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# Effects of pH, Moisture and Excreta Age on Ammonia Emission in a Poultry House: A Case Study for Kitwe, Zambia

**Maliselo, S. P and Mwaanga, P**

Department of Environmental Engineering, the Copperbelt University, Kitwe, Zambia

***Abstract-*** Ammonia emission from chicken excreta is due to high amino acid and protein diets given to the chickens to accelerate growth. The excess amino acids are deaminated and the derived nitrogen is excreted in the urine mainly as uric acid, which is readily converted to urea and finally to ammonia. The emission of high levels of ammonia in poultry houses is undesirable as ammonia is toxic and can adversely affect chicken growth. This study investigated the factors that influences the generation of high levels of ammonia in poultry houses. The factors investigated were pH, moisture content and the age of excreta. The investigation was conducted using two types of samples; one set of samples was obtained from poultry pen A, with chickens fed on unblended feed, without an adsorbent for ammonia and the other one was from pen B, with chickens fed on blended feed, with an adsorbent. The blended feed consisted of 0.7 % w/w bamboo charcoal of particle size ≤ 600 μm. The pH of the excreta was varied from 6.2 to 7.8 using HCl/NaOH each of 1.0 M with phosphate buffer (PBS) at concentrations of 1.0 M. The moisture content was varied from 20 % to 27 % by addition of water to the excreta (moistening), and the excreta age ranged from 7 days to 42 days. Samples for determination of ammonia for each factor were collected and analysed in triplicates. The pH results showed that ammonia emission increased as pH increased from 6.2 to 6.5 and peaked from pH 6.5 to 7.8. The moisture content results showed that 26 to 27 % moisture content led to the highest ammonia emission in the poultry houses. Interestingly, the excreta age results showed that the increase in ammonia emission peaks after 21 days. The results further showed that the use of an adsorbent for ammonia can significantly reduce ammonia emissions. Overall, the results of the study suggest that controlling pH, moisture content and age of excreta can help reduce ammonia emission in the poultry houses.

***Index Terms***- Ammonia emission, pH, moisture content, excreta age

## I. Introduction

Ammonia is a gaseous compound consisting nitrogen and hydrogen. It is a common by-product of animal waste through a metabolic process of protein deamination. The process of deamination in which the amino (-$NH_2$) group is removed from amino acids occurs under aerobic conditions, with liberation of ammonia ($NH_3$) into the surroundings (Kumar et al., 2015). Ammonia production from chicken excreta is mainly due to high amino acid and protein diets given to the chickens to accelerate growth. These diets have very high amino acid content which cannot all be completely metabolized by chickens. In addition to limited capacity for amino acid metabolism, chickens have no storage mechanisms for the amino acids consumed beyond the requirement of their protein synthesis (Goldstein and Skadhauge, 2000). Thus the excess amino acids are deaminated and excreted in the urine mainly as uric acid (Goldstein and Skadhauge, 2000). The uric acid excreted is readily converted to ammonia through a chain of reactions catalyzed by enzymes (uricase and urease) which are present in the excreta or manure.

The process of ammonia formation from uric acid starts with the conversion of uric acid to alloxan/mesoxalyl urea and urea by uricase in the presence of water and oxygen (Bahl and Bahl, 2004). Besides the number of enzymes involved researchers elsewhere (Teye and Hautala, 2008; Becker and Graves, 2004; Bahl and Bahl, 2004) have shown that other factors such as relatively high moisture content, high temperatures and high pH can facilitate production of ammonia from excreta. The high levels of ammonia in poultry houses is undesirable because ammonia is toxic and has been implicated in high chicks' mortality and poor chicken growth (Moore, 2008). Although factors causing high ammonia production are known in generic terms, specific details about these factors required to control and reduce ammonia emission in the poultry houses are lacking.

With increasing number of small scale poultry famers in Zambia, coupled with lack of concrete technical information for reduction of ammonia in poultry houses, there is need to bridge this gap and add weight of evidence to the existing generic knowledge. Thus this study focused on the effects of pH, moisture and excreta /manure age on ammonia emissions from poultry litter produced by chickens fed on unblended feed and feed blended with bamboo charcoal of particle size ≤ 600 μm at concentration of 0.7 % w/w. The bamboo charcoal was used to reduce concentrations of ammonia through adsorption process.

