Acid-Activated Bentonite

Livestock

Identification of Petitioned Substance

Chemical Names:
Acid-activated bentonite

Other Name:
Acid-activated clay
Acid-activated bleaching earth
Sulfuric acid clay

Trade Names:
Poultry Guard®

CAS Numbers:
98561-46-7

Other Codes:
none

Summary of Petitioned Use

Acid-activated bentonite is a synthetic substance petitioned for addition to 7 CFR 205.603 as a poultry litter treatment. The primary intended use of the petitioned substance is to reduce the level of ammonia generated by certain urease-producing bacteria commonly found in poultry litter. Acid-activated bentonite sequesters the gaseous ammonia so that the ammonia does not pose negative health risks to poultry and will not escape into the atmosphere. The petitioned substance is not intended to be added to feed.

Characterization of Petitioned Substance

<u>Composition of the Substance:</u>
The petitioned acid-activated bentonite substance is a granular clay material impregnated with sulfuric acid (40-50% by weight). The clay, bentonite, is in the smectite group of clays which are described as 2:1 layer silicates. This signifies that their structure is made up of two sheets of silicon-oxygen tetrahedrons that sandwich a single alumina octahedral sheet. Exchangeable cations and water molecules are loosely held between these sets of three sheets. See Evaluation Question 2, Figure 1 for the structure. Tables 1 and 2 below show typical chemical compositions of bentonite prior to activation.

Table 1. Typical composition of bentonite clay (mass %) for constituents with a presence larger than 1%. (Rameback, et al. 1999)

SiO_2	61-64
Al_2O_3	20-21
CaO	1.2-1.4
Fe_2O_3	3.8-3.9
MgO	2.4-3.7
Na_2O	2.1-2.4
Loss On Ignition*	5.2-6.3

*Loss on ignition represents carbonates, sulfides, sulfates and crystal water.

Table 2. Mineral composition of bentonite clay (mass %). (Ramebäck, et al. 1999)

Montmorillonite	75
Quartz	15
Mica	<1
Feldspar	5 - 8

Carbonate	1.4
Coalinites	<1
Pyrite	0.3
Other minerals	2
Organic carbon	0.4

Acid activation of the bentonite clay maintains the layered structure, but changes its physical and chemical properties by replacing cations at the edges and within the lattice with hydrogen ions (Enslin, van der Mey and Waanders 2010).

Source or Origin of the Substance:

Acid-activated bentonite as petitioned is produced by treating bentonite clay with sulfuric acid. The purpose of the acid treatment is to increase the surface area of the clay, which improves the adsorption and catalytic properties of the clay (Tyagi, Chudasama and Jasra 2006).

Bentonite (CAS #1302-78-9) is a soft light-colored rock composed primarily of clay minerals of the smectite group, primarily montmorillonite, which is formed from volcanic ash under marine or hydrothermic conditions (Clay Minerals Society 2015). Bentonite deposits are typically obtained by quarrying.

Sulfuric acid (CAS #7664-93-9) is commercially manufactured from sulfur dioxide, which is a byproduct of industrial pollution control systems. The manufacturing process involves a two-step chemical reaction using oxygen, water, and a vanadium oxide catalyst.

Properties of the Substance:

The physical state of the substance is solid and appears as dark granules.

Acid-activated bentonite is highly acidic. The exact pH level of the activated substance depends on the conditions of the acid activation, but it is generally below 1.5 (Taylor 1999). The petitioner describes the typical pH of the petitioned substance as 0.43 (5% slurry in deionized water). The Material Safety Data Sheet (MSDS) for Poultry Guard® provided by the petitioner identifies a pH of 0.6. The substance has a slight odor due to its acidity.

The specific surface area of acid-activated bentonite is 150–350 m^2/g (Baranowsky, et al. 2001).

Specific Uses of the Substance:

The petitioned substance is intended to be used as a poultry litter treatment for the purpose of reducing ammonia volatilization and sequestering gaseous ammonia. Poultry litter is composed of bedding material, excreta, feathers, wasted feed and wasted water. The litter mixture represents a significant source of ammonia emissions due to the breakdown of uric acid and organic nitrogen. Atmospheric ammonia is detrimental to poultry welfare (Miles, Branton and Lott 2004). To control ammonia volatilization, acid-activated bentonite is applied to poultry litter. Specific application methods are dependent on house conditions such as ventilation control and litter moisture levels (Blake and Hess 2001).

