

Poultry Litter Amendments

AIR QUALITY EDUCATION IN ANIMAL AGRICULTURE

Mitigation: Litter Amendments
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This publication discusses litter amendments and how they can be used to reduce ammonia and improve productivity in poultry houses.

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High ammonia levels in poultry houses can result in poor bird performance and health, and a loss of profits to the grower and integrator. When broilers and turkeys are raised on litter, amendments (Figure 1) can be used to reduce ammonia levels in the houses and improve productivity.

Broiler and turkey litter typically consists of wood shavings, rice hulls, or peanut hulls. Uric acid and organic nitrogen (N) in the bird excreta and spilled feed are converted to ammonium (NH₄⁺) by the microbes in the litter. Ammonium, a plant-available nitrogen form, can bind to litter and also dissolve in water. Depending on the moisture content, temperature, and acidity of the litter, a portion of the ammonium will be converted into ammonia (NH₃). Ammonia production is favored by high temperature and high pH (i.e., alkaline conditions).

Ammonia is a pungent gas that irritates the eyes and respiratory system and can reduce resistance to infection in poultry. At high-enough concentrations, ammonia will reduce feed efficiency and growth while increasing mortality and carcass condemnations. The result is economic loss to the grower and integrator. Carlile (1984) recommended limiting ammonia concentration in poultry houses to 25 parts per million (ppm) or less. However, Blake and Hess (2001) reported that continuous exposure to ammonia concentrations as low as 10 ppm can damage a bird's respiratory system and increase the risk of infectious disease.

Due to the high price of wood shavings and the increasing scarcity of land avail-



Figure 1. A1+Clear (alum) is being applied inside a poultry house using a spinner spreader. Sprinkling water helps reduce dust levels during application and activates the amendment. (Photo courtesy of C. Kim, General Chemical Corp.)

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able for litter application, complete poultry house cleanouts may be done only once every two years or longer. Only the crust or cake (top portion of the litter) may be removed after each flock. The increased duration between complete cleanouts results in a greater buildup of litter and ammonia.

Because chicks are more susceptible to the negative effects of ammonia, placing broods in houses with high levels of built-up litter is particularly harmful. Also, the high temperatures required during brooding increase ammonia levels. Moist litter (due to leaky drinkers or high water tables) and insufficient winter ventilation contribute to high ammonia levels as well. In these situations, some growers rely mainly on ventilation to reduce ammonia in the houses. However, ammonia loss from the litter reduces its fertilizer value, and venting ammonia into the environment can cause health and environmental problems.

Ammonia helps to form fine particulate matter (PM_{2.5}, particles with aerodynamic diameters less than 2.5 µm, 1/30th diameter of average human hair), which aggravates asthma and contributes to haze. Ammonia deposition (dry or with rainfall) may contribute to soil acidification and algal growth in water bodies. Neighbors also complain about odor from animal facilities, and ammonia may contribute to this smell.

Currently, interest is growing in regulating ammonia emissions from animal facilities at the federal, state, and local levels. Research has shown that litter amendments reduce ammonia levels in the poultry house and improve bird performance and health; the amendments may offer other economic and environmental benefits as well.

Types of Litter Amendments and Their Performance

Five types of litter amendments are available to manage ammonia: acidifiers; alkaline material; adsorbers; inhibitors; and microbial and enzymatic treatments.

Acidifiers

This type of amendment creates acidic conditions (pH less than 7) in the litter, resulting in more of the ammoniacal-N being retained as ammonium rather than ammonia. The acidity also creates unfavorable conditions for the bacteria and enzymes that contribute to ammonia formation, resulting in reduced ammonia production. Many different types of acidifiers, such as alum, sodium bisulfate, ferrous sulfate, and phosphoric acid, were found to be effective in controlled studies. However, some acidifiers are not recommended for use in poultry houses for reasons such as bird toxicity (ferrous sulfate) or increased phosphorus (P) levels in the already P-rich litter (phosphoric acid).

The properties, effectiveness, and costs relative to the three commercial acidifiers that have been evaluated in scientific research are presented in *Table 1*. Summaries of research on the acidifiers follow. It may be noted that in some research studies, higher application rates than those recommended by the manufacturers (*Table 1*) were used; the reader is advised to take this into account.

