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# Performance of Broiler Birds Managed on Recycled Litter Treated with Graded Levels of Aluminium Sulphate (Alum)

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*Keywords:* *broiler, performance, carcass, recycled litter.*

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PERFORMANCEOFBROILERBIRDSMANAGEDONRECYCLEDLITTERTREATEDWITHGRADEDLEVELSOFALUMINIUMSULPHATEALUM

*Strictly as per the compliance and regulations of:*

# Performance of Broiler Birds Managed on Recycled Litter Treated with Graded Levels of Aluminium Sulphate (Alum)

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*Keywords: broiler, performance, carcass, recycled litter.*

## I. Introduction

Poultry are generally accepted as the fastest way of increasing animal protein consumption in the developing countries of the world (Ogundipe, 1999). This increasing rate of production is raising alarm on the effect of pollution that arises from the land in which this poultry waste is deposited.

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Aluminium Sulphate (Alum) has been described as one of the best chemicals used in litter amendment to reduce pathogen levels in litter (improving bird health and food safety), reduce ammonia levels in the poultry houses, reduce phosphorus run off and improve productivity. alum is normally applied at a rate of 5 to 10 percent by weight of the litter (Moore *et al*., 2000). This study was designed to evaluate the effect of alum treated bedding material and poultry litter on litter microbial load and chemical characteristics and its effect on the performance of broilers.

## II. Materials and Methods

### *a) Experimental site and Location*

The study was carried out at the poultry unit of the Department of Animal Science teaching and research farm, Ahmadu Bello University, Zaria. The pen is located in northern guinea savannah zone of Nigeria, latitude $11^0$ 09' 76'' N and longitude $7^0$ 38' 20'' E at an altitude of 610 mm above sea level. The climate is relatively dry with a mean annual rainfall of 700-1400mm, occurring between the months of April and September (Ovimaps, 2015).

### *b) Experimental Diets and Material*

Broiler starter and finisher diets were formulated to meet the nutrient requirement of broilers (NRC, 1994) and used in feeding the experimental birds throughout the period of the study in both experiment one and two. The experimental diets are shown in Table 1. The alum used was obtained from the Sabon-garimarket in Zaria, Kaduna State.

*Table 1:* Ingredients Composition and Calculated Analysis of the experimental Diets

| Ingredients | Composition (%) | |
|---|---|---|
| | Starter (0 – 4 weeks) | Finisher (5 – 8 weeks) |
| Maize | 51.90 | 54.50 |
| Groundnut cake | 16.00 | 22.20 |
| Soya bean cake | 25.00 | 15.00 |
| Palm oil | 2.00 | 3.40 |
| Lime stone | 1.00 | 0.90 |
| Bone meal | 3.00 | 2.80 |
| Common Salt | 0.30 | 0.30 |
| Premix* | 0.25 | 0.30 |
| Lysine | 0.25 | 0.30 |
| Methionine | 0.30 | 0.25 |
| Total | 100.00 | 100.00 |
| Calculated analysis | | |
| Crude protein (%) | 23.20 | 21.80 |
| Metabolisable energy (kcal/kg) | 2929 | 3037 |
| Ether extract (%) | 6.57 | 7.74 |
| Crude fibre (%) | 4.18 | 3.78 |
| Calcium (%) | 1.23 | 1.13 |
| Available Phosphorus (%) | 0.52 | 0.49 |
| Lysine (%) | 1.13 | 1.19 |
| Methionine (%) | 0.96 | 0.86 |
| Feed cost (₦/kg) | 91.80 | 88.00 |

**Composition of premix supplies the following per kg of feed: Vit. A = 12000IU, Vit. E = 15000IU, Vit. $D_3$ = 2500IU, Vit. C = 30,000mg, Folic acid = 100mg, Nicotine acid = 5000mg, Panthotenic acid = 15000mg, Fe = 1750mg, I = 40,000mg, Zn = 50,000mg, Mn = 100mg, CU = 1500mg, Cu = 200mg, Si = 100mg, Biotin = 600mg, Metabolisable energy calculated according to formulae of Peuzenga (1985). M.E = (37 x %CP) + (81 x %EE) + (35.5 x %NFE).*

c) *Experimental Animals and their management*

Two hundred and forty (240) day old MarshallStrain broiler chicks of mixed sexes were used for the study. The birds were randomly allocated to four treatment groups on arrival in a completely randomised design. The birds were fed a common diet during the period of the study (56 days). The treatments were replicated three times with 20 birds per pen. They were housed under a deep litter system with 40kg poultry litter per pen. Aluminium sulphate (alum) was applied to the poultry litter by mixing it with alum thoroughly using hands covered with hand gloves. The rates of alum application was as follows: T1 control (normal poultry litter with no alum), T2 (5% alum by kg weight treatment of litter from used 5% previously treated wood shaving), T3 (10% alum by kg weight treatment of litter from used 10% previously treated wood shaving) and T4 (15% alum by kg weight treatment of litter from used 15% previously treated wood shaving). Feed and water was supplied *ad libitum* throughout the 56 days study period and routine vaccination schedule was administered.