Use instructions for Poultry Guard® state that the product should be applied directly over the surface of the poultry litter in an even layer. Application is typically done three days prior to bird placement in the house, but can be done up to the day of placement. The substance can be applied by hand (gloved) broadcasting or by properly calibrated mechanically propelled push cart, tractor-mounted spinner, or drop-type fertilizer spreaders (McWard and Taylor 2000).

In general, application rates are between 50-100 lbs/1,000 ft^2, depending on the ammonia conditions and the age of the litter (Blake and Hess 2001). "Cake" is the clumping of litter as it retains moisture over time.

Use instructions for Poultry Guard® state that an application rate of 50 lbs/1,000 ft^2 should be used in ideal situations (e.g., when litter is less than a year old, with cake being taken out in between flocks), and a rate of 75 lbs/1,000 ft^2 should be used when litter is greater than a year old, or if conditions exist that increase the ammonia challenge, such as deep litter. Literature estimates that most litter treatments are effective for 3-4 weeks, which is useful for controlling ammonia during the brooding period (Blake, Hess and Macklin 2014). Higher application rates will extend ammonia control.

The petitioner describes three specific scenarios for application of acid-activated bentonite to poultry litter. The application rates described in the petition meet or exceed the high end of the range of normal application rates as described by Blake and Hess (2001).

1. Apply on top of new litter once at the beginning of each grow-out cycle at a rate of about 100 lbs/1,000 ft^2 (0.8 – 1.6 oz/ft^2).
2. Apply to bare ground after old litter is removed and before new litter is added at a rate of 100 lbs/1,000 ft^2 (0.8 – 1.6 oz/ft^2). New litter is added directly on top of acid-activated bentonite immediately after application.
3. For deep litter treatment, apply on top of litter after crusting (removing the hard cake or crust) at a rate of 200 lbs/1,000 ft^2 for every 3 inches of litter depth and then till into the litter.

The petitioner also describes reapplication methods in cases where ammonia levels exceed 25 ppm. The reapplication is intended to occur while birds are present at an application rate of 100 lbs/1,000 ft^2, as indicated by the petitioner. Use instructions for Poultry Guard® do not address the need for reapplication, but do state that the product will be effective to reduce ammonia for several weeks. Broilers are grown out to 6 or more weeks, while other poultry such as laying hens and turkeys have longer grow out periods. If litter treatment loses effectiveness while birds are still in the poultry house, it is likely that reapplication or other ammonia mitigation measures may need to occur.

Use instructions do not differentiate between different types of bedding material in the litter. The National Organic Program (NOP) organic regulations at 7 CFR 205.239(a)(3) require that livestock are provided with clean, dry bedding. Ideal poultry bedding materials are hardwood shavings, sawdust, pine or hardwood chips, which have high moisture absorption and release qualities to minimize litter caking (Ritz, Fairchild and Lacy 2004). Other common bedding materials used in broiler and turkey production are wheat straw, rice hulls and peanut hulls (Moore, et al. 1996). Due to the costs associated with purchasing bedding materials, and the difficulty of handling and disposing of used litter, it has become a common practice in commercial broiler production to reuse litter throughout the production of multiple flocks over the course of a year or up to three years (S. E. Watkins 2008). Since litter buildup can contribute to elevated ammonia release, de-caking and using litter amendments are common practices to control ammonia volatilization in poultry production where litter is reused.

Acid-activated bentonite has numerous other uses as an absorptive and bleaching material. It has been used to absorb and thereby remove environmental pollutants such as heavy metals and petroleum hydrocarbons from contaminated solutions (Emam 2013), and nitrogen oxides from industrial exhaust streams (Schneider, et al. 1987). It is also used in the industrial processing of vegetable, animal and mineral oils and waxes as a bleaching and decolorizing agent (Valenzuela Díaz and de Souza Santos 2001). Acid-activated bentonite powders are also used in manufacturing of carbonless copy paper (Onal and Sarikaya 2007).

<u>Approved Legal Uses of the Substance:</u>

The use of acid-activated bentonite as a poultry litter treatment is not specifically addressed in Federal Regulations.