A1+Clear (Alum)

Moore et al. (2000) compared ammonia levels in Arkansas broiler houses treated with alum (0.2 pounds per bird or about 285 pounds per thousand square feet) with broiler houses that received no alum (the untreated houses). Ammonia concentrations during the first three weeks were 6 to 20 ppm in the alum-treated houses, compared with 28 to 43 ppm in the untreated houses. Birds were 4 percent heavier, and feed conversion was 3 percent better in the alum-treated houses than in the control houses due to lower ammonia levels in the early growth stage. The alum-treated houses also had lower electric and propane bills, as extra ventilation was not required to reduce ammonia. Alum likely reduced ammonia emissions from the houses, both by reducing its production in the litter and by reducing ventilation needs. It also reduced losses of soluble and total P in runoff from land-applied poultry litter, both by 73 percent. The amount of aluminum added to the litter through alum was unlikely to reduce soil

Table 1. Summary of Commercially Available Acidifier-Type Poultry Litter Amendments

Amendments	Al+Clear®	Poultry Guard®	Poultry Litter Treatment® (PLT®)
Manufacturer	General Chemical Corp. genchemcorp.com 1-800-631-8050	Oil Dri Corp. poultryguard.com 1-800-643-3064	Jones Hamilton Co. jones-hamilton.com 1-800-379-2243
Common name; chemical formula	Alum; aluminum sulfate [Al ₂ (SO ₄) ₃ • 14H ₂ O]	Acidified clay; 36% sulfuric acid (H ₂ SO ₄) soaked in a type of clay	PLT; 93% sodium bisulfate (NaHSO ₄)
Type of product	Solid (powder+granules) or liquid	Granules	Granules
Controls ammonia ¹	Yes	Yes	Yes
Potential to neutralize mass of ammonia per 100 lb product ²	17.0 (solid) 8.6 (liquid) ³	12.5	13.3
Improves bird health & performance ¹	Yes	Yes	Yes
Saves energy ¹	Yes	Not evaluated but likely	Yes (company research)
Reduces darkling beetles ¹	Yes	Yes	Yes
Reduces pathogens ¹	Yes	Yes	Yes
Reduces loss of P & soluble metals in runoff ¹	Yes ⁴	Not evaluated	Not evaluated
Manufacturer recommended application rate after each growout (lb/1,000 sq ft)	50-75 75 (litter with more than 5 flocks, short layouts or extremely dry litter)	50 75-100 (litter older than 1 year, deep litter, shorter layouts)	50-75 75-100 (litter with more than 5 flocks or layouts less than 10 days)
Application timing before placing chicks ⁵	0-7 days depending on litter conditions	0-3 days	1-24 hours
Application method ⁶	Surface-apply on dry litter; mix into top ½ inch and re-level in wet litter	Surface-apply	Surface-apply
OSHA Communication Standard for safety	Hazardous ⁷	Corrosive	Mild irritant ⁸
2004/05 price (per ton) ⁹	\$86 ¹⁰ \$355 ¹¹ \$473 ¹²	\$438-500	\$373 (bulk) \$398 (50 lb bag)

¹Based on published, scientific research.

²All dry acids require sufficient moisture for activation; with inadequate moisture, ammonia removal will be reduced.

³8.7 gallons of liquid equal to 100 lb.

⁴Heavier application rates (for instance, 275-300 lb/1,000 sq ft) required for substantial (about 70-75%) reduction in P losses in runoff (based on published literature).

⁵Between growouts on litter on which at least one flock has been raised.

⁶Drop spreader preferred for solids to get uniform application.

⁷Hazardous only if quantity greater than 8,700 lb per Material Safety Data Sheet (MSDS).

⁸Generally regarded as safe (GRAS) as a food additive by FDA.

⁹Provided for general guidance by manufacturer/supplier; price based on location, volume, and purchase source.

¹⁰For liquid delivered to Raleigh, NC.

¹¹For Al+Clear by the truckload, FOB Wilmington, Del.

¹²50 lb bag, retail.

Currently, interest is growing in regulating ammonia emissions from animal facilities at the federal, state, and local levels.

productivity. Overall, Moore et al. reported that the benefits of using alum to both the producer and integrator were nearly twice as great as the cost of buying and applying it.

Worley et al. (2000) compared gas usage, bird performance, darkling beetle populations, and litter composition with alum applied at 100 and 200 pounds per thousand square feet to northern Georgia broiler houses between flocks. Ventilation rates were increased when ammonia concentrations exceeded 25 ppm. While ammonium was higher and soluble phosphorus was lower in the litter with the higher application rate, gas usage, bird performance, feed conversion, and mortality were unaffected by application rate. The higher alum application rate reduced darkling beetle populations, compared with the lower application rate. Worley et al. concluded that 100 pounds per thousand square feet of alum provided adequate ammonia management.

