MITIGATION STRATEGIES FOR AMMONIA MANAGEMENT

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Ammonia formation

Ammonia in poultry houses is not directly produced by the bird. Birds excrete nitrogen waste in the form of uric acid. Ammonia is formed through the breakdown of uric acid. More accurately the uric acid is broken down by microbial enzymes to form ammoniacal nitrogen. Conditions that favor bacterial growth will favor the production of ammoniacal nitrogen. These factors include warm temperatures, moisture, pH in the neutral range or slightly higher (7.0 – 8.5) and the presence of organic matter. All of these factors are normally present in abundance in poultry waste handling systems. The extent to which we can control some of these factors will influence the amount of ammoniacal nitrogen formed.

Ammonia forms

Once formed, ammoniacal nitrogen will exist as either ammonia or ammonium. Ammonia is the free gaseous form that is of primary concern. Ammonium is the ionic form and is most frequently bound to other molecules. Ionic binding of ammonium is dependant on the availability of anions (negatively charged particles) in the environment that are capable of reacting with ammonium. The strength of this binding is largely dependant on the properties of the molecule to which ammonium binds. Under most situations, the ionic binding of ammonium is quite reversible and thus ammonium may change to ammonia and *vice versa* if the environmental conditions change. The relative amount of each form present in any given situation is largely dependant on the pH of the environment. Ammoniacal nitrogen exists largely as ammonia at pH greater than 9.25 and at pH of less than 7 the ammonium form prevails. In practical terms, this means that at a pH above 7, the production of ammonia will occur.

Ammonia volitization

The underlying environmental difficulty with ammonia is related to the fact that it is a free gas. It moves throughout the environment quite easily, thus the impacts of ammonia are difficult to control because there are few effective means to control where ammonia will go after it is released. As with any compound, the key to appropriate environmental stewardship is to retain control of the compound. Once ammonia has volatized and left a layer facility, the control of its environmental impact is difficult at best.

Environmental Impact of Ammonia

Prior to examination of methods to reduce ammonia emissions from poultry houses it is best to briefly review the environmental impacts of ammonia and thus gain a perspective on why these emissions are of concern. When ammonia nitrogen is released to the atmosphere it can immediately contribute to the formation of haze and small airborne particles. As ammonia or ammonium are removed from the atmosphere through various processes, they can contribute to fertilization of ecosystems and thus change the biodiversity in the ecosystems. They can also acidify the environment and contribute to eutrophication of water bodies. “Ammonia can through these processes impact atmospheric visibility, soil acidity, forest productivity, terrestrial ecosystem biodiversity, stream acidity, and coastal productivity” (Galloway and Cowling, 2002). Because ammonia compounds can persist in the atmosphere for several days, these impacts may occur some distance from the source. It is estimated that animal agriculture is responsible for 50% of the ammonia entering the environment (van Aardenne et al. 2001). Thus it is imperative that animal agriculture take the issue of ammonia emissions seriously.

Strategies to reduce ammonia production of poultry facilities

Management and control of ammonia begins with a discussion of means to reduce the excretion of uric acid. A reduction in the amount of uric acid present will naturally lead to a reduction in the amount of ammonia that may be formed and released. Since uric acid is the end product of protein metabolism, it is natural to presume that reductions in the crude protein level of the feed will reduce the amount of uric acid – ammonia produced. Elwinger and Svenson, 1996 demonstrated that increasing crude protein levels in broiler diets from 18 to 20% yielded an almost 2% increase in nitrogen loss. Nearly all methods that these researchers used to evaluate ammonia levels indicated an increase in ammonia levels among the birds fed the higher protein level. Ferguson et al., 1998b compared low, medium and high crude protein levels in broiler diets. The low and medium treatments were supplemented with synthetic amino acids. Litter ammonia levels tended to be lower for the low and medium crude protein treatments compared to the high treatment. Litter pH of the low treatment was significantly reduced compared to the high treatment group. Litter moisture and total nitrogen was significantly reduced between the high and medium group and also between the medium and low treatment group. Terada et al. 1994, demonstrated that the inclusion of lactosucrose in broiler diets significantly reduced cecal ammonia levels. These researchers also noted a reduction in ammonia levels in the broiler pens.

Means to prevent uric acid conversion to ammonia

In addition to means to reduce uric acid excretion, ammonia management strategies also need to examine means to reduce the conversion of uric acid to ammoniacal nitrogen. Kim and Patterson, 2004, demonstrated that high level of zinc in broiler diets reduced nitrogen loss and increased the levels of uric acid in broiler manure samples. High zinc supplementation of may not prove feasible at these levels but this work demonstrates the potential for reduction of ammonia production through manipulation of the microbial enzyme activities.

Research has shown that antibiotics reduce the production of ammonia (Alvares, et al. 1964, Kitai and Arakawa, 1979). While it is not feasible or ethical to utilize antibiotics solely for the reduction of ammonia this work further demonstrates that the microbial environment of poultry manure can be altered to reduce ammonia production.

Means to prevent volitization of ammonia

Once ammoniacal nitrogen has been formed, the most appropriate strategy to control ammonia is to reduce ammonia volitization. This can be accomplished through several means. As mentioned earlier, the form of ammoniacal nitrogen is dependent on the pH of the environment. A number of compounds have been used to reduce the pH of poultry litter and/or manure to promote the formation of ammonium ions that will bind to other compounds and thus reduce the amount of volatile ammonia. Most compounds provide pH control but the counter-active force of the abundant organic matter tends to neutralize these acidifying agents thus they need to be applied frequently under most circumstances. Automated methods of spray applying compounds has been investigated. Other compounds approach the problem through acting as a sorbant of ammoniacal nitrogen. Several different types of extracts and proprietary compounds have been tested with varying levels of control. One factor that most producers can control with minimal relative cost is the moisture level of the manure. Ferguson et al. 1998a confirmed the relationship between higher litter moisture and increased litter ammonia. Increases in litter moisture from approximately 56% to 60% resulted in an increase in litter ammonia release. While keeping manure dry will not totally eliminate ammonia, it will enhance the effectiveness of all other ammonia control strategies. Other benefits to dry manure include odor and fly control. Means to control moisture can be as simple as routine drinker maintenance or as complex as the design of the entire caging system. The proper ventilation of a facility obviously plays a late role in moisture control.

Integrated approaches

Hale, 2005 reports that a dietary approach that utilizes lower protein, dietary acidifiers and zeolite absorbent compounds can reduce ammonia volitization from layer flocks by as much as 80%. In most situations, no single strategy will offer adequate ammonia control. An integrated approach will be required to accomplish significant reductions on ammonia emissions. Thus all aspects need to be examined. What impact (positive or negative) does each of the following have on ammonia production from your facility; diets, drinker maintenance, water quality, ventilation, and cage design. This list is not exhaustive but exemplifies the multiple factors that must be considered in approaching ammonia control. Beyond these factors, ammonia control products of various types can also be utilized but they are not a “magic bullet” that cures all problems. These products must be utilized in cooperation with the other good management strategies discussed.

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