Alum-Treated Poultry Litter as a Fertilizer Source

Chad Penn
Associate Professor
Plant and Soil Sciences

Hailin Zhang
Professor
Plant and Soil Sciences

Oklahoma Cooperative Extension Fact Sheets are also available on our website at:
http://osufacts.okstate.edu

Use of Alum in Poultry Houses

Alum is the common name for aluminum sulfate [$Al_2(SO_4)_3$], which is commonly applied to poultry houses for several purposes:

1. To reduce ammonia levels in the house.
2. To reduce pathogen levels in litter and on birds.
3. To improve bird performance (due to less ammonia and fewer pathogens).
4. To reduce energy costs due to less ventilation required to remove ammonia.
5. To increase nitrogen content of the litter.
6. To reduce water soluble phosphorus (P).

Alum used for poultry houses is sold under the commercial name of "Al^+ Clear" in either liquid or dry form. Alum should not be confused with other litter treatment chemicals such as "PLT" (poultry litter treatment), as PLT is comprised mainly of sodium bisulfate ($NaHSO_4$). Although PLT is effective at reducing ammonia levels, pathogens in house, energy costs, and potentially increasing forage yields, this product will have little impact on P solubility and subsequent runoff concentrations upon land application of treated litter. For alum, the active component is aluminum and for PLT the active component is the bisulfate (HSO_4^-), not to be confused with sulfate (SO_4^{2-}). Both alum and PLT acidify litter. However, application of the treated litter to soils for crop nutrients does not cause the soil to acidify.

Alum is typically applied to poultry houses at a rate of 5 percent to 10 percent by weight of the litter (or 0.1 lb/bird to 0.2 lb/bird). Thus, for a typical poultry house (16,000 ft^2) containing 20,000 broilers, a 5 percent alum application would equal 1 ton alum per flock or 125 lb/1000 ft^2. For a 10 percent application, 2 tons of alum would be applied per flock or 250 lb/1000 ft^2. These calculations assume that an average broiler weighing 4 lbs produces 2 lbs of manure. For larger birds (6 lbs), the recommended alum application rate increases to 0.15 and 0.30 lbs/bird for a 5 percent and 10 percent rate, respectively.

Phosphorus content of alum treated vs. normal litter

In theory, alum applications only have an impact on the forms and water solubility of P in poultry litter, not the total mass of P contained in it. For instance, in a poultry barn containing 20 tons of litter with a P concentration of 1.3 percent, the total amount of P in the barn is 520 lbs. If that same barn is amended with alum at a rate of 10 percent by weight, the total amount of P in the barn remains unchanged at 520 lbs. However, the *concentration* of P in the alum treated litter will decrease by 10 percent due to simple dilution with alum. Using the same example, a 10 percent alum application to this barn will change the P concentration from 1.3 percent (26 lbs P/ton or 59.5 lbs P_2O_5/ton) to 1.17 percent (23.4 lbs P/ton or 53.6 lbs P_2O_5/ton), a small decrease in P concentration. When obtaining litter on a mass basis (i.e. equal tonnage), alum litter purchases will result in slightly less P compared to normal litter. Another way to think of this is that it would require slightly more alum-treated litter than normal litter in applying equal amounts of total P and other nutrients to a field.

Reduction in phosphorus loss through alum treatments

Alum serves to reduce transport of P from agricultural land to surface waters by significantly decreasing the water solubility of P in litter. As a result, when litter is land applied to

fields, there is less dissolved P produced in runoff from alum-treated litter compared to that of normal litter. The mechanism by which alum reduces water solubility of P is through binding of P onto the added aluminum as show below:

$Al^{3+} + H_2PO_4^-$ (water soluble P) -----> $AlPO_4$ (water insoluble) + $2H^+$ (acidity generated)

Figure 1 shows the significant reduction of P loss in runoff from alum-treated litter compared to normal litter. In addition to P, treatment of litter with alum has also been shown to reduce transport of heavy metals and naturally produced hormones upon land application (relative to normal litter).

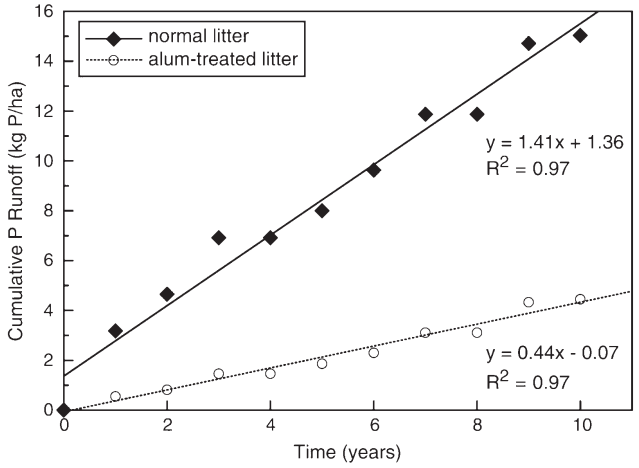


Figure 1. Cumulative phosphorus (P) loads in runoff from paired watersheds fertilized with alum-treated and normal poultry litter (adapted from Moore and Edwards, 2007).

