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Influence of ferrous sulfate hepta hydrate on poultry manure pH and microbial life to reduce ammonical odors

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ABSTRACT

High levels of ammonia in poultry farms is an old time issue of major concern to stake holders that has continued unabated. Poultry producers are under pressure from interested groups and neighbors to reduce ammonia emissions for health and environmental reasons. Inhibition of putrefying and ammonifying bacteria in poultry manure is therefore critical to reduce NH_3 volatilization. Ferrous sulfate heptahydrate at concentrations of 2%, 5% and 10% was used to lower manure pH in order to inhibit the activities of putrefying and ammonifying bacteria and hence reduce ammonia volatilization. The various concentrations of the ferrous sulfate heptahydrate ($FeSO4.7H_2O$) were added to about 300g each of the poultry waste and thoroughly mixed together using a mixer. pH, microbial load count and odors were evaluated according to standard methods. Results showed that Ferrous sulfate hepta hydrate at 10% lowered the poultry manure pH from an initial 7.68 to 3.78 in 7days, and 4.60 at the end of 35 days of treatment respectively. Total coliform bacteria in 10% were reduced from 2.85×10^3 CFU ml^{-1} to 0.29×10^1 CFU ml^{-1}. The pH ranges are in agreement with the value of 5.0 recommended to fix ammonia in stored animal waste, supported by the fact that a positive correlation exists between manure pH and ammonia volatilization. Panelist results for odor levels were equally impressive at 10% concentration.

Key words: Poultry manure, ammoniacal odors, Ferrous sulfate heptahydrate, coliform bacteria

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INTRODUCTION

Increases in poultry production in recent years, driven by the demand for low cholesterol meat, high protein source and economic incentives have lead to tremendous expansion in the industry the world over [1]; [2]. In Nigeria for example, there exists an uncontrolled proliferation of poultry farms, particularly in the urban cities. In addition to providing food and income, poultry manure is equally generated as an important byproduct. It is a major factor in the economic consideration of today's poultry industry. If handled correctly, manure can be an excellent source of income upon commercialization. Due to its high nutrient content, poultry manure is widely applied to crop lands as fertilizer and is also processed and utilized as a rich protein source in animal feed [3].

However as important as it is, its lose management is reported to raise ecological and health issues [4]. An important consideration is high levels of NH_3 volatilization and other odorous emissions [5]; [6]. These emissions occur as a result of microbiological breakdown of manure nitrogenous organic compounds and undigested protein.

In poultry fecal waste, NH_4 – N is excreted as uric acid and undigested protein. The N in uric acid is quickly converted to NH_3 by microbial hydrolysis and volatilization. Once this uric acid is converted to NH_3 it serves as a buffer, keeps the pH elevated and enhances NH_3 volatilization [7]. In previous research it was found that pH, temperature and moisture all contribute to NH_3 release and that pH has more effect than temperature which has more effect than moisture content [8].

The pH of unmodified manure is 7.5 – 8.5 [8]. When poultry manure increases in age and therefore in manure content, the pH will rise. As the pH rises to a more alkaline state, NH_3 will shift to a unionized state and become available for volatilization [9].This is because NH_3 has no ionic charge which allows for its volatilization. Adding an H^+ transforms NH_3 into NH_4^+, which is a non volatile form. Ammonia production is therefore negligible when manure pH is at levels below 7.0, increasing as pH approaches 7.0 and high when pH of 8.0 or greater is reached [5]; [6]. It has been suggested that pH levels below 5.0 are required to completely fix nitrogen within poultry manure [10]. In addition pH levels below 5.0 are reported to provide hostile conditions for microbes and therefore enhance inhibition of ammonifying and putrefying bacteria [11].

High levels of ammonia (odors) in poultry farms is an old time issue of major concern to stake holders that has continued unabated. It is reported to induce overall low performance in birds and increase susceptibility to diseases, a wide range of physiological responses in humans and also considered as an odor nuisance [12]. Symptoms of ammonia poisoning in birds include slicking, tracheal irritation, air sac inflammation, conjunctivitis and dyspepsia [12]; [13]. In the atmosphere, NH_3 is converted through secondary reactions to aerosols of ammonium sulfate and nitrates. This is reported to influence ecological imbalance, biodiversity and water systems [14].