In a study of 194 broiler houses in Delaware, Maryland, and Virginia, half of which received alum (average of 287 pounds per thousand square feet per application), the alum treatment increased total nitrogen by 5.4 pounds per ton, ammonium by 4.4 pounds per ton, and sulfur by 23.2 pounds per ton above control litter concentrations (Sims and Luka-McCafferty, 2002). Alum reduced soluble fractions of phosphorus by 67 percent, arsenic by 63 percent, copper by 37 percent, and zinc by 48 percent, compared with untreated litter. Thus, alum increased the litter's fertilizer value and reduced the potential of phosphorus and heavy metal pollution. Soluble phosphorus and metal concentrations in the litter changed very little in the range of aluminum to phosphorus ratios of 0.2 to 1.0, while to obtain higher ammonium in the litter, a ratio greater than 0.6 was required. Sims and Luka-McCafferty suggested that further studies would be required to determine the most effective and economic alum application rate to achieve different production and environmental objectives.

Poultry Guard

McWard and Taylor (2000) evaluated the impact of Poultry Guard™ on ammonia levels and broiler performance in Colorado over 48 days. When applied at 112 pounds per thousand square feet to litter, Poultry Guard-treated pens had ammonia concentrations of about 12 to 20 ppm, compared with 60 to 85 ppm in the untreated pens during the first 28 days. For the remainder of the study, the treated pens had ammonia concentrations of 40 ppm, at least 20 ppm lower than the untreated pens. The litter amendment increased broiler body weight by 5 percent, improved carcass quality, and reduced breast blisters, foot-pad dermatitis, and air-sac lesions. McWard and Taylor attributed improved bird performance to reduced ammonia levels in the house. They also found Poultry Guard offered the potential to reduce darkling beetle populations.

In another study, Poultry Guard, with 40 percent sulfuric acid, applied at 25, 50, 100, and 150 pounds per thousand square feet reduced salmonella levels in the litter by 74 percent, 83 percent, 98 percent, and nearly 100 percent, respectively, compared to no amendment (Watkins et al., 2002).

Poultry Litter Treatment

Pope and Cherry (2000) compared the impact of using Poultry Litter Treatment® (PLT®) on ammonia levels and bacterial loads in broiler houses in Texas. PLT was applied at 50 pounds per thousand square feet in the half-house brooding area one day prior to placement, at 50 pounds per thousand square feet to the off chamber (non-brooded area) just before migration, and then at 50 pounds per thousand square feet to the whole house one week before processing. During weeks 0, 1, and 2, the PLT-treated houses had ammonia concentrations of 6, 18, and 11 ppm, compared with 62, 28, and 20 ppm, respectively, in the untreated houses. No ammonia data were presented for the later weeks. Due to litter acidification, bacterial loads in the litter were greatly reduced prior to stocking. Under commercial conditions, Pope and Cherry said that PLT may reduce bird pathogen levels entering the processing plant.

Line (2002) also reported that PLT (and alum) reduced *Campylobacter* infections in broiler chicks. Terzich et al. (1998a, 1998b) evaluated the effect of PLT on ammonia levels, body weight, respiratory-tract lesions, and death due to ascites in broilers

grown on used litter. PLT applied at 50 pounds per thousand square feet (0.0325 lb/bird) resulted in ammonia levels ranging from 5 to 22 ppm, compared with 53 to 115 ppm in the untreated pens over the 48-day study. Broilers in the treated pens weighed 8 percent and 5 percent more than the control birds at 23 and 49 days, respectively. Compared with the untreated birds, broilers in the treated pens had fewer lesions and fewer incidences of swollen mucous lining of the windpipes. Also, the ascites death rate in the treated birds was much lower (5.9 percent) compared to the untreated birds (31.5 percent), probably because the treated birds had larger lung/body weight ratio (by 4 percent on average) compared with untreated birds. Hence, PLT reduced ammonia levels in the house, resulting in improved bird performance and reduced carcass condemnations.

Acidifier Summary

Acidifiers reduce ammonia levels in the poultry house and improve in-house air quality. While some studies have shown that ammonia suppression below 25 ppm may last from three to four weeks after application, other studies have shown that some ammonia suppression may last even longer, up to seven weeks. The extent of ammonia suppression may depend on age and moisture content of poultry litter, application rate of amendment, and selection of amendment. Reduced ammonia levels not only improve bird performance and health but may also positively impact worker health. Heating costs may also be reduced during winter and brooding due to the reduced need for ventilation. Acidifiers may decrease pathogen loads in the litter, as well as pathogen movement to processing plants via the birds, thus becoming a useful tool in the overall Hazard Analysis and Critical Control Point (HACCP) plan. Acidifiers may diminish darkling beetle populations at higher application rates. Although PLT and Poultry Guard have not been evaluated for their potential to reduce the loss of phosphorus and soluble metals in runoff from land-applied litter, they are unlikely to be as effective as alum because of their chemical compositions. Hence, the use of alum may improve water quality by reducing the potential of phosphorus and heavy metals to reach streams and rivers.

