRY : EYE/SKIN/INGEST/INHALE
EMERGENCY AND FIRST AID PROCEDURES :
SEE DR;EYE/FLUSH UNDER LIDS W/WATER 15 MIN STAT;SKIN/WASH
W/SOAP&WATER;INGEST
DO NOT INDUCE-GIVE GELATIN/MILK/H2O/KEEP WARM/NO ACIDS;INHALE/FRESH AIR

==

SECTION X - Transportation Data and Additional Information

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N/A

(TM) and (R) : Registered Trademarks
N/A = Not Applicable OR Not Available
The information published in this Material Safety Data Sheet has been compiled from our experience and data presented in various technical publications. It is the user's responsibility to determine the suitability of this information for adoption of necessary safety precautions. We reserve the right to revise Material Safety Data Sheets periodically as new information becomes available.

CHLORINE REFERENCES

AU: Bartlett,-F.M.
TI: Listeria monocytogenes survival on shell eggs and resistance to sodium hypochlorite.
SO: J-food-saf. Trumbull, Conn. : Food & Nutrition Press. Dec 1993. v. 13 (4) p. 253-261.
CN: DNAL TP373.5.J62
AB: The survival of a mixture of five strains of Listeria monocytogenes inoculated onto the surface of chicken eggs and stored at 10 C for up to 14 days was studied. The numbers of survivors which were loosely bound to the shell decreased steadily from day 1 to 7, with no detectable Listeria after 11 days. Application of sodium hypochlorite solutions (50 ppm and 100 ppm available chlorine) to inoculated eggs completely eliminated the loosely bound cells after the shortest exposure time used (30 s), while little or no decrease was observed for the cells which were more strongly attached, even after 5 min.

AU: Mbithi,-J.N.; Springthorpe,-V.S.; Sattar,-S.A.
TI: Comparative in vivo efficiencies of hand-washing agents against hepatitis A virus (HM-175) and poliovirus type 1 (Sabin).
SO: Appl-environ-microbiol. Washington : American Society for Microbiology. Oct 1993. v. 59 (10) p. 3463-3469.
CN: DNAL 448.3-Ap5
AB: The abilities of 10 hygienic hand-washing agents and tap water (containing approximately 0.5 ppm of free chlorine) to eliminate strain HM-175 of hepatitis A virus (HAV) and poliovirus (PV) type 1 (Sabin) were compared by using finger pad and whole-hand protocols with three adult volunteers. In the finger pad protocol, an unmedicated liquid soap was the least effective agent (77.96% +/- 7.17% reduction) for removing HAV, and a medicated liquid soap was the most effective agent (92.04% +/- 4.02% reduction) for reducing the HAV titer; the smallest reduction in PV titer was obtained with tap water (85.22% +/- 2.91% reduction), and the same medicated soap was the most effective agent against PV (98.39% +/- 1.98% reduction).

AU: Grubinger,-V.
TI: Water chlorination for postharvest vegetable treatment.
SO: Grower. Storrs, Conn. : Cooperative Extension Service, U.S. Department of Agriculture, College of Agriculture and Natural Resources, The University of Connecticut,. June 1993. v. 93 (6) p. 4-5.
CN: DNAL SB321.G85

AU: Waldroup,-A.L.
TI: Summary of work to control pathogens in poultry processing.
SO: Poultry-sci. Champaign, IL : Poultry Science Association, 1921-. June 1993. v. 72 (6) p. 1177-1179.
CN: DNAL 47.8-Am33P
AB: The National Broiler Council and Southeastern Poultry and Egg Association sponsored a study to determine whether various processing modifications would significantly alter the microflora of processed broilers.

AU: Kupferman,-E.M.
TI: Update on the use of chlorine.
SO: Tree-Fruit-Postharvest-J. Pullman, Wash. : Washington State University Cooperative Extension. June 1992. v. 3 (2) p. 12.
CN: DNAL TP440.P67

AU: Lillard,-H.S.
TI: Bactericidal effect of chlorine on attached salmonellae with and without sonification.
SO: J-Food-Prot. Des Moines, Iowa : International Association of Milk, Food, and Environmental Sanitarians. Aug 1993. v. 56 (8) p. 716-719.
CN: DNAL 44.8-J824
AB: Broiler breast skin was immersed in a Salmonella typhimurium cell suspension for 0.25, 30, or 60 min, then i) shaken for 1 min or stirred for 30 min in a Cl2 solution with 0.5 ppm free residual Cl2 and ii) sonified for 15 or 30 min with or without chlorine (0.5 ppm free residual). Data showed that attached/entrapped salmonellae are not readily accessible to chlorine. Salmonellae were reduced by <1 log10 by chlorine.

