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Ammonia production in the poultry houses and its harmful effects

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Abstract
The ammonia concentration in the poultry houses should not exceeds 25ppm. Above 25 ppm the performance of the birds affects adversely. High levels also reduces body weight gain, feed conversion, overall liveability, carcass condemnation rate and the immune system of the birds and susceptible to diseases. The presence of excessively high levels of ammonia in the air, for any time period, will lead to discomfort to the birds. Ammonia is a strong oxidative stressor that can cause irritation and inflammation. Birds exposed to high level of ammonia concentrations negatively affect the development of immune system. The rate of ammonia volatilization from litter is dependent on pH, moisture content, ventilation rate, air velocity, manure nitrogen concentration, and temperature. The pH of the litter is an important factor in controlling ammonia volatilization because it determines the ratio of volatile ammonia to ammonium, the ionic and non-volatile forms of ammonical nitrogen. The damage to the mucous membranes of the respiratory system caused by higher level of ammonia increases the susceptibility of birds for respiratory infection, especially *E. coli* infection. Human can generally smell ammonia at concentrations between 20 and 30 ppm. The ammonia gas in poultry sheds critically affects the health and welfare condition of the birds.

Keywords: Ammonia, causes, poultry house, harmful effects

Introduction
Ammonia is a gas present in the atmosphere of every poultry house and critically affects the health and welfare condition of the birds which results from the chemical decomposition of uric acid in droppings by certain bacteria in the litter. Ammonia production is particularly high in houses where old litter is used for rearing successive flocks. The litter generated in poultry houses during poultry production consists of manure and the bedding material used for rearing of birds. The rate of ammonia volatilization from litter is dependent on pH, moisture content, ventilation rate, air velocity, manure nitrogen concentration, and temperature. The pH of the litter is an important factor in controlling ammonia volatilization because it determines the ratio of volatile ammonia to ammonium, the ionic and non-volatile forms of ammonical nitrogen. The condition of litter and ventilation are the main factors affecting ammonia concentration in poultry houses. Moisture content, pH and the temperature of the litter influence the degradation of uric acid by bacteria. Poor ventilation, loose droppings and faulty, over filled or low positioned drinkers, are common causes of wet litter in poultry houses which ultimately increases the ammonia concentration. Since ammonia is a harmful gas to poultry birds, other livestocks, and workers associated, it also pollutes the environment at large. Therefore, several strategies have been employed to minimize NH3 volatilization into the environment which includes NH3 gas adsorbers, enzyme inhibitors, dietary manipulation and other litter additives/amendments such as aluminium sulphate and sodium bisulphate [1]. Alum-amended litter (1 kg m^{-2}) decreased atmosphere ammonia concentrations by 30% in broiler house and alum amended litter maintained a lower pH until 35 d of age [2]. Ammonia volatilization to the environment from poultry manure contributes to atmospheric nitrogen pollution, negatively affects poultry performance and decreases the fertilizer value of manure [3]. The ammonia concentration in the poultry houses should not exceeds 25ppm. Above 25 ppm the performance of the birds affects adversely. High levels also reduces body weight gain, feed

conversion, overall liveability, carcass condemnation rate and the immune system of the birds and susceptible to diseases. Ammonia gas has a characteristic pungent odour which at high concentrations it is irritating to the conjunctiva, corneas of the eyes and mucous membranes of the respiratory tract and. The damage to the mucous membranes of the respiratory system caused by higher level of ammonia increases the susceptibility of birds for respiratory infection, especially *E. coli* infection. Human can generally smell ammonia at concentrations between 20 and 30 ppm. Ammonia gas in poultry sheds critically affects the health and welfare condition of the birds. Good litter management and ventilation will minimise the level of ammonia, improve productivity, reduce the chances of occurrence of respiratory diseases, overall improvement of the birds' welfare and creates a pleasant, safe and peaceful environment for workers also.