## II. MATERIALS AND METHODS

2.1 sampling and sample preparation of chicken excreta-litter for determination of ammonia, $_p$h and moisture content

Samples of chicken excreta-litter were collected weekly from both untreated (fed on unblended feed-Batch A) and treated (fed on feed blended with bamboo charcoal-Batch B). The blended feed consisted of 0.7 % w/w bamboo charcoal of particle size ≤ 600 μm. The excreta-litter mixture of approximately 500 g was collected by scooping the top material diagonally from each poultry house and put in clearly labelled sealable polythene bags. Two samples were collected, one from each pen. The samples were vigorously shaken to ensure proper mixing. After collection, samples were immediately taken to the laboratory for analysis.

2.2 measurement of ammonia in chicken excreta-litter samples at various $_p$h levels

A sample portion (100 g sample) each from Batch A and B was dissolved in 1 L ammonia free deionized water contained in a tightly closed sample bottle that was shaken vigorously and left to stand for 2 hours at low temperature of approximately 10°C. This was to minimize ammonia volatilization from the samples.
100 ml sample aliquots were taken from each sample solution made from batch A and B; to make sample solutions at various pH levels from 6.2 to 7.8 by drop-wise addition of HCl/NaOH each of 1.0 M with phosphate buffer (PBS) at concentrations of 1.0 M. For each pH level, ammonia was analysed by Kjeldahl method (American Public Health Association and American Water Works Association, 2005).

2.3 measurement of ammonia in chicken excreta-litter samples at various moisture levels

Six sample portions of 200 g each were collected from each poultry pen (batch A and B). The first portion from each poultry pen was not moistened while the other five portions were moistened with 15 ml, 20 ml, 25 ml, 30 ml and 35 ml of water respectively. The samples were mixed thoroughly and left to stand at room temperature for 48 hours. 50g from each portion was used for moisture content determination. 20 g from each portion was dissolved in 200 ml ammonia free deionized water, shaken and left to stand for 2 hours at 10°C. An aliquot of 50 ml was pipetted and used for ammonia analysis by Kjeldahl method (American Public Health Association and American Water Works Association, 2005).

2.4 measurement of ammonia in chicken excreta-litter samples in relation to excreta age

The measurement of ammonia in relation to excreta age was determined by keeping the excreta composite from both poultry pens (batch A and B) for six weeks (42 days). Every week, a sample was collected from each poultry pen and analysed for ammonia content by Kjeldahl method.

## III. RESULTS AND DISCUSSIONS

3.1 influence of $_p$h on ammonia concentration in excreta/litter

The results of pH and ammonia concentration in liter showed a positive relationship. Thus as pH of the liter was increasing, the amount of ammonia in the liter was observed to be increasing. These results confirmed the results observed by Philips, (1995). For instance, the average concentration of ammonia in the excreta/liter of the unblended feed at pH 6.2 is around 40 ppm, but the average concentration of ammonia in the liter for the same type of feed at pH 7.8 is around 70 ppm.