<u>Action of the Substance:</u>

Ammonium (NH_4^+) is present in poultry litter due to the breakdown of uric acid and organic nitrogen. Ammonium (NH_4^+) is converted to ammonia gas (NH_3) by microbes in the litter. The conversion to ammonia gas is accelerated under conditions of high temperatures, high pH, and high moisture (Shah, Westerman and Parsons 2006).

Acid-activated bentonite creates acidic conditions which inhibit the conversion of ammonium to ammonia. The acid-activated bentonite also removes existing gaseous ammonia from the air via adsorption, wherein the ammonia ions adhere to the surface of the clay. The capability of clays, particularly acid-activated clays, to adsorb other molecules is characterized by interactions such as hydrogen bonding and complexation, as well as acid-base interactions (Opalinski, et al. 2015). Retention of ammonia on the clay surface occurs at both Lewis and Brønsted acid sites (Ravichandran and Sivasankar 1997), where the clay acts as a proton donor or electron acceptor, respectively. Acid treatment of the clay greatly increases its surface area and pore size, making available more of these binding sites where the ammonia can be adsorbed, thereby increasing its adsorption capacity. The ammonia further reacts with sulfate ions of the sulfuric acid-activated bentonite to form ammonium sulfate, $(NH_4)_2SO_4$, which is retained in the litter (Blake, Hess and Macklin 2014).

Combinations of the Substance:

The petitioned substance is not formulated with any additional ingredients.

Status

Historic Use:

Acid-activated bentonite is not currently permitted in organic livestock production for the petitioned use as a poultry litter treatment or for any other use.

In conventional agricultural production, acid-activated bentonite is used as a poultry litter treatment. A 1999 patent describes using acidulated clay as litter to control ammonia in poultry pens (Taylor 1999), suggesting that it is a relatively new material for this use. Acid-activated bentonite had been in use as a bleaching material for much longer, described in patents dating to the 1920s.

Organic Foods Production Act, USDA Final Rule:

Acid-activated bentonite does not currently appear in the Organic Foods Production Act (OFPA) or in the USDA Final Rule for poultry litter treatments.

Bentonite, the starting material, is a nonsynthetic substance listed at 7 CFR 205.605(a) as a nonagricultural nonorganic material allowed as an ingredient or processing aid in processed products labeled as “organic” or “made with organic (specified ingredients of food group(s)).” Bentonite is also considered an allowed nonsynthetic material for use in crop and livestock production.

Sulfuric acid, the acid activator, is a synthetic substance that appears at 7 CFR 205.601(j)(7) in the listing for liquid fish production, where the fish can be pH adjusted with sulfuric, citric, or phosphoric acid. Sulfuric acid was petitioned to be added to 7 CFR 205.601 for stabilization of poultry manure. The National Organic Standards Board (NOSB) voted against the allowance of this substance because of adverse environmental and health impacts, lack of essentiality, and incompatibility with organic principles. Sulfuric acid was also petitioned to be added to 7 CFR 205.605(b) for use as a processing aid in the production of seaweed extract. The NOSB also voted against this allowance of this substance because of failure to meet several evaluation criteria, including impact on environment and human health.

International

Canada - Canadian General Standards Board Permitted Substances List (CAN/CGSB-32.311-2006)

Acid-activated bentonite does not appear in Table 5.3 Livestock Health Care Products and Production Aids.

CODEX Alimentarius Commission, Guidelines for the Production, Processing, Labelling and 208 Marketing of Organically Produced Foods (GL 32-1999)
Acid-activated bentonite is not included in GL-32-1999 Annex 1(b) Livestock and Livestock Products.

European Economic Community (EEC) Council Regulation, EC No. 834/2007 and 889/2008
Acid-activated bentonite does not appear in 834/2007 Article 14 Livestock Production Rules, nor does it appear in 889/2008 Chapter 2 Livestock Production or Annex I.

Japan Agricultural Standard (JAS) for Organic Production
Acid-activated bentonite does not appear in Notification 1608 Japanese Agricultural Standard for Organic Livestock, Partial Revision March 28, 2012.

IFOAM – Organics International (IFOAM)
Acid-activated bentonite does not appear in IFOAM Norms Appendix 5, Substances for Pest and Disease Control and Disinfection in Livestock Housing and Equipment.

