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Alum in Poultry Litter[†]

The use of alum in poultry houses to control ammonia odors has become a common practice. This practice also enhances the fertilizer value of poultry litter. Published research from Arkansas and limited experiences in Alabama indicate that it is a practical and economical way of doing both.

Background

When several flock of broilers are produced on the same bedding (shavings, peanuts hulls, or rice hulls), ammonia levels in the air can become so high in the house that the health of the birds (not to mention the humans working in the houses) could be in jeopardy. Over the years, broiler producers have tried numerous remedies. Several commercial products are on the market. Most work; cost is the main concern. One proven method is to apply approximately 100 pounds of normal superphosphate fertilizer per ton of litter in the house (ACES Cir. ANR-244). The phosphate will trap the ammonia as ammonium phosphate. While this method increases the value of the litter by increasing its nitrogen concentration, it also adds additional P to the litter. Excessive P on litter-treated fields is already an environmental concern and additional P is not needed. Also, normal superphosphate fertilizer is not as available as it used to be.

The soil pH beneath the litter tends to increase with time. As the soil pH increases, the ratio of ammonia (NH_3) to ammonium (NH_4^+) increases. A high soil pH (above 7.0) not only aggravates the ammonia problem in houses, but favors the survival of pathogens such as *E. coli* bacteria. Efforts to lower the pH of broiler house floors in Alabama have utilized elemental sulfur, alum (aluminum sulfate), phosphoric acid, and hydrochloric (muriatic) acid with varying degrees of success. Commercial products are available that contain sodium hydrogen sulfate (NaHSO_4) and a calcium-iron silicate with phosphoric acid coating. There may be others.

Some producers have added lime to litter in an attempt to reduce fly problems. Unfortunately, some have added ground agricultural limestone which is calcium carbonate lime (CaCO_3). This does nothing to control the fly problem and makes the ammonia problem worse. Hydrated lime or calcium hydroxide [$\text{Ca}(\text{OH})_2$] which is also called "builders lime" is the lime which should have been used. This lime reacts with moisture in the manure to create heat which dries out the manure, thus controlling fly problems. Unfortunately, hydrated lime will also raise the pH very high and aggravate ammonia problems.

[†] This publication is an update of T.I. no. S-01-97, May, 1997.

Alum [aluminum sulfate, $(\text{Al}_2\text{SO}_4 \cdot 18\text{H}_2\text{O})$] or elemental sulfur (S) is routinely recommended to lower the pH of overlimed soils where acid-loving plants are to be grown. In poultry broiler houses where the soil remains rather dry, these products may not be as effective at lowering the soil pH as a liquid such as dilute muriatic acid (HCl) or phosphoric acid (H_3PO_4).

Alum

Arkansas research has shown that alum may be very effective at reducing ammonia odors when it is applied to litter in the house. In laboratory studies, alum rates equivalent to 130 to 260 pounds alum per ton of litter (65 to 130 g alum/kg) reduced total ammonia-N losses from over 28 pounds N per ton litter to less than 1 pound N per ton litter over a 42-day period. Phosphoric acid was also very effective, but this treatment requires special equipment to handle the liquid acid, is expensive, and adds more P to the litter. More P is not needed. Ferrous sulfate was also effective in reducing ammonia volatilization, but cases of catastrophic mortality have been reported due to iron toxicity when ferrous sulfate is used in broiler houses.

Cost

Increased ventilation in the broiler house is the normal way to control ammonia. However, in the winter when heating costs are already high, this only adds to the costs. Moore et al. (1996) calculated that if the outside temperature was 45°F, ventilation costs would add approximately 5¢ per pound of bird when ammonia concentrations in the air increased from 25 to 85 parts per million (ppm). In a house with 19,000 birds weighing 4 pounds each, this would be about \$3,800 per flock. They suggested applying around 2 tons of alum to the house to achieve the same effect. They calculated the cost to be around \$100 per ton (or 5¢ per pound of alum) in Arkansas in 1995. Two dealers in Alabama quoted 1997 prices for alum in 50 pound bags at 17 to 24¢ per pound (\$340 to \$480 per ton). At a rate of 2 tons per house, the cost of alum at 1997 prices would still result in substantial savings over the cost of ventilation at 1995 prices. Alum is widely used to remove particulates in municipal water-treatment plants.

Rate to Apply

Rates used by the Arkansas researchers (Moore et al., 1996) in their laboratory studies were equivalent to 130 to 260 pounds alum per ton of litter. At this rate, the cost would be extremely high considering that a house may contain more than 100 tons of litter. However, the Arkansas researchers used an example of 2 tons per house containing 19,000 birds. This is both practical and economical. When surface applied over litter, perhaps, they reasoned that a lower rate would be effective at trapping the ammonia.

What happens

The ammonia that is released from the manure is trapped by the alum (aluminum sulfate) as ammonium sulfate $[(\text{NH}_4)_2\text{SO}_4]$. Some moisture is required for this reaction. Aluminum reacts with water to form gibbsite $[\text{Al}(\text{OH})_3]$. This releases H^+ which acidifies the litter, thereby lowering the pH and trapping more ammonia gas (NH_3) as ammonium (NH_4^+).