Ammonia and odor prevention, control and mitigation have been considered by numerous researchers involving the use of commercial manure amendments classified into masking agents, adsorbents, disinfectants, chemical and microbial agents, digestive enzymes and oxidizers [15]; [16]; [17]; [18]; [19]. Such abatement technologies are often targeted towards other livestock systems, but limited data exist for poultry waste odor management [20]. However, results from these and many other works have been mixed and generally unsatisfactory, particularly for long term treatments, partly due to high cost and unavailability of products and largely due to low performance [21].

Due to the health and environmental concerns associated with ammonia volatilization and other odorous emissions from the highly proliferated poultry farms and waste storage facilities, continued efforts and search for effective, cheap and available materials for its control is an urgent imperative. Therefore this work is an attempt to influence manure pH and microbial load via Ferrous sulfate heptahydrate at varying concentrations. This is expected to effectively inhibit putrefying and ammonifying bacteria responsible for NH_3 volatilization and provide the much needed solution to odor problems in poultry houses.

MATERIALS AND METHODS

Manure collection and preparation: Poultry fecal waste was collected from caged broilers and prepared as described in our previous work [22]. A clean 8 x 6ft nylon sheet was placed underneath the cages to avoid contamination of manure from the floor. This was neatly wrapped and transferred to the laboratory for further processing.

Treatment of Farm Manure: The Ferrous sulfate heptahydrate ($FeSO4.7H_2O$) at varying concentrations of 2%, 5% and 10% were added to about 300g each of the poultry waste and thoroughly mixed together using a motorized mixer. This was transferred into 1-L capacity wide mouth glass jars each and sealed with covers underneath which, was cotton swatches. The jars were painted black to minimize the visual impact of manure during sampling and analysis. The contents of the flask were sampled at days 1, 7, 14, 15, 21, 28 and 35, for pH monitoring and microbial load count and odor evaluation.

Measurement of pH: 100 ml DI water was added to 20g of sample in a beaker, continuously stirring the suspension for 5 minutes, and shaking for another 30 minutes before measurement. The waste suspension was allowed to stand for about 15 minutes to allow most of the suspended waste to settle out. The pH was then measured using digital pH meter.

Microbial Load Count: The microbial load in the samples was estimated using method outlined by [23]. 10 g of each sample was blended in 90 mL of saline water (0.9 % NaCl) with a Warring blender to prepare the initial dilution. Colony forming units (CFU) were determined by standard pour plate methodology. Decimal dilution for total viable counts was made in (0.85% saline solution) and 1 ml was placed in duplicates on standard plate count agar. Enterobacteria were enumerated on MacConkey Agar [24] after anaerobic incubation at 30°C for 24hrs.

Odor analysis: Analysis of odor was performed according to the procedures authored by [25]; [26]. A panel of 10 members was presented with the odor samples who rated the samples on a given scale of 0 – 5. The '0' represents no odor while '5' represents maximum odor levels. Observations were taken by lifting up the lids of the jars with a gloved hand and smelling the treated and controlled samples at a distance of 6 – 8 inches and odor levels were rated accordingly.

Statistical analysis: All treatments were in duplicate and data in figures are expressed as means. Statistically significant differences at $p< 0.05$ probability level were obtained from ANOVA tests.

RESULTS AND DISCUSSION

A positive correlation of ammonia volatilization with manure pH has been reported [27]. As pH levels increases in stored manure, ammonia volatilization also increases and vice versa. Ferrous sulfate hepta hydrate was used to lower manure pH in an attempt to inhibit putrefying bacteria growth and consequently reduce ammonia volatilization. The data in figure 1 confirmed that FeSO4.7H2O (2%, 5%, 10%) imposed significant decrease in poultry manure pH at both short and long term incubation periods. At 2%, the manure pH was seen to drop from an initial 7.68 to 5.28 in the first week. At the end of a 5 week treatment period, a pH of 5.56 was recorded. At a double concentration of 5%, the manure pH dropped to 4.12 in the first week and remained at 5.08 in the fifth week.