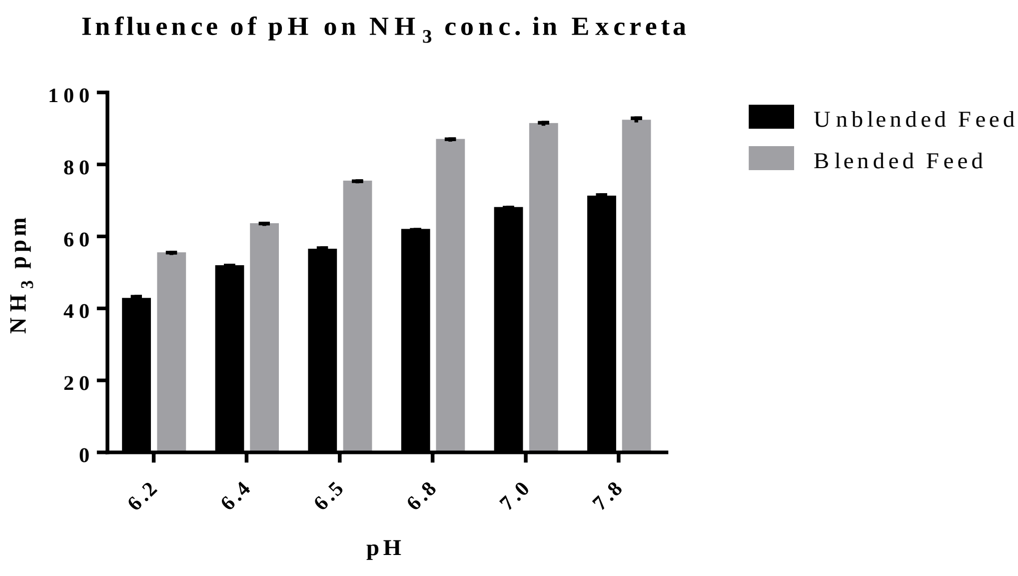


**Figure 1: Influence of pH on Ammonia Concentration in litter.**

The chart shows the mean values for n=3 and the error bars indicate the standard error of the mean for the three replicates.
The relationship observed in figure 1, showed that pH had an effect on ammonia evolution from excreta. When the excreta environment was getting close to alkaline conditions (going towards pH 7 from pH 6.2), ammonia evolution also increased proportionally. Despite pH having the same influence on both treated and untreated litter, there was more ammonia concentration in litter from the bamboo charcoal treated poultry pens than the untreated (Controls). Loss of ammonia from bamboo charcoal treated litter was minimised by the presence of bamboo charcoal through the process of adsorption.

3.2 influence of moisture on ammonia concentration in excreta/litter

The results of moisture in figure 2 showed that there was a direct relationship with ammonia concentration in litter. High moisture levels corresponded with high ammonia concentration in excreta/litter. Moreover, moisture content results showed that around 26 to 27 % moisture content led to the highest production of ammonia in both treated and untreated excreta. The observed increase in ammonia concentration in relation to high moisture levels in litter confirmed the findings of Philips (1995). High moisture levels contributed to more hydrolysis of urea to ammonia just as reported by Becker and Graves (2004). Moreover, there was more ammonia observed in treated litter than untreated, this was due to ammonia adsorption by bamboo charcoal in treated excreta/litter.

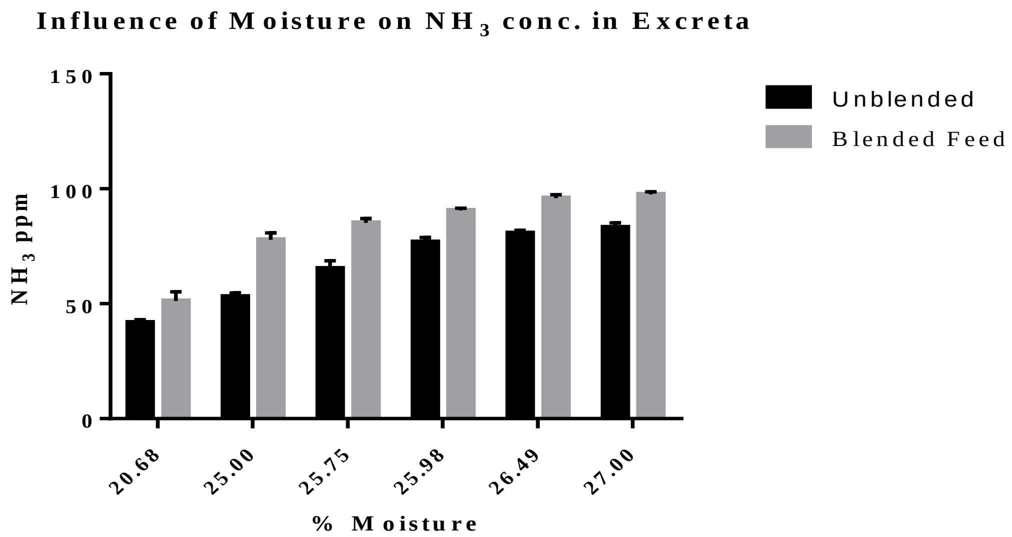


**Figure 2:** Influence of Moisture on Ammonia Concentration in litter**.** The chart shows the mean values for n=3 and the error bars indicate the standard error of the mean for the three replicates.

