Effectiveness of Litter Treatments for Reduction of Ammonia Volatilization in Broiler Production

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Species: Poultry (Broiler)
Use Area: Animal Housing
Technology Category: Chemical Amendment
Air Mitigated Pollutants: Ammonia

Description:

In commercial broiler production, a little over one ton of litter is produced per 1,000 birds and during the course of a year this could lead to 125 tons produced per 20,000 bird house. Built-up litter propagates higher in-house ammonia levels, which can adversely affect poultry health by making the birds more susceptible to respiratory diseases. Techniques to reduce ammonia levels and pathogenic microbes include changes in management practices and use of litter treatments. Most litter treatments are typically effective for only 3-4 weeks; whereas, broilers are housed for six or more weeks prior to slaughter. Information to be presented summarizes a series of experiments that evaluated six litter treatment strategies applied at three levels in reducing ammonia volatilization during broiler production: Poultry Litter Treatment (PLT™), granulated aluminum sulfate (Al-Clear™), Poultry Guard™, hydrated lime, liquid acidified aluminum sulfate (A-7™), and concentrated sulfuric acid.

Mitigation Mechanism:

Interest in the use of litter treatments has steadily increased over the last decade as growers and technical personnel alike recognize the health and productivity benefits of improving the broiler house environment. It is known that high ammonia levels make birds more susceptible to respiratory diseases. Numerous laboratory and field studies have shown how ammonia levels as low as 10 ppm affect bird health and performance (Carlile, 1984). Ammonia levels above 25 ppm in the poultry house can damage the bird's respiratory system and allow infectious agents to become established, leading to declining flock health and performance. Resistance to respiratory disease may be decreased and *E. coli* bacteria can be significantly increased in the lungs, air sacs and livers of birds exposed to ammonia because of damage that occurs to the tracheal cilia. In addition, body weight, feed efficiency and condemnation rate may be compromised in birds exposed to levels of ammonia exceeding 10 ppm.

Most litter treatments used in the broiler industry involve chemical reduction of litter pH so that bacteria associated with ammonia release are either inactivated, reduced in number or both. The volatilization of ammonia has been attributed to microbial decomposition of nitrogenous compounds, principally uric acid, in poultry house litter. Once formed, free ammonia will be in one of two forms: as the uncharged form of NH_3 (ammonia) or the ammonium ion (NH_4), depending on litter pH. Ammonia volatilization remains low when litter pH is below 7.0, but can be substantial when above 8.0. Uric acid decomposition is most favored under alkaline (pH>7) conditions. Uricase, the enzyme that catalyzes uric acid breakdown, has maximum activity at a pH of 9. As a result, uric acid breakdown decreases linearly for more acid than alkaline pH values. One principal ureolytic bacterium, *Bacillus pasteurii*, cannot grow at neutral pH, but thrives in litter above pH 8.5. Typically, litter pH in a broiler house ranges between 9-10.

Gaseous emission of NH_3 can be inhibited if converted to NH_4^+ (ammonium); which can be accomplished by lowering litter pH. In general, an effective litter treatment results in the production of hydrogen ions (H^+) when it dissolves and the hydrogen ions produced by this reaction will attach to ammonia to form ammonium, which further reacts with sulfate ions to form ammonium sulfate $(NH_4)_2SO_4$. Ammonium sulfate is a water-soluble fertilizer. As a result of these acid-based reactions, the amount of ammonia emitted from the litter will be reduced; which should increase the nitrogen (N) content of the litter.

Applicability:

The main goal in using a litter treatment is to effectively reduce ammonia emissions from poultry facilities, which will have a direct effect on improving litter management, nutrient enrichment, and reducing ammonia volatilization from poultry house litter. Recent research completed in the Department of Poultry Science at Auburn University has focused on a series of litter treatment experiments to evaluate six litter treatments at three application levels to evaluate their ability to prolong litter usage and to reduce ammonia volatilization and pathogenic microorganisms associated with this material. Poultry Litter Treatment (PLT™), granulated aluminum sulfate (Al-Clear™) (GA), Poultry Guard™ (PG), and Hydrated Lime (HL), were applied at 24.4, 48.8, or 73.2 kg/100 m^2 (50, 100, or 150 lbs/1000 ft^2); a

liquid acidified aluminum sulfate (A-7^{TM}) (LA), was applied at 81.4, 162.8, and 227.1 L/100m^2 (20, 40 or 60 gal/1000 ft^2); and concentrated sulfuric acid (98% H_2SO_4) (SA) was applied at 9.75, 19.50, and 29.26 kg/100m^2 (20, 40, or 60 lb/1000 ft^2) on new pine sawdust bedding and tested against a non-treated control (CON).

