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IMMOBILIZATION OF AMMONIA GENERATED IN POULTRY MANURE; REDUCTION OF ENVIRONMENT IMPACT

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Abstract

The increased intensity of animal meat production and the large volume of adjacent livestock manure need new management technologies to fulfill the environmental requirements and convert manure for landfield application. The goals of new technologies are to standardize the nutrient stabilization, to reduce pathogens and odors. One of the main sources of manure comes from the chicken industry. In general the density of birds in the house is 15 per square meter. The volume of deep litter used at the beginning in addition with the manure including moisture produced during 7 week growing period (light broiler) reaches 30-35 kg/squaremeter. The nitrogen content is high in the litter which fact requires two considerations. First point is to reduce the ammonia in house during growing process. Ammonia volatilization under aerobic and anaerobic manure decomposition occurs. The layer of litter at the end of period may riche 8 to 10 cm. It is estimated that both mechanisms participate in the decomposition processes that generate ammonia. One portion of ammonia enters in the air which then is removed from poultry house by ventilation. It means that this portion of nitrogen is air pollutant and is lost as potential fertilizer row material. At the same time ammonia content of air causes respiratory problems for birds. Production of ammonia in the litter increases the pH, thus causing leg injuries. Second point is that due to high nitrogen content the poultry manure requires specific treatment before is used as fertilizer to avoid the nitrate pollution.

Key words: poultry house, ammonia emission, immobilization, field study

INTRODUCTION

The estimated poultry deep litter production in 2009 in the member states of European Union was: 109518 kt, in Hungary was 2874 kt and in Romania was 7780 ktons (Technical Report No. I. to the European Commission; Bioteaut et al., European Commission (DG Environment Final Report (2014)). Ammonia is an air pollutant in the poultry houses and affects their environment (Kristensen, Wathes, 2000; Jones et al., 2013; Corkery et al., 2013).

Higher ammonia concentration affects the human, animal health and animal production (Jyoti et al., 2013; Wood, Van Heyst, 2016; Wood et al., 2015). On the other hand ammonia is a raw material generally manufactured by chemical synthesis; however, collection that is generated during the animal production may replace in part the synthetic form. Ammonia elimination occurs in the poultry house and during the manure management in the process installations.

There are several techniques developed for the stabilization of poultry manure as litter cultivation, litter pasteurization, stabilization by fermentation system (e.g., Hosoya), in-vessel composters, application for biogas generation and many others. In this report the ammonia immobilization in the poultry house and in a labor model device was studied.

There are several methods to reduce and to immobilize the ammonia in poultry house, using adsorbents as zeolites (Csiba, 2013; Islam et al., 2013; Schneider et al., 2016), natural charcoal (Toth, Dou, 2015) and other chemical methods (Bejan et al., 2013). The total volatile ammonia was removed by air steam and adsorbed by boric acid (Sheng et al., 2015).

Our goal is to determine the volatile ammonia in an undisturbed sample on site in order to unchange microorganisms responsible for degradation. For this purpose a portion of litter is sampled then is isolated with the ammonia chamber, and the ammonia generation vs time is measured.

MATERIAL AND METHOD

The broiler chickens are grown in a period of 6 weeks. The main elements of the material stream are as the follow: for 34k chickens on 2,000 m^2 surface, inlet stream: feed: 140,000 kg, water: 252,000 l, litter for bedding: 3500 kg straw; outlet stream: live chicken: undefined kg, manure: 45,000 kg, ventilated air: 80,000,000 m^3. The questions remain: what amount of ammonia is generated, what portion is released by ventilation, what portion is adsorbed in the manure.

In this study the in house ammonia fixation is discussed. Solid adsorbents were used in order to adsorb the generated ammonia. It is estimated that gradually adding adsorbents to the deep litter (granulated straw) is fixing the ammonia, thus the volatile portion is reduced, avoiding air pollution, and reducing the harmful effects on the birds. It seems to be important to detect the ammonia on the surface of litter where the birds are breathing. On the other hands the nitrogen content increases in the manure; however, that fact requires a post treatment to avoid the nitrate pollution.

For adsorption of generated ammonia in the litter two adsorbents have been used. Zeolite was mixed with the straw in portions of 1%, 2 % and 5 %. Biochar as a naturally originated adsorbent was applied in similar ratios. Finally a mixture of both adsorbents was tested. Volatilized ammonia content was determined with a specific ammonia chamber covering a surface of 0.04 m^2. Concentration of ammonia was measured by Oldham BM25 gas meter. Data collected are saved on the instrument and data processing was done by COM2100 software. The home-made ammonia chamber and the primary data graph are shown in Figure 1.