Evaluation Questions for Substances to be used in Organic Crop or Livestock Production

Evaluation Question #1: Indicate which category in OFPA that the substance falls under: (A) Does the substance contain an active ingredient in any of the following categories: copper and sulfur compounds, toxins derived from bacteria; pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals; livestock parasiticides and medicines and production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleansers? (B) Is the substance a synthetic inert ingredient that is not classified by the EPA as inerts of toxicological concern (i.e., EPA List 4 inerts) (7 U.S.C. § 6517(c)(1)(B)(ii))? Is the synthetic substance an inert ingredient which is not on EPA List 4, but is exempt from a requirement of a tolerance, per 40 CFR part 180?

(A) The substance contains sulfur compounds (sulfuric acid).
(B) The substance is not an inert ingredient.

Evaluation Question #2: Describe the most prevalent processes used to manufacture or formulate the petitioned substance. Further, describe any chemical change that may occur during manufacture or formulation of the petitioned substance when this substance is extracted from naturally occurring plant, animal, or mineral sources (7 U.S.C. § 6502 (21)).

The manufacturing process for acid-activated bentonite utilizes bentonite as the starting material. Mined bentonite is typically crushed, dried, and ground to produce a uniform material. Most commercially available bentonite clay contains calcium-montmorillonite as the major clay mineral and is referred to as calcium bentonite (Onal and Sarikaya 2007).

The activation step is the chemical treatment applied to the bentonite that develops its capacity for use as an adsorbent. An aqueous or concentrated sulfuric acid solution is added to the clay by mixing or spraying (Taylor 1999). Commercial production of the petitioned substance Poultry Guard® occurs by spraying 46% by weight concentrated sulfuric acid onto bentonite clay granules as they are tumbled in a Munsen mixer. The petition does not indicate that any further processing (e.g., heating, washing), other than packaging, is done to the substance following the activation step. However some processes have described washing the clay following treatment to remove metal ions liberated from the clay as well as excess acid in order to avoid degradation of the clay's crystalline structure (Aqua Technologies of Wyoming Inc. 2015). Acid treatment and washing may also be followed by drying.

Prior to activation, bentonite exists in its natural crystalline structural unit made up of layers of two silica tetrahedral sheets (T) with a central alumina octahedral sheet (O) bound together by oxygen ions and hydroxyl groups, as show in Figure 1. The T-O-T layers are negatively charged and the interlayer spaces are occupied by exchangeable cations of the natural clay minerals to neutralize the charge (Tyagi, Chudasama and Jasra 2006).

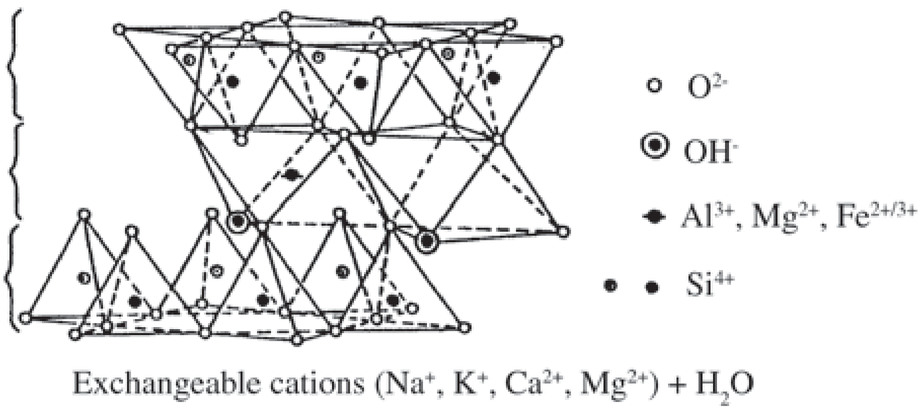

Figure 1. Crystalline structure of bentonite clay. (Volzone, Rinaldi and Ortiga 2002)

During acid-activation, the cations in the interlayer spaces of the crystal are replaced by protons of the acid, as shown in the equation below, which causes bulging of the layers (Baranowsky, et al. 2001).

$$\text{Ca-Bentonite} + 2\ H^{+} \rightleftharpoons \text{H-Bentonite} + Ca^{2+}$$

The mineral cations are leached from the interlayers of the structure. The higher the degree of activation, the higher the degree of cation substitution and leaching that is experienced by the clay structure (Usman, et al. 2012). As a consequence of activation, surface area is increased, bulk density is decreased (Baranowsky, et al. 2001), and pore diameters increase (Valenzuela Díaz and de Souza Santos 2001). These structural changes contribute to the resulting substance's increased adsorption capacity.