In each experiment, a total of 1120 commercial broiler chicks (Cobb X Ross) were obtained from a commercial hatchery and were randomized with 70 birds assigned to each of 16 enclosed chambers (2.44 x 2.44 x 2.44 m; 8 x 8 x 8 ft). Birds were fed a corn-soybean meal starter (0.68 kg/bird; 22% CP, 3087 kcal/kg ME), grower (1.36 kg/bird; 20% CP, 3131 kcal/kg ME), finisher (1.81 kg/bird; 17.5% CP, 3197 kcal/kg ME) and withdrawal (c.a. 1.36 kg/bird; 16.5% CP, 3219 kcal/kg ME) to meet or exceed NRC (1994) requirements. New pine shavings (54.42 kg; 120 lbs) were placed in each pen at the start of each experiment. Feed and water were provided *ad libitum* with 24 hr light. Birds and feed were weighed at 21, 42 and 49 d to determine growth and feed performance. Litter and air quality samples were obtained for analysis initially and weekly through day 49. Ammonia measurements were conducted using a closed container of specified dimension (46 x 36 x 12 cm; 21 x 15.5 x 5 in) inverted over the litter bed and determined using a Drager CMS Analyzer equipped with a remote air sampling pump and appropriate ammonia sampling chip (0.2-5, 2-50, or 10-150 ppm). The tube from the sampling pump was located in the top center of the container. The sampling pump was evacuated (calibrated) for 60 seconds followed by a measurement period of up to 300 seconds. Most readings were usually achieved with 60 seconds following evacuation. Litter was collected weekly, starting the day prior to chick placement and continued through day 49. Collection was performed in each pen by using the grab sampling technique. Individual litter samples (3g) were mixed with 60 ml distilled water for pH measurement. Data from these experiments was analyzed by analysis of variance using the General Linear Models procedure of the Statistical Analysis System (SAS Institute, 1997). When significant ($P<0.05$), means were separated by Tukey's HD multiple comparison procedure.

There were no differences ($P>0.05$) in growth performance in any experiment attributed to type or level of litter treatment. Initial litter pH was significantly lower ($P<0.05$) for PLT, GA, PG, LA, and SA treated pens as compared to CON (ca 2.3 vs. 6.4) and was influenced by level of application. Results indicated that PLT, GA, and LA significantly ($P<0.05$) reduced ammonia volatilization as compared to CON through day 42 at the intermediate and highest application rates. SA significantly ($P<0.05$) reduced ammonia volatilization through day 35 at only the highest application rate as compared to CON. Although PG exhibited the ability to lower pH, it failed to elicit a significant ($P>0.05$) reduction in ammonia. Conversely, HL elevated litter pH initially as compared to CON (12.8 vs. 6.3), but this effect disappeared after day 21. HL failed to support any reduction in ammonia volatilization. Litter analysis results did not indicate a significant ($P>0.05$) increase in amount of nutrients retained due to treatment. Results indicate that PLT, GA, LA, and SA were capable of reducing ammonia volatilization during broiler production. Results show that higher levels of litter treatments can extend ammonia control and may contribute to improvements in bird health. In these trials, ammonia levels were often controlled at the intermediate and highest application levels for up to 42 days (starting with new pine shavings litter).

Limitations:

Litter treatments, by nature, can be corrosive and hazardous to work with and appropriate measures as defined by the manufacturer should be observed during handling and application procedures. As with any acid-based material, gloves, eye protection and appropriate clothing should be used. In some cases the litter treatment may be applied by a professional applicator, thus reducing hazards to the producer during handling and application.

Cost:

The delivered cost of a litter treatment is highly dependent upon transportation costs and competitive pricing offered among manufacturers and distributors. Also, costs for transporting, handling, and applying dry versus liquid products should also be considered. Due to the competitive nature of pricing for the various litter treatment products it is difficult to provide a reasonable and consolidated cost for the treatments tested in these experiments. However, it can be concluded that low levels (50 lb/1000 ft^2) only provide ammonia control during the brooding period (maybe for 3 weeks); whereas higher application rates will extend the effective period for ammonia control, but the producer must balance the cost of applying a higher level of litter treatment with benefits associated with longer ammonia control.