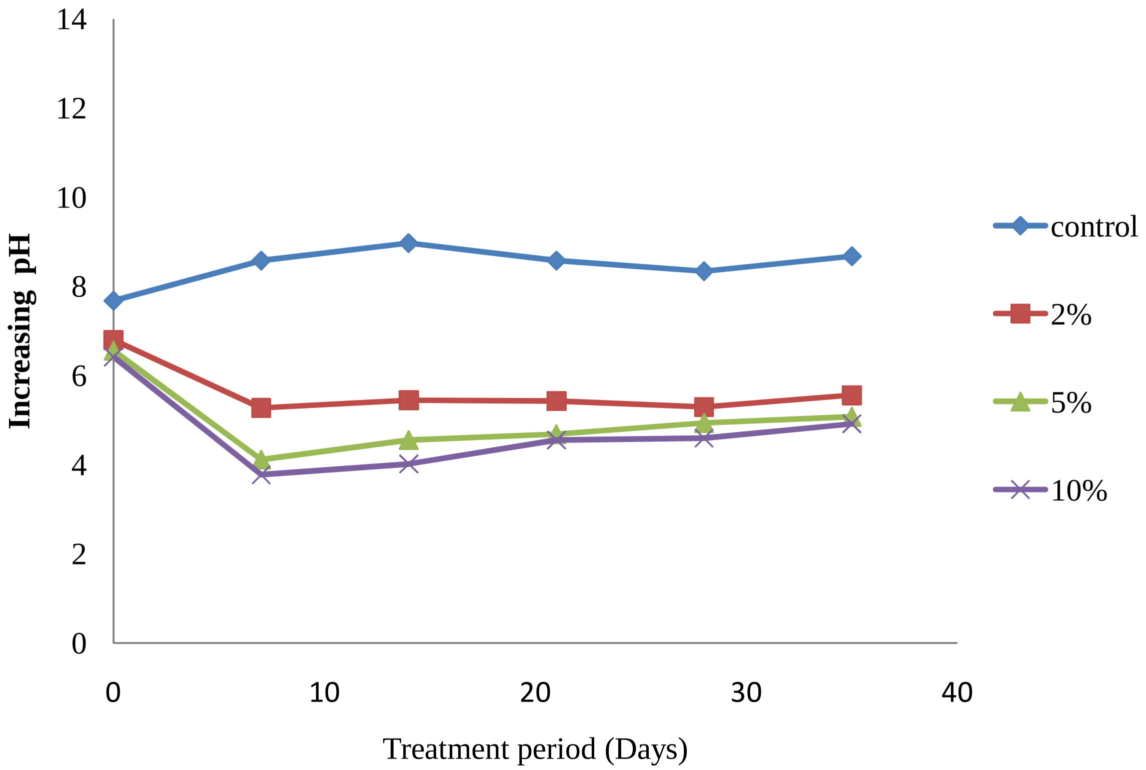


Figure 1: Lowering of poultry manure pH at various concentrations of $FeSO_4.7H_2O$

A better result was obtained when the strength was again doubled to 10%. In the first week, the pH was altered by about a factor of 2, from 7.68 t0 3.78. By the end of the incubation period of 5 weeks, it stabilized at 4.60. Throughout the treatment period, the control pH increased from 7.68 to 8.68. Although there was slight variation in the pH levels from week one to five in all the treatments, they were still below 5.0. It has been suggested that pH levels below 5.0 are required to completely fix nitrogen within stored poultry manure [10]. In addition, pH levels below 5.0 are reported to provide hostile conditions for microbes which enhance inhibition of ammonifying and putrefying bacteria [11]. However the pH of control remained above 7 suggesting that the putrefying bacteria were not inhibited.

Figure 2 represents microbial decay responses to the various treatment ratios of Ferrous sulfate. As can be seen from the figure, the initial microbial population of the unmodified manure was 4.65 x 10^5 (CFU ml^{-1}). At 2% concentration, the total CFU was down to 2.31x10^3 and 0.38x10^3 at the first and 5th weeks respectively. The response to 5% treatment showed similar trend with even lower values. From the initial value, the total CFU decreased to 3.95 and 0.41 x 10^1 in the first and last weeks. The results of the 10% treatment against the same quantity of waste within the same time frame was impressive, with a range of 2.85 to 0.29 x 10^1 and compared well with other reports [19].