Studies show that adsorption capacity and micropore volume of the activated bentonite is increased with increases in acid concentration, and that the optimum amount of acid and the exact conditions for activation depends on the structural makeup of the particular bentonite clay (Baranowsky et al. 2001; Jovanovic and Janackovic 1991; Valenzuela Díaz and de Souza Santos 2001).

Activation of bentonite can occur by treatment with acids other than sulfuric acid. Experimental models performed in laboratories used in the study of clay activation utilize hydrochloric acid, nitric acid and sulfuric acid as activation substances. One study demonstrated that hydrochloric acid is more efficient than sulfuric acid, and nitric acid is the least efficient (Srasra, et al. 1989). There is no evidence that acids other than sulfuric acid are used in production of acid-activated bentonite for the purpose of poultry litter treatment.

<u>Evaluation Question #3:</u> Discuss whether the petitioned substance is formulated or manufactured by a chemical process, or created by naturally occurring biological processes (7 U.S.C. § 6502 (21)).

The petitioned substance is manufactured by a chemical process wherein bentonite is treated with sulfuric acid. The chemical and physical structure of the bentonite crystals is transformed as a result of the activation, as described in Evaluation Question #2. The synthetic sulfuric acid activator remains in the final product.

Evaluation Question #4: Describe the persistence or concentration of the petitioned substance and/or its by-products in the environment (7 U.S.C. § 6518 (m) (2)).

The by-products of acid-activated bentonite used as a poultry litter treatment are ammonium sulfate ($(NH_4)_2SO_4$) and spent clay. Ammonium sulfate is produced as a result of the reaction between gaseous ammonia in the poultry house and the sulfate ions of the sulfuric acid-activated bentonite.

Ammonium sulfate is a common water-soluble inorganic fertilizer used in conventional crop production. Ammonium sulfate has little to no surface volatilization loss when applied to most soils and is effective as a starter nitrogen source. Compared to other forms of soil nitrogen, the ammonium ion is less subject to leaching from clay since its positive charge keeps it held by the clay's negatively charged sites (Vitosh, Johnson and Mengel 1995). However, ammonium sulfate has a neutral charge and so would not be held to clay in the same way. Increased loss of nitrogen through leaching has been associated with greater application rates of ammonium sulfate fertilizer (Olson 1979). Another study reported that while nitrogen derived from ammonium sulfate is more readily taken up by plants than nitrogen from leguminous nitrogen–fixing plants, it is also lost from the soil more readily in the first year after application (Harris, et al. 1993).

Evaluation Question #5: Describe the toxicity and mode of action of the substance and of its breakdown products and any contaminants. Describe the persistence and areas of concentration in the environment of the substance and its breakdown products (7 U.S.C. § 6518 (m) (2)).

Poultry litter treated with acid-activated bentonite experiences an initial sharp decrease in pH, but as the ammonia is converted into ammonium sulfate, the pH returns to neutral within 5 to 7 days (McWard and Taylor 2000).

Spent poultry litter is typically intended for application to agricultural land for the purpose of improving soil fertility and organic matter content. Environmental concerns that arise from the land application of poultry manure include nitrogen leaching, phosphorus contamination of surface waters, and heavy metal buildup in soils (Bolan, et al. 2010).

Ammonium sulfate is contained within the spent poultry litter from poultry houses where the litter was treated with acid-activated bentonite. In soil, ammonium sulfate will dissociate into its ammonium and sulfate components which are normally present in the environment. The ammonium ions are converted to nitrate via the nitrification process, which also releases hydrogen ions into the environment, leading to soil acidification (Fageria, Dos Santos and Moraes 2010). Nitrates in the soil are either taken up by plants as nutrients or lost to leaching. Leached nitrogen from soils is a documented source of groundwater contamination (Staver and Brinsfield 1990).

Evaluation Question #6: Describe any environmental contamination that could result from the petitioned substance's manufacture, use, misuse, or disposal (7 U.S.C. § 6518 (m) (3)).