Implementation:

Originally, litter treatments were placed at a relatively low level (generally 50 lb/1000 ft^2) to give early ammonia control during the brooding period. More recently, higher levels have been suggested as the industry becomes more comfortable with the performance benefits associated with improving air quality in the broiler house with litter treatment use. Broiler growers must balance the cost of applying extra amounts of a litter treatment and benefits associated with longer ammonia control. In general, though, improved bird health normally translates into improved broiler weights and improved feed efficiency.

A principal question for those involved in poultry production is: "What is the best litter treatment?" Unfortunately, this most frequently asked question has no general answer and the difficulties in addressing this question may be complicated and numerous. There has never been an experimental study evaluating the various litter treatment products under various management conditions. Litter moisture, brooding and lighting programs, ambient temperature, strain type, ventilation management, litter management, and disease challenge are only a few of the variables that have a potential impact on product selection, efficacy and potential return on investment.

In selecting a litter treatment product, one must identify the goals for application. Litter treatments may be cost-effective and justifiable under one or more of the following situations:

- high fuel prices
- extreme cold weather
- short layout periods
- persistent disease challenges
- severe vaccination reactions
- reduction of ammonia-related stress
- prolonged litter reuse
- increased bird density
- address marginal management or housing situations

In general, control of house ammonia level is the primary purpose for using a litter treatment. In recent years, reasons for using a litter treatment and any potential benefits from its use have expanded to include improvements in performance and environmental concerns. Some litter treatments may be used to enhance the composition of the litter as a fertilizer or as part of a best management practice to reduce food-borne pathogens. Ammonia-reducing litter treatments offer a potentially better in-house environment for the birds. They may also play a role in reducing ammonia and odor emissions from poultry facilities. Although different litter treatments vary in their ability to control ammonia, each offers a unique set of characteristics that need to be considered in selecting the appropriate product to meet an individual's needs. The litter treatment that offers the best return on investment will depend on the user's ability to select the product that best meets application goals.

To maximize the effectiveness of any litter treatment, one must properly prepare and apply the litter treatment in addition to managing the house and litter. Prior to application of any litter treatment, the house needs to be de-caked or tilled. Afterwards, the litter treatment can be broadcast at the chosen level using a drop or cyclone spreader or spray applied. Before birds are placed in the house, spills or concentrated areas should be raked into the litter to prevent consumption by the young birds. As with any litter treatment product, the rate selection for an individual's operation will be dependent on current management practices and needs based on such factors as ventilation control and litter moisture levels. Higher rates may be recommended when high ammonia conditions prevail. Litter treatments have become a common means of improving the broiler house environment throughout much of the broiler industry. It is likely that the use of these products will continue as growers manage reused litter to their best advantage.

Technology Summary:

Recently, poultry producers have come under increased regulatory scrutiny regarding the amount and type of emissions exhausted from poultry housing during the course of normal house ventilation. Ammonia and dust have both been discussed as potential problems with poultry house exhausts. The main goal in using a litter treatment is to effectively reduce ammonia emissions from poultry facilities, which will have a direct effect on improving litter management, nutrient enrichment, and reducing ammonia volatilization from poultry house litter. Research completed by the Department of Poultry Science at Auburn University indicates that increased levels of litter treatments can extend their ammonia control usefulness and most worked well with the exception of lime. In these experiments, ammonia levels were often controlled at the intermediate and highest level of application for 35 to 42 days. If more strict environmental regulations are put into effect regarding ammonia emissions from poultry facilities, litter treatments may become an important technique to allow producers to remain compliant.

The delivered cost of a litter treatment is highly dependent upon transportation costs and market competitiveness among manufacturers and distributors. Also, costs for transporting, handling, and applying dry versus liquid products should also be considered. Due to the competitive nature of pricing for the various litter treatment products it is difficult to provide a reasonable and consolidated cost for the treatments tested in these experiments. However, it can be concluded that low levels only provide ammonia control during the brooding period (maybe for 3 weeks); whereas higher application rates will extend the effective period for ammonia control, but the producer must balance the cost of applying a higher level of litter treatment with benefits associated with longer ammonia control.

Additional Resources:

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