The use of Ferrous sulfate hepta – hydrate on poultry manure waste has a desirable effect because it is ionically a strong acid that rapidly reduces pH. This is an advantageous condition necessary for conserving NH_3 in the waste [28]; [29].

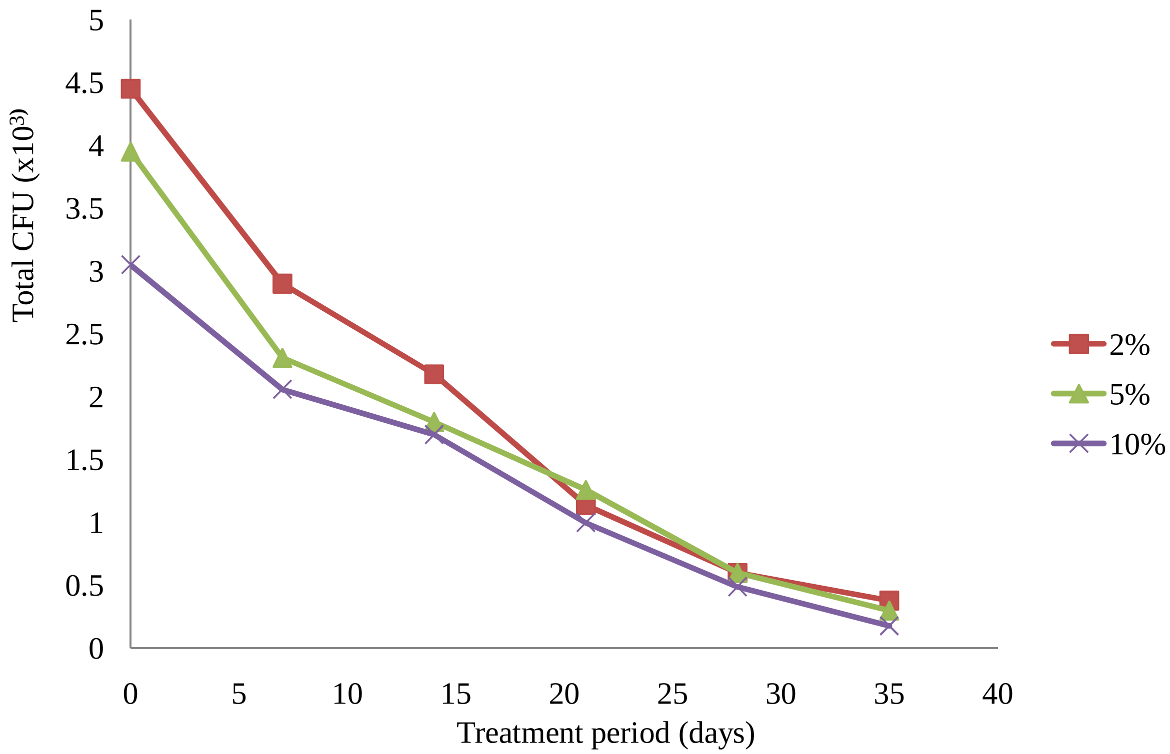
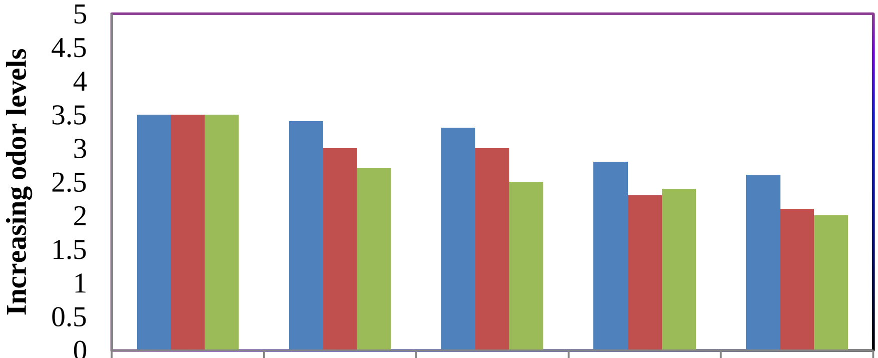