Manufacturing – Bentonite, the starting material, is sourced by quarry mining. Mining usually has negative environmental impacts that can include release of heavy metals to soil and water, and generation of the air pollutants sulfur and nitrogen dioxide, residual waste tailings, slag and acid drainage. The manufacturing of the acid treatment sulfuric acid generates sulfuric acid emissions into the air which, if not otherwise neutralized, result in dilute acid solutions that may contribute to acid rain. The activation of bentonite with sulfuric acid as described in the petition does not appear to add additional negative environmental impacts beyond the manufacturing of its ingredients.

Use and Handling – The U.S. Department of Transportation regulates the shipping of acid-activated bentonite as a "corrosive material" (Hazard Class 8) due to the sulfuric acid content. This class of materials is defined at 49 CFR 173.136 as a liquid or solid that causes full thickness destruction of human skin at the site of contact within a specified period of time. Care must be taken to ensure that incompatible corrosive materials are not mixed. The Material Safety Data Sheet for the petitioned acid-activated bentonite indicates that it does not emit any volatile organic compounds. Applying water directly to the material must be avoided; aqueous runoff is acidic and corrosive.

Misuse – Since the substance is a granular solid material, spills are relatively manageable to contain and clean up. The Material Safety Data Sheet for the petitioned acid-activated bentonite indicates that spills greater than 2,000 lbs must be reported to the National Resources Center.

Disposal – Use instructions for Poultry Guard® state that the product can be neutralized with household ammonia or baking soda.

<u>Evaluation Question #7:</u> Describe any known chemical interactions between the petitioned substance and other substances used in organic crop or livestock production or handling. Describe any environmental or human health effects from these chemical interactions (7 U.S.C. § 6518 (m) (1)).

The literature does not indicate that the petitioned substance would have chemical interactions with other substances used in organic livestock production, other than what has been described in previous evaluation questions regarding the mode of action of the petitioned substance with poultry litter.

<u>Evaluation Question #8:</u> Describe any effects of the petitioned substance on biological or chemical interactions in the agro-ecosystem, including physiological effects on soil organisms (including the salt index and solubility of the soil), crops, and livestock (7 U.S.C. § 6518 (m) (5)).

The intended use of the petitioned substance is to reduce ammonia volatilization in poultry houses, which effectively improves the air quality and thus the living conditions of poultry. With reduced ammonia concentration in poultry houses, birds are at lower risk of respiratory damage, infectious disease, and other negative effects of ammonia, including mortality (Shah, Westerman and Parsons 2006). One study associated the use of acid-activated bentonite as a poultry litter treatment with reduced instances of breast blisters, foot-pat dermatitis, and air-sac lesions in poultry (McWard and Taylor 2000).

Since acid-activated bentonite is a highly acidic substance and handlers of the substance are required to prevent direct contact, it is reasonable to expect that direct contact of the substance with poultry, either on their feet or through incidental ingestion, would also pose health risks. The potential for direct contact depends on the structure of the poultry house. In some houses, the birds are placed on raised slatted flooring overtop of the litter, in which case the birds would not have direct contact with the litter or litter treatments. Houses without raised flooring would allow birds to peck and scratch through the litter, posing a higher risk of direct contact with the litter treatment. Data is not available in the literature to quantify the amount of litter containing acid-activated bentonite that may be ingested by birds. It is unlikely that significant amounts would be ingested unless there was a shortage of suitable feed.

The acidifying function of litter treatments can inhibit growth and survival of pathogenic and nonpathogenic bacteria in litter (Choi, Kim and Kwon 2008). Use of acid-activated bentonite litter treatments is also associated with reductions in salmonella levels in litter (Watkins, Southerland and Hunt 2002) and darkling beetles (McWard and Taylor 2000).

Because the petitioned substance is applied to poultry litter, the subsequent use of the spent poultry litter must be considered in assessing the total impact of the petitioned substance on the agro-ecosystem. There are many environmental considerations if the poultry litter is applied to agricultural land. Some considerations are addressed in Evaluation Question #5. See Technical Reports for aluminum sulfate (OMRI 2015a) and sodium bisulfate (OMRI 2015b) for additional information regarding the reuse of treated poultry litter for fertility purposes.