Because there is growing interest in basing poultry litter land-application rates on the phosphorus content of litter instead of the N content, growers may be able to apply alum-treated litter (due to lower soluble phosphorus content) at higher rates than untreated litter. For this to happen, the North Carolina Phosphorus Loss Assessment Tool (PLAT), which is used to assess the risk of phosphorus losses in runoff or leaching from agricultural land, would have to be modified to account for the reduced soluble phosphorus content of alum-treated litter. Finally, higher nitrogen content (as well as reduced phosphorus levels with alum) will result in a more balanced fertilizer because the nitrogen/phosphorus ratio of the litter will be closer to the requirements of most crops. Overall, acidifiers are the most effective and widely used type of poultry litter amendment.

Alkaline Materials

Materials such as agricultural lime (CaCO_3), hydrated or slaked lime (Ca(OH)_2), or burnt lime (CaO) increase litter alkalinity (to a pH greater than 7) and convert more of the ammonium in the litter into ammonia gas. The amount of ammonia produced is governed by the litter pH, which depends on the amount and type of amendment. Burnt lime is the most effective in raising pH, and lime is the least effective. Combining ventilation and heating with the application of alkaline material between flocks can lead to the venting of large amounts of ammonia, which will result in lower ammonia levels later when the chicks are placed in the house. Adding alkaline material may also reduce soluble phosphorus levels in the litter. However, when this method is used and ammonia is released into the atmosphere, the fertilizer value of the litter diminishes, and there may be a negative impact on the environment. In addition, if the alkaline material is not completely used up during the layout period between flocks, ammonia levels in the house may increase when fresh manure is added to the litter.

Five types of litter amendments are available to manage ammonia: acidifiers; alkaline material; adsorbers; inhibitors; and microbial and enzymatic treatments.

Adsorbers

Naturally occurring materials like clinoptilolite (a type of zeolite, a natural clay mineral) and peat tend to adsorb ammonia (i.e., bind on the surface instead of absorb). However, the performance of clinoptilolite has been mixed. Nakaue et al. (1981) reported modest reductions in ammonia levels in the poultry house, while Amon et al. (1997) reported large increases in ammonia levels when clinoptilolite was applied to litter. Researchers in Finland used peat as litter material in poultry houses and reported lower ammonia levels. However, in North Carolina, using peat as litter in place of the cheaper and more abundant wood shavings may not be economically attractive.

Inhibitors

Inhibitors slow the conversion of uric acid and urea to ammonia by inhibiting enzymes and microorganisms. Phenyl phosphorodiamidate inhibits urease activity, reducing conversion of urea into ammonia (McCrary and Hobbs, 2001). However, McCrary and Hobbs report that inhibitors are currently too expensive and too easily broken down to be practical or economical to growers.

Microbial and Enzymatic Treatments

Such treatments may consist of beneficial microbes and enzymes that create the right environment in the litter to convert uric acid and urea rapidly into ammonia. The manufacturers of these products say that such treatments allow microbes to work in suboptimal conditions in the litter or improve the conditions in the litter to enhance performance of the microbes or the enzymes. Venting the produced ammonia during layout will result in lower ammonia levels when the chicks are placed in the house later. One microbial product, USM-98, marketed by UAP Southwest [(903) 855-0481] of Pittsburg, Texas, was evaluated in North Carolina by UAP Southwest, which reported that the product reduced ammonia levels, improved bird weight, and reduced mortality and crust loads. However, since the above statements come from studies not published in scientific journals, they were not reviewed by impartial scientists. Further, venting ammonia into the environment degrades air quality.

Summary

High ammonia levels in a poultry house can reduce bird performance and health, reducing profits to the grower and integrator. Using litter amendments after each flock is removed can reduce these ammonia levels, and it also may decrease energy use by reducing ventilation needs during the winter. Acidifiers, the most widely used type of amendment, lessen ammonia levels by converting ammonia to ammonium. Reducing ammonia losses also will improve the fertilizer value of the litter. Odor complaints from neighbors may be reduced. Pathogen and pest levels may also decrease.

A grower or applicator should follow the instructions provided by the manufacturer or supplier on how and when to apply the amendment to make sure that the material is fully activated and effective. Different amendments may require different application or activation methods. Personal protective equipment should be worn while applying amendments — at a minimum, protective gloves, long pants, a long-sleeved shirt, goggles, and a mask (to guard against “dust” from granular material). The grower/applicator should obtain a Material Safety Data Sheet (MSDS) from the supplier to be aware of the hazards associated with use of the material. The MSDS also will be useful to emergency responders in case of an accident.

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