Figure 2 :Reduction of faecal coliforms at 2%, 5% and 10% $FeSO_4.7H_2O$

Several researches have been conducted with the aim of lowering the pH in waste slurries in order to reduce ammonia emissions. Euginol and thymol were used [30] to stimulate accumulation of lactate in cattle and swine waste which lowered the pH from 7.9 to 4.5 and 4.6 respectively. In another study, [19] investigated the effects of various concentrations of thymol and carvacrol on manure pH and showed that the data remained between 6.5 and 7. Some involved direct additions of organic acids to reduce the pH to 5.5 [16]; [29]. Still others directly added lactic acid at 5% by volume which lowered the pH to 4.5 and reduced ammonia, CH_4 and nitrous oxide emissions. The results of this work were comparable to these findings. Ferrous sulfate hepta hydrate at 5% and 10% lowered the poultry manure pH from an initial 7.8 to 4.12 and 3.18 in 7 days, and 5.08 and 4.60 at the end of 35 days of treatment respectively. These ranges are in agreement with the pH value of 5.0 recommended to fix ammonia in stored animal waste, supported by the fact that a positive correlation exists between manure pH and ammonia volatilization sensed as odors [27]. Consequently, an odor evaluation was conducted on the treated samples to establish this correlation.

Figure 3 shows the weekly performances of Ferrous sulfate hepta hydrate in odor inhibition at the three levels for the five week treatment period. It can be seen from the figure that odor levels decreased with time. The 2% concentration reduced odor levels by 30% in the first week and by the end of the treatment period, the odors were altered by 48%. The 5% also influenced odor reduction at the first week by 30%, and then rose to 58% at the end of the fifth week. The effectiveness of 10% addition was equally 30% in week one. However, by the end of week five, the odor levels were reduced by 60%. On the whole, the 10% proved worthy on a weekly basis compared to the other levels of the factor.

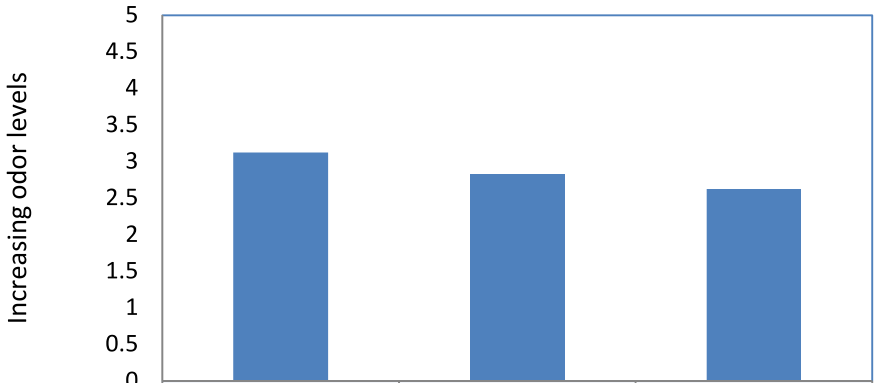


	Wk1	Wk2	Wk3	Wk4	Wk5
A1	3.5	3.4	3.3	2.8	2.6
A2	3.5	3	3	2.3	2.1
A3	3.5	2.7	2.5	2.4	2

Ferrous sulfate hepta hydrate

Figure 3: Weekly performances of Ferrous sulfate at 5%, 5%,and 10% on odor levels

Figure 4 represents the overall effectiveness of Ferrous sulfate heptahydrate at all levels during the period of treatment. It can be seen that 2% was 37.6% effective and 5% was 43.6% while 10% reduced the odors by 47.6%.



	A1	A2	A3
odor levels	3.12	2.82	2.62

Ferrous sulfate heptahydrate

Figure 4: Overall effectiveness of Ferrous sulfate hepta hydrate on odor levels

Ferrous sulfate heptahydrate is a highly acidic industrial waste. When disposed to the environment, it causes soil acidity. Its newly tested and discovered role in controlling poultry waste odor would be a profitable alternative of its disposal and a relief to the producing industry as well as a solution to environmental problems of soil pollution and ammonia volatilization. However, studies under field conditions are expected to verify claims of efficacy at the optimized concentrations.

CONCLUSION

It is here concluded that Ferrous sulfate hepta hydrate at 10% concentration significantly reduced the viable population of the putrefying and ammonifying bacteria in the stored waste and effectively suppressed ammoniacal odors.

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