Sonification of skin in a chlorine solution was the most effective treatment which reduced Salmonella counts by 2.44 to 3.93 logs.

AU: Sallam,-S.S.; Donnelly,-C.W.
TI: Destruction, injury, and repair of Listeria species exposed to sanitizing compounds.
SO: J-Food-Prot. Des Moines, Iowa : International Association of Milk, Food, and Environmental Sanitarians. Oct 1992. v. 55 (10) p. 771-776.
CN: DNAL 44.8-J824
AB: The efficacy of four commonly used dairy plant sanitizers against Listeria coupled with an examination of ability of these sanitizers to induce injury was investigated. Listeria monocytogenes F 5069, F 5027, and Listeria innocua CWD 350 were tested against different concentrations of sanitizers (for periods of 30 s and 2 min) which included two quaternary ammonium compounds (QAC), an acid anionic sanitizer, and a chlorine-containing sanitizer. The extent of cell death, injury, and repair was found to be affected by the type and concentration of sanitizer, exposure time, bacterial strain, and the enrichment procedure. QAC were the most effective while the acid anionic sanitizer was the least effective. The lethal effect of the sanitizer was found to increase by increasing its concentration or exposure time.

AU: Emswiler-Rose-B.; Kotula,-A.W.
TI: Inhibition of bacterial growth by two chlorine sources in a model system.
SO: J-Food-Sci-Off-Publ-Inst-Food-Technol. Chicago, Il. : The Institute. May/June 1984. v. 49 (3) p. 931-933.
CN: DNAL 389.8-F7322

AU: Dickson,-J.S.; Anderson,-M.E.
TI: Microbiological decontamination of food animal carcasses by washing and sanitizing systems: a review.
SO: J-Food-Prot. Ames, Iowa : International Association of Milk, Food, and Environmental Sanitarians. Feb 1992. v. 55 (2) p. 133-140.
CN: DNAL 44.8-J824
AB: Microbial contamination of animal carcasses is a result of the necessary procedures required to process live animals into retail meat. A variety of methods have been developed to reduce the levels of contaminating bacteria on carcasses, although most of the current methods focus on washing and sanitizing procedures. The commonly used sanitizing agents include hot water, chlorine, and short-chain organic acids. The consensus of the research is that carcass sanitizing can reduce the initial levels of bacteria on the surface of the carcass.

AU: Overdahl,-B.J.; Zottola,-E.A.
TI: Evaluation of selected sanitizers to control bacteria in a simulated sweet water coolant system.
SO: J-Food-Prot. Ames, Iowa : International Association of Milk, Food, and Environmental Sanitarians. Apr 1991. v. 54 (4) p. 305-307. charts.
CN: DNAL 44.8-J824
AB: Three types of sanitizers commonly used in dairy processing plants were evaluated at varying concentrations and at 25 and 4 degrees C for their ability to control potential spoilage and pathogenic bacteria in water. Test organisms included Pseudomonas fluorescens, Staphylococcus haemolyticus, and Bacillus spp. All three organisms were reduced >90% at both test temperatures with concentrations of 25 ppm chlorine, 12.5 ppm iodine, or 20 ppm QAC.

AU: Beuchat,-L.R.; Brackett,-R.E.
TI: Survival and growth of Listeria monocytogenes on lettuce as influenced by shredding, chlorine treatment, modified atmosphere packaging and temperature.
SO: J-Food-Sci-Off-Publ-Inst-Food-Technol. Chicago, Ill. : The Institute. May/June 1990. v. 55 (3) p. 755-758, 870.
CN: DNAL 389.8-F7322
AB: The effects of shredding, chlorine treatment and modified atmosphere packaging on survival and growth of Listeria monocytogenes, mesophilic aerobes, psychrotrophs and yeasts and molds on lettuce stored at 5 degrees C and 10 degrees C were determined. Significant increases occurred within 3 days when lettuce was stored at 10 degrees C; after 10 days, populations reached 10(8)-10(9) CFU/g. Chlorine treatment, modified atmosphere (3% O_2, 97% N_2) and shredding did not influence growth of L. monocytogenes. It was concluded that L. monocytogenes is capable of growing on lettuce subjected to commonly used packaging and distribution procedures used in the food industry.