Added benefits

When ammonia is trapped in the litter rather than being lost to the air, the fertilizer value of the litter increases. In the Arkansas lab, the total inorganic N in broiler litter after 42 days ranged from 10 pounds N per ton where no alum was applied up to 28 pounds N per ton where the high rate of alum was used - an increase of 18 pounds of plant-

available N per ton. At 2005 fertilizer prices, this would add more than \$8 per ton to the fertilizer value of the litter.

Ammonia released to the atmosphere has been implicated in acid atmospheric deposition, not to mention nuisance complaints by neighbors. Keeping the ammonia in the litter has both positive environmental and public relations benefits.

Additional research has shown that aluminum from alum reacts with water-soluble phosphorus in litter to form insoluble aluminum phosphates. This reduces the probability of P runoff from fields that are already very high in soil P (Moore and Miller, 1994). As more litter is applied to fields around and near poultry-producing areas, excessive soil P may limit additional litter applications. When excessive P gets into surface waters, eutrophication may occur. Eutrophication results from excessive algal growth and decay which results in oxygen depletion in waters and fish kills. In some states where there are few alternatives except to land apply litter, higher disposal rates of litter may be applied if the litter is treated with alum to reduce the potential for phosphorus runoff.

Negative effects

Most Alabama soils need lime for optimum pasture and crop production. Broiler litter contains some lime which is fed to the birds. One ton of broiler litter, on the average, contains the equivalent of about 300 pounds of lime. Producers who soil test and use broiler litter on their crops, rarely have to apply ground agricultural limestone. However, when alum is applied to trap ammonia, it will acidify the litter. As mentioned earlier, alum is often recommended to lower the soil pH (increase acidity) for acid-loving plants. As more alum is used in broiler houses, producers who use litter as a fertilizer may find that they need to also apply agricultural lime. The added value of the N in the litter may be offset by the grower's added cost of agricultural limestone. In Alabama, all land that receives animal wastes must be soil tested at least every 3 years. The soil test will indicate the drop in soil pH and will recommend ground limestone to correct the situation.

Summary

Alum is being used in poultry houses in Alabama to (1) reduce ammonia odors and (2) reduce the solubility of phosphorus in the litter. Arkansas research has proven that it is effective and economical. It also adds value to the litter by increasing the N concentration of the litter, but it may increase soil acidity (lower pH) when the litter is land applied. Optimum rates of application are not clear, but around 2 tons per house containing 19,000 birds has been suggested. It needs to be applied whenever ammonia levels reach a critically high concentration that is not economical to control with ventilation.

References

- Moore, P.A., Jr. and D.M. Miller. 1994. Decreasing phosphorus solubility in poultry litter with aluminum, calcium and iron amendments. *J. Environ. Qual.* 23:325-330.
- Moore, P.A., Jr., T.C. Daniel, D.R. Edwards, and D.M. Miller. 1996. Evaluation of chemical amendments to reduce ammonia volatilization from poultry litter. *Poultry Science*: 75:315-320.

Some frequently asked questions about alum in poultry litter:

Does alum affect the N availability in poultry litter?

About 2/3 of the total N in poultry litter is readily available anyway. Any increased N from the addition of alum would be 100% available as ammonium sulfate. A litter analysis will report this as ammonium-N or $\text{NH}_4\text{-N}$.

Is the phosphorus in chicken litter treated with alum plant available?

The short answer is that alum reduces P availability because it converts soluble calcium phosphates into relatively insoluble aluminum phosphates. Of course, not all the phosphate is converted so considerable calcium phosphates remain in the litter. On the other hand, this is really not a big issue when litter is used as a fertilizer because excess P is usually applied anyway. Consider that a ton of litter may contain as much as 70 pounds P_2O_5 . This is more than is normally recommended for most soil situations. Also the Mehlich-1 extract used by many of the southern soil testing laboratories tests mainly the more soluble calcium phosphates. It does a poor job of extracting the less soluble iron and aluminum phosphates which occur normally in acid soils. Therefore, if the soil test is "HIGH", then no more P is needed anyway and any applied in litter is just more P in the soil.

Does alum affect K levels and availability in any way?

NO

Does PLT® have the same effect on N, P and K as alum?

PLT®/Poultry Litter Treatment is a trademark of Jones-Hamilton Co., Walbridge, Ohio. The product's active ingredient is sodium hydrogen sulfate (NaHSO_4) which is mentioned in the above information. It is water soluble, acid forming and may also trap ammonia as ammonium sulfate. It could also increase the N value of the litter but should have no effect on other nutrients.

Will alum in poultry litter make my soil more acid?

Alum will acidify the litter somewhat, but I doubt if most growers who use poultry litter as a fertilizer and soil test every 3 years will notice much difference in their ground limestone recommendations.

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