Plant availability of phosphorus in alum-treated litter

Because of the ability of alum to reduce the water solubility of litter P, there have been questions in regard to the plant availability of P in alum-treated litter. Does the aluminum tie-up P so strongly that it might not be available for uptake by a growing plant? Based on recent studies focused on P uptake by tall fescue and soil test P values, the answer is "no." Mehlich-3 extractable P is the soil test used to estimate plant available P in both Oklahoma and Arkansas. Research has shown that soils receiving alum-treated litter over 7 years resulted in similar Mehlich-3 extractable P to un-treated litter (Figure 2).

More convincing are studies showing that there is no significant difference in P uptake in tall fescue between soils amended with alum-treated litter compared to normal litter (Figure 3). This suggests the P in alum-treated litter has a similar availability as untreated litter.

At first, the ability of alum to reduce water solubility of P without compromising plant availability might seem like a contradiction. However, the explanation is found in the mechanisms by which alum binds P and how plant roots extract P from soils. Recent research has shown that alum not only binds inorganic P with the added aluminum, but it also stabilizes or

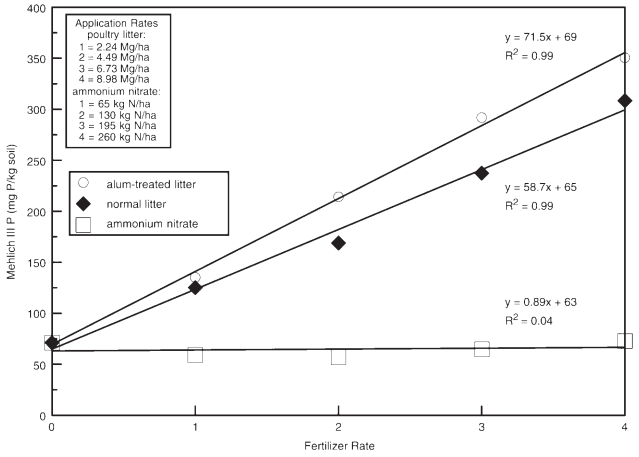


Figure 2. Mehlich 3-extractable P (0 to 5 cm) in soil as a function of fertilizer application rate after 7 yr of fertilization ($LSD_{0.05}$ = 47.3). Data from Moore and Edwards, 2007.

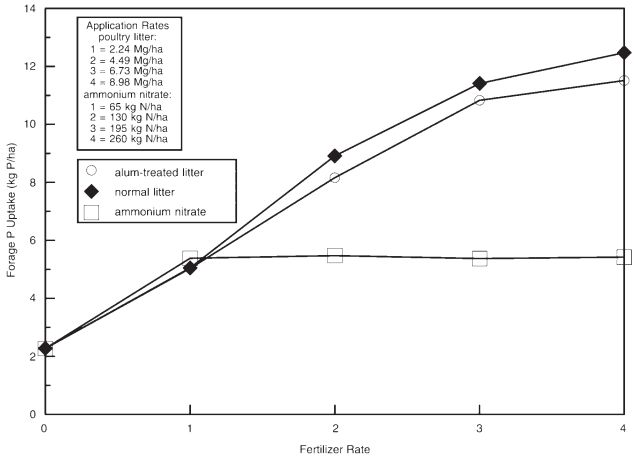


Figure 3. Average P uptake by tall fescue during Year 7 as a function of fertilizer rate ($LSD_{0.05}$ = 3.8). Data from Moore and Edwards, 2007.

prevents decomposition of organic P. Stabilization of organic and inorganic P helps to depress its water solubility. However, this stabilized P is still available to plants since plant roots typically excrete organic acids and chelating agents to help aid in obtaining P that is non-water soluble. In this regard, alum-treated litter behaves like a "slow-release" P fertilizer. On the other hand, the P in un-treated litter is also subject to fixations by soil components.

Does aluminum additions to soils through application of alum-treated litter result in potential aluminum toxicity?