Evaluation Question #9: Discuss and summarize findings on whether the use of the petitioned substance may be harmful to the environment (7 U.S.C. § 6517 (c) (1) (A) (i) and 7 U.S.C. § 6517 (c) (2) (A) (i)).

In general, the petitioned substance improves the living conditions for poultry within the poultry house by reducing ammonia volatilization and thereby mitigating negative impacts of gaseous ammonia. The use of spent poultry litter may pose negative environmental impacts as discussed in Evaluation Question #5.

Evaluation Question #10: Describe and summarize any reported effects upon human health from use of the petitioned substance (7 U.S.C. § 6517 (c) (1) (A) (i), 7 U.S.C. § 6517 (c) (2) (A) (i)) and 7 U.S.C. § 6518 (m) (4)).

Handlers of acid-activated bentonite must take care to protect themselves from direct contact with the substance. Direct exposure to the substance may cause skin irritation or burns. The petitioned product contains crystalline silica which is naturally occurring in the bentonite starting material, a small fraction (0.00064% by weight) of which is in the respirable range. Inhalation of excessive concentrations of the substance may lead to lung injury. Applicators should wear protective clothing, impervious gloves, goggles, and a dust mask.

Use of the substance as petitioned is not likely to have negative effects on human health because the substance decreases ammonia concentration in the atmosphere of poultry houses, which has a positive impact on both the health of the birds and the health of the handlers.

Evaluation Question #11: Describe all natural (non-synthetic) substances or products which may be used in place of a petitioned substance (7 U.S.C. § 6517 (c) (1) (A) (ii)). Provide a list of allowed substances that may be used in place of the petitioned substance (7 U.S.C. § 6518 (m) (6)).

Clay-based adsorbents can be used to bind NH_3 to the surface of the clay, and they also decrease NH_3 volatilization by absorbing moisture (McCrory and Hobbs 2001). Nonsynthetic forms of these substances include naturally occurring zeolite, diatomaceous earth, and montmorillonite (non-activated bentonite). Peat (*Sphagnum facum*) has physical and chemical properties that result in effective ammonia management. Peat can adsorb 2.5 times its weight in NH_3 and absorb up to 20 times its weight in water (McCrory and Hobbs 2001). Clay and peat are both nonhazardous materials. At the time of this report, there are several products that are OMRI Listed® for this use, such as Barn Fresh Natural Ammonia Control manufactured by Absorbent Products Ltd, which is listed in the "diatomaceous earth" category (OMRI 2015). Another product, Litter Life manufactured by Southland Organics, is a liquid poultry litter treatment that is approved under the U.S. EPA Design for the Environment program (Southland Organics 2015).

Microbial and enzymatic treatments can be used to inhibit microbial growth and urease production through competitive exclusion and enzyme inhibition (Ritz, Fairchild and Lacy 2014). These types of products are generally not practical or economical for growers due to the rapid breakdown of the product, and they are more expensive than other alternatives (McCrory and Hobbs 2001).

See Technical Reports for aluminum sulfate (OMRI 2015a) and sodium bisulfate (OMRI 2015b) for additional information on alternative substances used for ammonia reduction in poultry houses.

Comparative analysis of acidifying litter treatments

Acidifying agents such as the petitioned material function by lowering the pH of the litter, thereby inhibiting the bacteria that transforms manure nitrogen into ammonia, and they also convert NH_3 to NH_4^+ (Ritz, Fairchild and Lacy 2014). This class of treatment is the most widely used type of litter amendment in commercial poultry production. The most prevalent acidifying litter treatments are synthetic. There are no synthetic substances that are currently allowed for organic poultry litter treatment.

Acid-activated bentonite and two other substances, aluminum sulfate and sodium bisulfate, have each been petitioned for use as litter treatments in organic poultry production. These three treatments represent the most common poultry litter treatments in the poultry industry (McWard and Taylor 2000). Table 3 compares acid-activated bentonite with the other two substances using information from their respective 2015 Technical Reports, and other references as identified in the table.