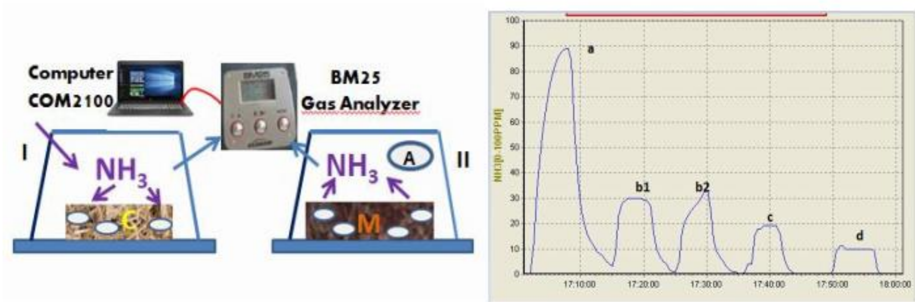

Fig. 1. Left: Schematic representation of system assembled for ammonia measurements equipped with Oldham BM25 gas meter and data processing computer with COM2100 software. Ammonia chamber I for model measurements with added ammonia including cellulose (C) as matrix and adsorbent (denoted A in a grey circle). Chamber II for field measurements for determination of ammonia emission from poultry manure (M) and immobilized with adsorbent (A) mixed in the litter. Right: Model measurements representing ammonia concentration (ppm) (a) empty chamber, (b1 and b2) parallel experiments dry cellulose matrix inside, (c) wet cellulose with 25% moisture inside, (d) wet cellulose and zeolite mixture with 25% moisture inside.

Laboratory tests. For validation of equipment and the system test measurements were performed. Concentrated aqueous ammonium hydroxide was injected into the chamber (left on the Fig. 1) in a water bath at 80 ^{o}C, where volatilization of ammonia occurs. After 5 minutes interval the ammonia concentration was measured with Oldham BM25 instrument. Since the sampler pump of BM25 removes 20 l/h air gas mixture from the chamber, thus longer than 5 minutes sampling results a dilution in the chamber which fact must be taken in consideration.

On site tests. Ammonia release in the poultry house was investigated. The ammonia chamber was placed on the litter sample prepared with a cut around method applying the steel frame as shown in Figure 2c and 2d. Control sites were untreated, and for immobilization of ammonia with zeolite (Fig. 2a) and Biochar (Fig. 2b) was applied. The investigated area covered with zeolite or biochar was 12 m^2, and three parallel sites were investigated. Effect of adsorbents were measured 7 days later. It was important to differentiate two zones as the line of drinking water suppliers where the litter is moisturized. The other line is for food supply where the litter is dryer. It is considered that the moisture content of litter is important for adsorption capacity of matrix and that of adsorbent.

RESULTS AND DISCUSSION

Model experiment treatments were used in the laboratory tests before to investigate the NH_3 emission from bedding in the poultry house. Figure 3 shows the adsorption characteristics of injected NH_3 gas onto cellulose matrices and zeolite adsorbent material. Control experiment was performed in an empty chamber.