Effects of Ammonia Gases

Respiratory System

Ammonia gas effects on the mucosal surface of the trachea causing paralysis of cilia, sometimes deciliation (loss of cilia) of epithelial cells and causes injury (necrosis) to the mucosal epithelium. Shrinkage of the mucosal epithelium, with loss of cilia and proliferation of goblet cells, are common lesions of aerial ammonia toxicity seen in the tracheas of affected birds. The nature and extent of damage depends on the concentration of ammonia in the poultry house and the duration of exposure. Cilia are tiny, hair-like projections on the surface of epithelial cells of respiratory tract. These cilia form the part of the "mucociliary apparatus" popularly called as mucociliary blanket or mucociliary escalator, consists of the cilia and secretion of mucus. Due to high concentration of ammonia in the poultry house the cilia become paralyzed or lost and the mucus on the mucosal surface of the trachea cannot be cleared, and thus entrap bacteria on dust particles may reach the lungs and air sacs and cause infection which otherwise have been prevented. The tracheal mucosa may become devitalized due to high incidence of airsacculitis, pneumonia and septicemia caused by *E. coli* in poultry flocks that have been exposed to high ammonia levels.

Eyes

High concentrations of atmospheric ammonia for prolong duration causes irritation, conjunctivitis and damage the cornea of the eyes. Swelling and reddening of the eyelids, irritation, reddening of the conjunctiva and nictitating membrane, and partial or complete closure of the eyes are common clinical signs. The eyelids are often closed shut in severe cases. Eyes may become almond shaped after prolong exposure to high ammonia concentration because of scarring and retraction of the eyelids. The severe conjunctivitis caused by high ammonia concentration also increases the risk and severity of swollen head syndrome in respiratory viral infections.

Cornea

Ammonia induced corneal erosion sometimes called "ammonia burn", but this term is inaccurate, as ammonia does not directly injure the corneal epithelium. The basement membrane on which the epithelium rests is damaged which is responsible for detachment of the epithelial layer, is the characteristic eye lesion resulting from exposure to excess ammonia. However, the periphery of the cornea is unaffected, probably because of partially covered by the eyelid and receives less exposure to ammonia than the central cornea. These birds may become partially to completely blind in long term exposure. In some cases, the denuded basement membrane is thickened and basophilic because of the deposition of calcium salts and the band of mineralized basement membrane is known as "calcifyc band keratopathy" which is characteristic of ammonia toxicity in poultry.

Ammonia emissions

Ammonia in a poultry house comes from the birds themselves. Due to bad litter management ammonia problem is seen in poutry houses reared under deep litter. When the birds fed high protein diet then unused nitrogen is excreted as uric acid (80%), ammonia (10%), and urea (5%) [4]. When ammonia gas is exposed to moisture, it reacts and forms corrosive solution called ammonium which causes harm to birds. The ammonium corrodes the lining of chickens' respiratory tract causing paralyses cilia. Due to paralysis of cilia of trachea, the mucus on the mucosal surface of the trachea cannot be cleared and bacteria become trapped reaches the lungs or the air sacs causing infections. The Gaseous ammonia is released from litter during poultry production and various chemicals have been used to treat the litter to minimize ammonia emissions from poultry litter [5].

The ammonia levels in the poultry house should not exceed 25ppm for poultry as well as the worker. However, in practice, the concentration of ammonia in some poultry houses may easily exceed 30-70 ppm, particularly during wintertime. One of the most important factors that can affect NH_3 release is litter pH. Reece *et al.* [6] reported that very little NH_3 was released from litter with a pH below 7, whereas it was rapidly released from litter with a pH above 8.

Effects of ammonia

Ammonia concentration in the poultry house is closely associated with ventilation systems. Poor ventilation leads to high ammonia concentration in the poultry houses, which is frequently encountered during winter in temperate regions. A high concentration of ammonia i.e above 25 ppm in the poultry house has adverse effects on the health and performance of birds. However, it is very difficult to measure the magnitude of such adverse effects on the performance of the birds.

The main cause of exposure to a very high concentration of ammonia for long periods to the birds is the poor ventilation, or birds are fed a nutritionally unbalanced diet *i.e.* high protein diets. If the birds are exposed, even for short periods with a high concentration of ammonia, many molecular changes can take place. The presence of excessively high levels of ammonia in the air, for any time period, will lead to discomfort to the birds. Ammonia is a strong oxidative stressor that can cause irritation and inflammation. Birds exposed to high level of ammonia concentrations negatively affect the development of immune system.

Management of Ammonia

In poorly ventilated poultry houses coupled with diets containing high protein, ammonia which is a colourless gas produced by the action of microbes breaking down the nitrogen-rich fractions of poultry faeces. Inside the poultry house ammonia levels exceeding 25 ppm can result in decreased bird performance [7]. Reduction of in-house ammonia emissions can improve bird performance and reduce emissions from poultry housing. The ammonia concentrations greater than 25 ppm, can normally be detected the smell by

humans. However, poultry can be negatively predisposed at concentrations as low as 20 ppm by long term exposure of ammonia. Keratonconjuctivitis can result from exposure of birds to high levels of ammonia. Birds exposed to high levels of ammonia are often more susceptible to respiratory tract infections. Damage to the mucus membranes and lung tissue is not uncommon.