In recent years, there has been some concern about the possibility of aluminum toxicity among soils amended with alum-treated litter. However, alum-treated litter is no more likely to cause aluminum toxicity than normal litter. In fact, use of ammonium nitrate as a nitrogen source (without lime additions) will generally result in much greater soil exchange-

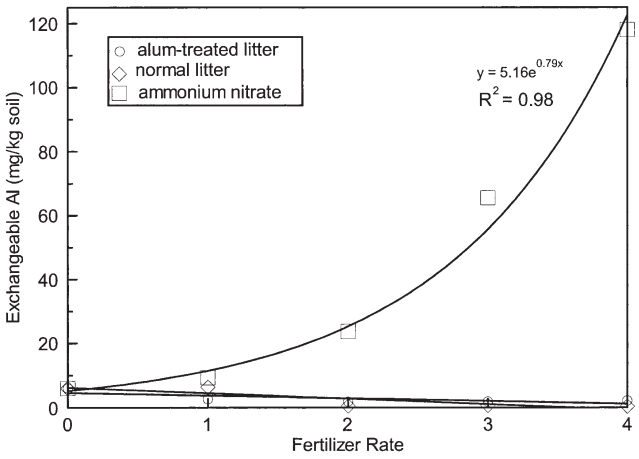


Figure 4. Exchangeable Al as a function of fertilizer treatment and rate after 7 yr ($LSD_{0.05}$ = 15.1). Samples taken from the 0- to 5-cm depth. Fertilizer rates (Rates 1, 2, 3, and 4) were about 2, 4, 6, and 8 tons per acre for poultry litter and 60, 120, 180, and 240 lbs N per acre as ammonium nitrate. Data from Moore and Edwards, 2007.

able aluminum concentrations compared to using either alum-treated or normal litter as a nitrogen source for crops (Figure 4).

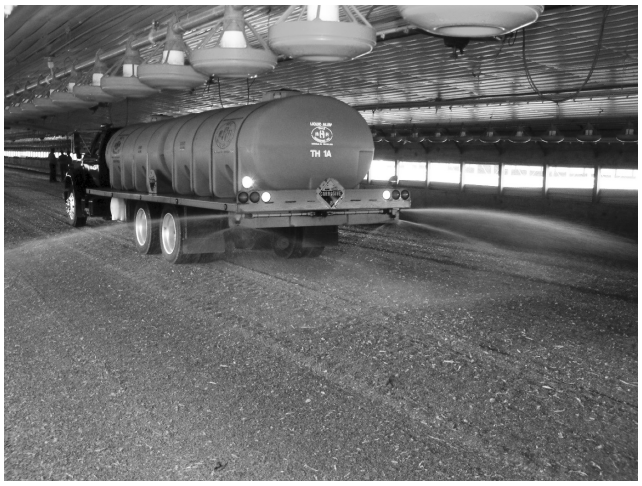
The explanation for this is that soil exchangeable aluminum concentrations are mostly controlled by soil pH. Because alum-treated and normal litter tends to maintain or increase soil pH in acid soils, added aluminum will not be soluble if soil pH is in the normal range (>5.0). On the other hand, ammonium nitrate has an acidifying effect on the soil, thereby resulting in increased exchangeable aluminum concentrations as soil pH decreases.

Nitrogen content of alum-treated litter

One of the benefits of using alum-treated litter is that the nitrogen concentration tends to be elevated compared to normal litter. Therefore, on an equal mass application basis, more nitrogen is applied to soils for alum-treated litter compared to normal litter. A large scale study involving 194 poultry houses conducted on the Delmarva (Delaware-Maryland-Virginia) Peninsula showed that average total nitrogen contents of alum-treated litter was 4.24 percent compared to 3.97 percent for normal litter. As a result, when applied on an equal mass basis, yields from crops amended with alum-treated litter are sometimes higher than that amended with normal litter due to the higher nitrogen application with alum-treated litter.

Safety precautions when applying alum to poultry houses

The acidic nature of alum requires it to be treated with extra care and caution, similar to all acids. Applicators should always wear goggles for eye protection and a dust mask to avoid breathing alum dust, particularly if a spreader is used that broadcasts the material. Gloves should also be worn when handling alum to prevent skin irritation. The acid in alum will be neutralized in the litter after two to four weeks depending on application rate. Thus, there are no precautions needed for handling the litter at cleanout. Minimize exposure of equipment and footings to alum since acids are corrosive to metal surfaces. Growers should also be aware that application of alum to the litter does not mean that ventilation can be completely ignored. Since birds generate a great deal of moisture throughout the life of the flock, it is essential that producers provide the required minimum ventilation from day one so that moisture buildup in the house is prevented.



References and Other Related Fact Sheets

Moore, P.A. and D.R. Edwards. 2007. Long-term effects of poultry litter, alum-treated litter, and ammonium nitrate on phosphorus availability in soils. J. Environ. Qual. 36:163-174.

Warren, J.G., C.J. Penn, J.M. McGrath, and K. Sistani. 2008. The impact of alum additions on organic P transformations in poultry litter and soils receiving alum-treated poultry litter. J. Environ. Qual. 37:469-476.

Zhang, H., D.W. Hamilton, and J. Payne. 2013. Using poultry litter as fertilizer. PSS-2246.

The Oklahoma Cooperative Extension Service
Bringing the University to You!

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of the Cooperative Extension system are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and research-based information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
- It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
- Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Robert E. Whitson, Director of Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of 20 cents per copy. 0213 Revised GH