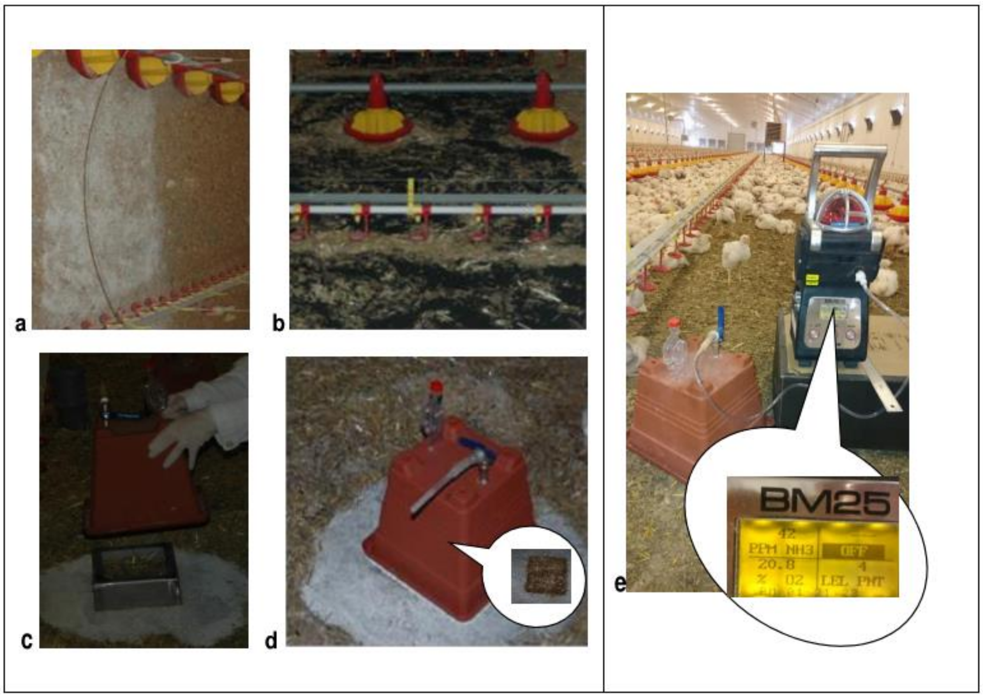

Fig. 2. Sample preparations for the measurements of ammonia emission from the poultry litter. Zeolite (a) and Biochar (b) were applied for ammonia adsorption. Samples for measurements were cut with the metal frame (20 cm x20 cm) (c). Ammonia chamber placed over the sample (d) and ammonia concentration was measured with Oldham BM25 gasometer (e). The gasometer displays the ammonia (in ppm, the upper left) oxygen (in %, bottom left) and volatile organic compounds, e.g., methane, pentane, etc. (in ppm, bottom right.

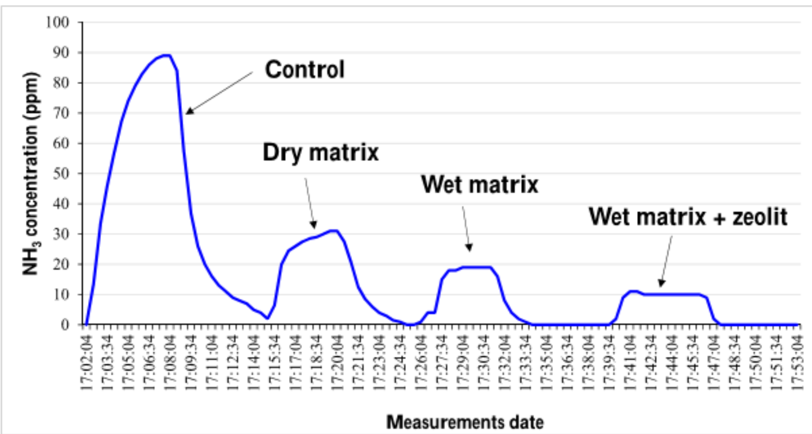

Fig. 3. The NH_3 emission curves in the case of different treatments

It is estimated that the plastic wall adsorption is minimal and was used as a background value (Fig. 3). As a dry matrix cellulose sheets were used that were useful for incorporate appropriate moisture, respectively. The same cellulose seethes were capable to incorporate adsorbent particles as zeolite and biochar, as well. This layer by layer structure created from cellulose sheets and adsorbent may mimic the structure of litter where birds immediately mix the adsorbent and the straw. It was observed that in the model experiment the wet cellulose matrix adsorbed more ammonia compared to the dry matrix. The adsorption capacity increased when wet matrix was mixed with zeolite adsorbent.

The average NH_3 concentration (42.35 ppm) was the highest in the case of the control measurement. In this case there was no any matrices with cellulose content (as in chicken barns), so the emission was “limitless” from the NH_3 source. In the case of using dry matrix, the ammonia air flow was moderate (more than 60 % compared with the control treatment), since the gas was adsorbed by the cellulose.

It was frequently experienced that the surroundings of the chicken drinking equipments the moisture content of the straw is higher than in the other region of the chicken barn’s floor. In our investigation, the effect of wetted matrix in NH_3 emission was investigated as well. Decreasing of gas emission was observed due to the moisture content of the matrix (more than 75 % compared with the control treatment). Adding zeolite to the wet matrix, NH_3 fixation was more intensive, so more than 80 % of the emitted ammonia was adsorbed by the matrix and zeolite, respectively. A negative polynomial trend could be realized between the measured NH_3 concentrations, when different matrices were used (Fig. 4).