d) *Data collection and Analyses*

i. *Growth Parameters*

Feed intake, weight gain and feed conversion ratio were determined weekly. Feed intake was calculated by the difference between supplied feed and feed left in each pen. Weight gain was determined as the difference between the weight of the bird in the week under consideration and the previous week. Feed conversion ratio was calculated as the ratio of feed intake and weight gain within each week for each pen. Mortality was recorded as they occurred and body weight was recorded. Mortality percentage was calculated by dividing the number of birds that died within a period by the initial number of birds placed and multiplying by 100.

ii. *Carcass evaluation*

At the termination of the experiment (day 56), two birds from each pen having representative weights for the group (6 birds per Treatment) were selected. The selected birds were bled, dressed and eviscerated. Prime cuts and organs were separated and weighed individually and were expressed as percentages of carcass and live weight respectively.

iii. *Chemical analysis of litter*

The litter samples were analyzed for pH, ammonium ion ($NH_4^+$) concentration, soluble reactive phosphorus and total nitrogen at the Department of Agronomy, Ahmadu Bello University, Zaria while samples for total VFA were analysed at the chemical laboratory of National Animal Production Research Institute, Zaria, Kaduna State. A 20-g subsample of the litter sample was extracted with 200 ml of deionized water for 2 hours on a mechanical shaker, then centrifuged at 3,687 × *g* for 15 minutes (DeLauneet *al*., 2004). Aliquots were taken for pH, total nitrogen, $NH_4^+$, soluble reactive phosphorus (SRP), and total VFA. Unfiltered samples were used for pH using a pH meter and were analyzed immediately. Samples for total nitrogen and ammonium ions were filtered through a 0.45-µm membrane filter and were determined usingKjeldahl method with Kjeldahlapparatus as described by A. O. A. C. (1990). Samples to be tested for soluble reactive phosphorus were filtered through a 0.45-µm membrane filter, acidified to a pH of 2.0 with HCl and frozen until when required for analyses (Moore *et al*., 1995). Soluble reactive phosphorus was determined using the Bray1 method with an auto-analyzer (Spec 20D) according to APHA (1992). Samples for total VFA were not filtered but frozen until when required for analyses Kim (2003). Total VFA was analyzed using steam distillation technique with steam distillation apparatus as described by Chakrabarty(2003).

iv. *Statistical analyses*

All the data collected from the experiment were subjected to analysis of variance (ANOVA) using the general linear model of statistical analysis system (SAS, 2001) software package and the mean separation was done using Duncan multiple range test.

## III. Results

### a) *Performance of Broiler Chickens Raised on Alum Treated and Untreated Poultry Litter*

The performance of broiler chickens raised on alum treated and untreated poultry litter is shown in Table 2. The result showed no significant (P>0.05) differences among treatment groups in the daily weight gain, daily feed intake and daily water intake. However, there were significant (P<0.05) differences in final weight, total weight gain, feed conversion ratio, cost/kg gain and mortality across the treatments. The result showed higher final weight in alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter), with 10% alum treated litter having the highest final weight of 2.41kg and 0% alum treated litter having the least final weight of 1.96kg. Total weight gain was highest in 10% alum treated litter with 2.36kg and least in 0% alum treated litter with 1.91kg. FCR was higher in 0% alum treated litter with 2.43 and least in 10% alum treated litter with 2.18. Cost/kg gain was highest in 0% alum treated litter with ₦216.05 and least in 5% alum treated litter with ₦194.72. Mortality percentages was highest in 0% alum treated litter with 43.33% and least in 10% alum treated litter with 1.66%.

### b) *Carcass Characteristics of Broiler Chickens Raised on Alum Treated and Untreated Litter*

Table 3 shows the carcass characteristics of broiler chickens raised on alum treated and untreated litter. There were significant (P<0.05) differences in live weight, dressed weight, carcass weight, dressing percentage, breast, wings, back, thigh, drum stick and the weight of spleen, heart, liver, lungs and kidney across the treatments. The live weight was significantly higher in 5% and 10% alum treated litter with both having 2400.00g each, followed by 15% alum treated litter with 2270.00g and the least live weight was observed in 0% alum treated litter with 1970.00g. dressing weight was also significantly higher in 5% and 10% alum treated litter with 2320.00g and 2270.00g respectively, followed by 15% alum treated litter with 2080.00g and the least dressing weight was observed in 0% alum treated litter with 1720.00g. Carcass weight followed the same trend as live weight and dressed weight, the carcass weight was significantly higher in 5% and 10% alum treated litter having 1740.00g and 1750.00grespectively, followed by 15% alum treated litter with 1530.00g and the least carcass weight was obtained in 0% alum treated litter with 1310.00g. The dressing percentage was significantly higher in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control group (0% alum treated litter), with the highest dressing percentage in 5% alum treated litter with 96.53% and least in the control group with 87.32%. Percent breast, thigh and drum stick were significantly higher in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter) while percent wings and back are significantly higher in the control (0% alum treated litter) compared to the alum treated litter groups (5%, 10% and 15% alum treated litter). The percent weight of spleen, heart, liver, lungs and kidney were significantly higher in the control (0% alum treated litter) compared to all the alum treated litter groups (5%, 10% and 15% alum treated litter).