MATERIAL SAFETY DATA SHEET CHLORINE

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SECTION I - Product Identification

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PRODUCT NAME: CHLORINE
MANUFACTURERS NAME : CHEMCENTRAL
COMPANY NAME: PENNWALT CORPORATION
EMERGENCY TEL. NO. : (503)286-5821
DATE: 3/10/88
EMERGENCY TEL. NO. : (503)238-7230
CAS #: 7782-50-5
SYNONYMS:
PRODUCT CLASS : HYDROCARBON/KETONES BLEND

PREPARATION DATE : 03/31/86
PRODUCT NUMBER : 00156
PRODUCT NAME : #1 LACQUER SOLVENT

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SECTION II - Hazardous Components

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CHLORINE 99% TOXIC
KETONE
CORROSIVE COMPRESSED GAS
ALIPHATICS
AROMATICS

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SECTION III - Physical Data

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BOILING RANGE : 133-219 F VAPOUR DENSITY(AIR=1) : >1
EVAPORATION RATE: UNKN VOLATILE VOLUME : 100 WT/GAL: UNKN
EVAPORATION RATE: >.21->11.6 VOLATILE VOLUME : 100 WT/GAL: NA
OTHER PROPERTIES :
GREENISH-YELLOW GAS-SHARPLYPENETRATING ODOR SIMILAR TO BLEACH-PUNGENT
WATER WHITE - PUNGENT ODOR

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SECTION IV - Fire and Explosion Hazard Data

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FLAMMABILITY CLASSIFICATION : UNKN
FLASH POINT : UNKN
FLAMMABLE LIMITS UPPER - UNKN LOWER - UNKN
EXTINGUISHING MEDIA :
EXCLUDE AIR- USE FOAM, CARBON DIOXIDE, DRY CHEMICAL, WATER FOG
UNUSUAL FIRE AND EXPLOSION HAZARDS :
MANY METALS IGNITE IN PRESENCE OF CHLORINE-FIRE/EXPLOSION UPON CONTACT W/ETHR
TURPENTINE, AMMONIA, HYDROCARBONS, FINELY DIVIDED METALS OR OTHER
FLAMMABLES
SPECIAL FIRE-FIGHTING PROCEDURES :
RESPIRATION EQUIP TO AVOID INHALATION OF CONCENTRATED VAPORS
REM CONTAINERS FROM FIRE ZONE IF POSS-WATER TO COOL THEM UNLESS CHLORINE IS
ESCAPING THEN USE SELF CONTAINED BREATHING APP W/FIRE TURNOUT CLOTHING

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SECTION V - Health Hazard Data

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EFFECTS OF OVEREXPOSURE :

BLINDNESS, CORROSIVE-LIQUID AND GASS CAPABLE OF CAUSING A BURN
MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE :
PRIMARY ROUTE(S) OF ENTRY : INGEST, SKIN/EYE CONTACT, INHALE
EMERGENCY AND FIRST AID PROCEDURES :
INGEST-GIVE LOTS WATER INDUCE VOMITING SEE DR; SKIN-WASH S/W SEE DR; EYES-FLUSH 15 MIN SEE DR; INHALE-GET FRESH AIR-CPR IF NEEDED, SEE DR

SECTION VI - Reactivity Data

STABILITY : STABLE
HAZARDOUS POLYMERIZATION : WILL NOT OCCUR
HAZARDOUS DECOMPOSITION PRODUCTS : IS AN ELEMENT CANNOT DECOMPOSE
CONDITIONS TO AVOID : HEAT
INCOMPATIBILITY (MATERIALS TO AVOID) : SEE UNUSUAL FIRE/EXPLOSION HAZARDS

SECTION VII - Spill and Disposal Procedures

SPECIAL PRECAUTIONS :
NOT ON SKIN, EYES, CLOTHING, DON'T BREATH VAPORS, MIST, DUST, GAS
DISPOSAL PROCEDURE :
CONSULT LOCAL, STATE OR FEDERAL AUTHORITIES FOR DISPOSAL PROCEDURES
OTHER PRECAUTIONS :
KEEP UPWIND, EVACUATE ENCLOSED SPACE

SECTION VIII - Protective Equipment

RESPIRATORY PROTECTION :
25PPM CHEMICAL CART RESP W/FULL FACEPEICE/OR SELF CONTAINED BREATHING APP
VENTILATION :
TO CONTROL BELOW PEL - CHLORINE HEAVIER THAN AIR-TENDS TO COLL @ GROUND LEVEL
SKIN PROTECTION : PLASTIC OR RUBBER NON-PORUS
EYE PROTECTION :
ALWAYS WEAR GOGGLES EVEN W/FACE SHIELD
OTHER PROTECTIVE EQUIPMENT :
PROTECTIVE CLOTHING TO LIQUID CHLORINE/HI CONC GAS-OPEN-FIRE TURN-OUT CLOTHIN
HYGIENIC PRACTICES :
WASH THROUGHLY AFTER HANDLING

SECTION IX - Storage and Handling Precautions

SECTION X - Transportation Data and Additional Information

N/A