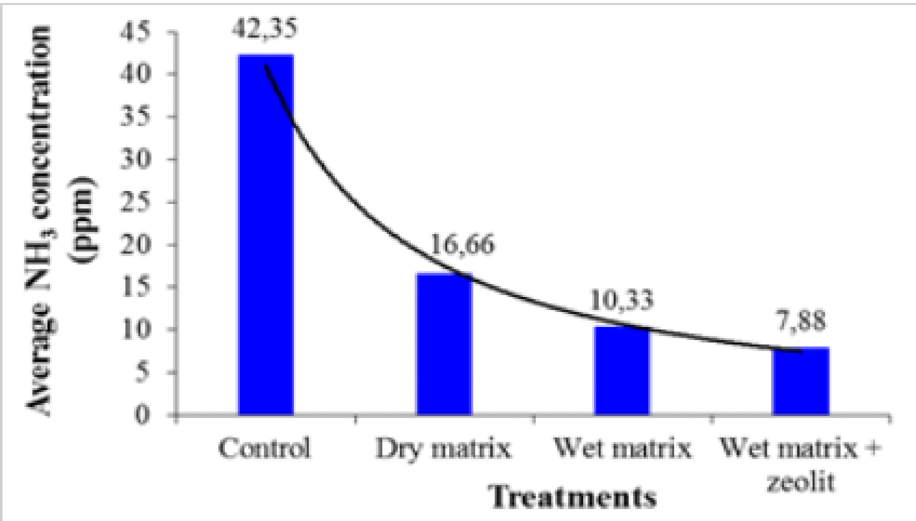

Fig. 4. Average NH3 concentrations in the case of different treatments

After laboratory tests, the NH_3 gas emission was investigated on poultry house. The Figure 5 shows the gas emission form the different samples.

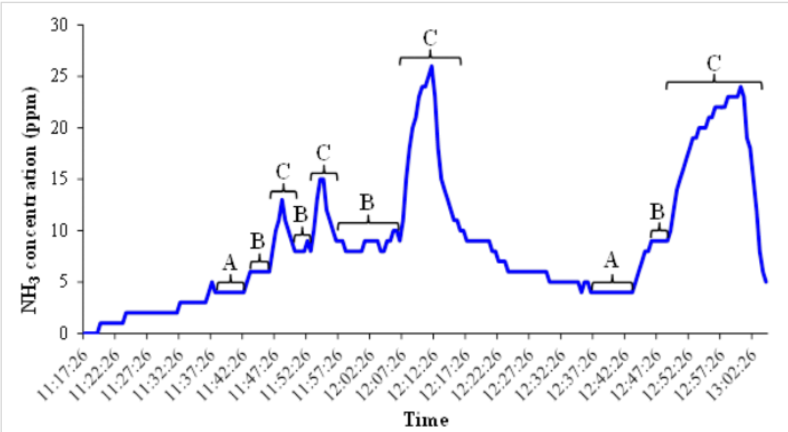

Fig. 5. Changing of NH_3 gas emission in the case of different samples: A – Poultry house air; B – Poultry house dry litter; C – Poultry house wet litter

Mean of the NH_3 concentration of poultry house air was 4 ppm. The gas emission form dry litter was lower than from the circumstances of chicken drinking, where the litter has higher moisture content. In contrast the laboratory tests, the gas emission of dry litter was approximately the half compared to the wet litter (Fig. 6).

It was found in the model experiments moisture that the matrix applied has significant role, due to their chemical structure, the active surface capacity.

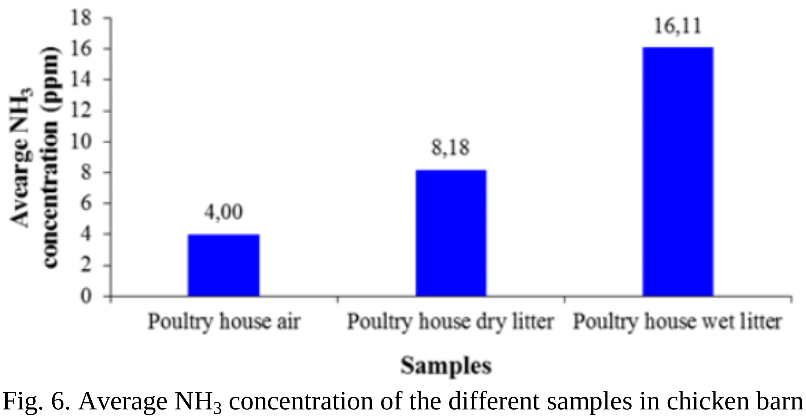

Fig. 6. Average NH_3 concentration of the different samples in chicken barn

It was found that the rate of ammonia generation increases at the third part of the growing period. The ammonia concentration in the air is related with temperature controlling and ventilation. This later process has to be in concert with the in and outside temperature and humidity of inside air and the moisture content of the litter. In addition it is important to avoid the formation of dust in the poultry house.

CONCLUSIONS

It was observed that application of adsorbents in the poultry house may support animal health and environmental concerns. Adsorbents fix most of the ammonia generated and control the pH, keeping it close to neutral, which is harmless to the legs of birds. In consequence the released ammonia content during ventilation decreases reducing the pollution of outside air.

It was observed that most of the ammonia generated in the poultry house can be kept by application of adsorbents. The ammonia content in the air decreased that serves the animal health. However, the manure obtained at the end of growing period requires further management, e.g., aerobic fermentation.

Acknowledgments

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