Most of the producers try to keep their birds free from exposure to high level of ammonia. Here are five ways to reduce ammonia levels in poultry houses:

1. **Dietary management:** The birds should be provided of a balanced diet fulfilling all the nutritional requirements. Excess protein in the diet will excrete through faeces will lead to more ammonia production. High fibre in the diet will encourage birds to drink more water resulting wet problems causing increased ammonia production.
2. **Stocking density:** Adequate floor space should be provided to the birds according to different age group and type of the birds. Dense population will lead to wet litter problem which ultimately favours the production of ammonia in the poultry houses.
3. **Proper ventilation:** Poultry house should be adequately ventilated to facilitate the quick release of ammonia from the house. If ammonia levels increase, more ventilation is needed to restrict the level below 25 ppm. However, the rate of ventilation depends on the climatic condition. In temperate climates during winter ventilation rates has to be reduce to maintain the house temperature especially during brooding of chicks. In those cases special care should be taken.
4. **House Temperature:** The temperature inside the house should be adjusted to provide comfort to the birds especially during winter season without compromising the ventilation systems.
5. **Nutrient digestibility**: Improvement in nutrient digestibility could be achieved by supplementing diets with various feed additives, enzymes, probiotics, prebiotics etc.
6. **Litter management:** Litter moisture should be kept between 15-25%. High litter moisture will leads to ammonia problem in the poultry houses. Litter quality should be tested regularly to keep the litter moisture under control. Excessive caked litter should be immediately replaced with fresh dry litter. One of the most important factors that can affect NH_3 release is litter pH. When the litter pH are maintained below 7, a very little NH_3 is released whereas it released rapidly when pH is above
7. **Litter amendment:** Many chemical are being used to control ammonia in poultry houses such as alum, liquid alum, aluminum chloride, Sodium bisulfate etc. can also be used to control the ammonia in poultry houses.
8. **Water management:** The water trough should be placed carefully to avoid spillage of water in the litter material which will increase moisture content of litter. Water trough should be checked periodically for any leakage.
9. **Phytogenic Feed Additives:** A phytogenic feed additive increases the digestibility of nutrients within the gastrointestinal tract and reduces the gut inflammation caused by stressors. Thereby may considerably increase the gut integrity of the birds. Phytogenic feed additives also alter gut microflora, minimizing the negative effect of harmful bacteria on the gut. Less undigested and unabsorbed nutrients will be excreted through faeces from a healthy gut, which means less nitrogen excretion from the birds to the environment. Less nitrogen excretion reduces ammonia volatilization within the chicken house to a great extent, ultimately reduces the ammonia production in the poultry houses.

Dietary management is one of the most important preventative measures to control ammonia gas in the poultry houses. The amount of nitrogen in faeces can be considerably reduced by feeding diets containing less protein. Diet management has been recognized as means to reduce ammonia emissions from poultry operations, as the dietary nitrogen intake affects the nitrogen content in manure. Manure nitrogen content was significantly ($P<0.01$) reduced to 3.98% DM when fed 13 g of protein as compared to 5.68% DM of those hen fed 17 g of protein [8]. A reduction in 3-5%of dietary protein may cause a reduction of 60% or more in total nitrogen excretion from broilers and laying hens.

The performance of birds is decreased by excessive level of ammonia in poultry houses, as ammonia has negative effects on bird health. The rate of body weight gain was decreased and mortality was increased as broiler chicks were exposed to 100 or 200 ppm of ammonia [9]. Ready-to-lay pullets consumed less feed and gained less body weight exposed to 200 ppm of ammonia for 17 day than control groups [10]. The specific effects of high level of ammonia concentrations to the birds are on eye and respiratory tract tissues [11, 12].

Conclusion

The ammonia production in the poultry houses should be kept below 25 ppm to protect the birds from the harmful effects otherwise the performance of the bird will be greatly reduced**.** Reduction of in-house ammonia emissions can improve bird performance. Ammonia gas in poultry sheds critically affects the health and welfare condition of the birds. Therefore, various possible measures are to be adopted to restrict the ammonia emission in the poultry houses and welfare of the birds.

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