3.3 influence of excreta age on ammonia concentration in excreta/litter

The age of exreta/manure showed a positive effect on ammonia concentration in both treated (Batch B) and untreated (Batch A) litter. This confirmed that the older the manure, the faster the decomposition of uric acid to urea and finally to ammonia due to the presence of micro-organisms (bacteria) to quicken the decomposition process (Schefferle, 1965). The observed direct positive relationship between excreta/manure age and ammonia concentration in litter was shown in figure 3.

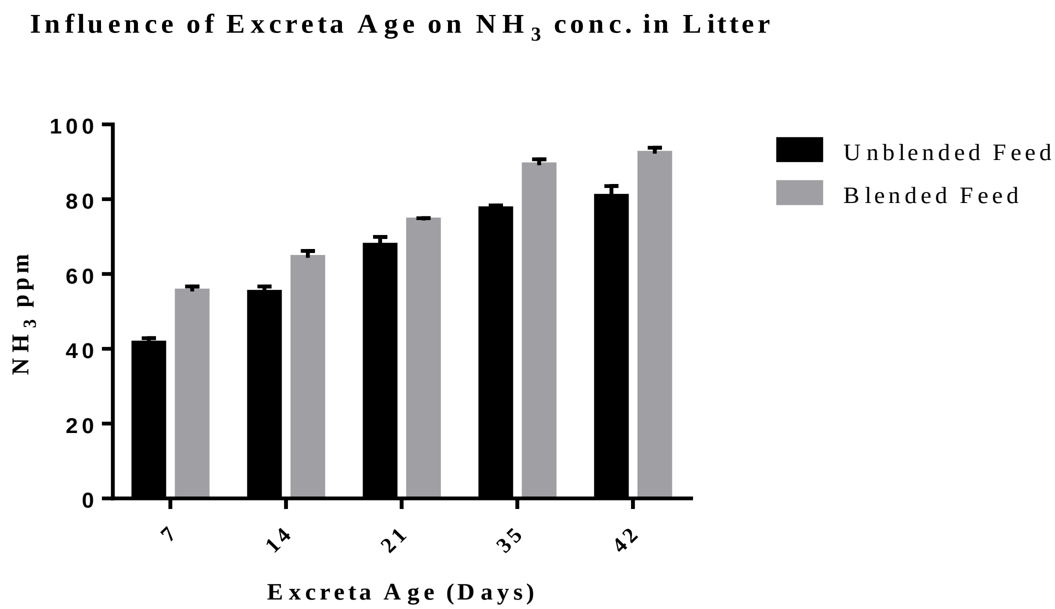


**Figure 3:** Relationship between the age of manure and ammonia concentration in litter. The chart shows the mean values for n=3 and the error bars indicate the standard error of the mean for the three replicates.

## IV. CONCLUSION

According to the findings of this study, factors such as age of excreta, pH and moisture were found to have a significant influence on ammonia volatilization. pH above 6.2 resulted in high ammonia volatilization due to favourable conditions for urea hydrolysis to form ammonia. High levels of moisture also contributed to hydrolysis of urea resulting in high ammonia evolution. It was established that older excreta/manure produced more ammonia than fresh manure. It was further observed that the inclusion of bamboo charcoal in feed had significantly reduced the evolution of ammonia from chicken excreta. Hence having more ammonia bound to the excreta from batch B than what was observed in unblended feed poultry pen (batch A).

## V. ACKNOWLEDGEMENTS

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## AUTHORS

**First Author** – Maliselo, S. P, Department of Environmental Engineering, the Copperbelt University, Kitwe, Zambia, Email: maliselosp2@gmail.com

**Second Author** – Mwaanga, P, Department of Environmental Engineering, the Copperbelt University, Kitwe, Zambia, Email: phennym@yahoo.co.uk