Table 3: Comparison of common poultry litter treatments

	Acid-activated bentonite (Poultry Guard®)	**Sodium bisulfate (PLT®)**	**Aluminum sulfate (AL+ Clear®)**
Physical State	Solid granules	Solid granules	Solid granules or Liquid
Manufacturer's recommended application	Top dress on litter 0-3 days before placement at 50 – 75 lbs. per 1000 ft^2 (Shah, Westerman and Parsons 2006)	Top dress on litter 1 day before placement at 50–100 lbs. per 1000 ft^2 (Shah, Westerman and Parsons 2006)	Top dress or mix into litter 0-7 days before placement at 50–100 lbs. per 1000 ft^2 (Shah, Westerman and Parsons 2006)
Mode of Action	Reduces litter pH; binds ammonia	Reduces litter pH; binds ammonia	Reduces litter pH; binds ammonia; binds phosphorus
Spent litter characteristics compared to untreated litter	Higher nitrogen levels	Higher nitrogen levels	Higher nitrogen levels; Less soluble phosphorus

Several studies have compared the efficacy of these three substances. A laboratory study by Choi and Moore (2008) evaluated the effects of alum, liquid alum, high acid alum, aluminum chloride, fly ash, Poultry Litter Treatment, and Poultry Guard® on ammonium volatilization and nitrogen content of the litter. The findings showed that alum amendments and the sodium bisulfite amendments significantly decreased NH_3 volatilization. The results for Poultry Guard® had mixed results due to inconsistencies of the experimental setup in each trial (Choi and Moore Jr. 2008). A broiler pen study at the University of Auburn demonstrated that Poultry Guard® failed to elicit a significant reduction in ammonia, although it was effective in reducing litter pH (Blake, Hess and Macklin 2014). Another broiler pen study by McWard and Taylor compared the effects of Poultry Guard® with sodium bisulfate and alum, and showed that all three litter treatments were effective in reducing ammonia levels for about 30 days (McWard and Taylor 2000). Acid-activated bentonite and sodium bisulfate are more acidic than aluminum sulfate, and thus cause a higher degree of acidification (McWard and Taylor 2000). A more recent study compared the efficacy of various litter treatments, including Poultry Guard®, PLT® and AL+Clear®. Poultry Guard® was found to be the least effective of the acidifier treatments, although it was more effective than the control (Cook, et al. 2011).

<u>Evaluation Question #12:</u> Describe any alternative practices that would make the use of the petitioned substance unnecessary (7 U.S.C. § 6518 (m) (6)).

Ammonia must be controlled in poultry houses to avoid harmful living conditions. Variables that may influence ammonia emissions from poultry litter include air and litter temperature, air exchange rate, litter pH, litter nitrogen content, and litter moisture content (Liu, et al. 2007).

Wet litter is the primary cause of ammonia emissions in poultry houses (Ritz, Fairchild and Lacy 2014). Litter moisture can be controlled by selecting bedding materials that have high moisture absorption and release qualities, such as hardwood shavings, sawdust, and pine or hardwood chips (Ritz, Fairchild and

Lacy 2004). Using nipple drinkers to provide water for poultry is a method of reducing waste water and avoiding moisture buildup (Shah, Westerman and Parsons 2006). Of the water that a bird drinks, approximately 80% is excreted through manure or is exhaled (Donald, et al. 2009). More frequent litter cleanouts will reduce accumulating ammonia emissions.

Ventilation is the most practical way to remove excess moisture from a poultry house (Donald, et al. 2009). Organic operations are required to provide shelter for organic animals that is designed to provide temperature levels, ventilation and air circulation suitable to the species in accordance with 7 CFR 205.239(a)(4)(ii). The combination of ventilating and heating will remove considerable moisture from the house (Ritz, Fairchild and Lacy 2014). Ventilation can also lead to external environmental impacts because the ammonia emissions are moved from the poultry house to the outside atmosphere. Atmospheric ammonia has been shown to contribute to acid rain production (Moore, et al. 1996).

Frequent litter cleanout and running ventilation fans and heaters can be effective in controlling ammonia inside poultry houses. Although these practices increase the production costs for the operation, the costs may be outweighed by the benefits of avoiding negative living conditions brought on by accumulating ammonia emissions.

Feed additives such as yucca extracts can be used to adjust the diet and reduce the amount of ammonium that can be generated from the litter. See Technical Reports for aluminum sulfate (OMRI 2015a) and sodium bisulfate (OMRI 2015b) for additional information on alternative practices for ammonia reduction in poultry houses.

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