*Table 2:* Effect of Alum Treated and Untreated Litter on Broiler Chickens Performance

| Parameter | Treatments Alum Inclusion (%) | | | | SEM |
|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | |
| Final Weight(g) | 1961.00$^{c}$ | 2403.00$^{a}$ | 2413.00$^{a}$ | 2295.00$^{b}$ | 11.21 |
| Daily Feed Intake (g) | 86.00 | 95.00 | 95.00 | 91.00 | 4.65 |
| Daily Water Intake (ml) | 276.00 | 264.00 | 244.00 | 239.00 | 11.97 |
| Daily Weight Gain (g) | 35.00 | 39.00 | 38.00 | 34.00 | 2.88 |
| Total Weight Gain (g) | 1911.00$^{c}$ | 2353.00$^{a}$ | 2363.00$^{a}$ | 2245.00$^{b}$ | 9.43 |
| FCR | 2.43$^{a}$ | 2.19$^{ab}$ | 2.18$^{b}$ | 2.35$^{ab}$ | 0.07 |
| Cost/kg Gain (₦) | 216.05$^{a}$ | 194.70$^{b}$ | 195.50$^{b}$ | 196.00$^{b}$ | 3.51 |
| Mortality (%) | 43.33$^{a}$ | 3.33$^{b}$ | 1.67$^{b}$ | 5.00$^{b}$ | 1.08 |

*$^{abc}$ = Means on the same row with different superscripts are significantly (P<0.05) different.FCR = Feed conversion ratio. SEM = Standard error of mean.*

*Table 3:* Effect of Alum Treated and Untreated Litter on Carcass Characteristics of Broiler Chicken

| Parameter | Treatments Alum Inclusion (%) | | | | SEM |
|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | |
| Live weight (g) | 1970.00$^{c}$ | 2400.00$^{a}$ | 2400.00$^{a}$ | 2270.00$^{b}$ | 25.40 |
| Dressed Weight (g) | 1720.00$^{c}$ | 2320.00$^{a}$ | 2270.00$^{a}$ | 2080.00$^{b}$ | 18.60 |
| Carcass Weight (g) | 1320.00$^{c}$ | 1740.00$^{a}$ | 1750.00$^{a}$ | 1530.00$^{b}$ | 14.50 |
| Dressing Percentage (%) | 87.32$^{c}$ | 96.53$^{a}$ | 94.44$^{ab}$ | 91.93$^{b}$ | 1.05 |
| Prime cuts expressed as percent of carcass weight | | | | | |
| Breast (%) | 22.56$^{b}$ | 26.60$^{a}$ | 26.66$^{a}$ | 26.40$^{a}$ | 0.96 |
| Wings (%) | 10.66$^{a}$ | 9.73$^{b}$ | 9.67$^{b}$ | 10.66$^{a}$ | 0.25 |
| Back (%) | 20.43$^{a}$ | 16.75$^{b}$ | 16.86$^{b}$ | 16.66$^{b}$ | 1.08 |
| Thigh (%) | 14.40$^{b}$ | 16.83$^{a}$ | 16.66$^{a}$ | 16.46$^{a}$ | 0.34 |
| Drum Stick (%) | 12.70$^{c}$ | 15.70$^{a}$ | 15.56$^{a}$ | 15.16$^{b}$ | 0.29 |
| Organs expressed as percent of live weight | | | | | |
| Spleen (%) | 0.26$^{a}$ | 0.16$^{b}$ | 0.16$^{b}$ | 0.14$^{b}$ | 0.08 |
| Heart (%) | 0.82$^{a}$ | 0.46$^{b}$ | 0.46$^{b}$ | 0.46$^{b}$ | 0.07 |
| Liver (%) | 3.81$^{a}$ | 2.26$^{c}$ | 2.27$^{c}$ | 2.87$^{b}$ | 0.02 |
| Lungs (%) | 0.99 | 0.98 | 0.98 | 0.98 | 0.04 |
| Kidney (%) | 1.17$^{a}$ | 0.57$^{d}$ | 0.57$^{c}$ | 0.61$^{b}$ | 0.04 |

*$^{abc}$ = Means on the same row with different superscripts are significantly (P<0.05) different.SEM = Standard error of mean.*

*c) Chemical analysis of recycled litter treated with graded levels of Alum*

The fortnightly(week 2, week 4, week 6 and week 8) result of the effect of alum treated poultry litter on litter pH is presented in Figure 1. The result shows significantly (P<0.05) Lower pH values in all the alum treated litters groups (5%, 10% and 15% alum treated litter) compared to the control group (0% alum treated litter) for weeks 2, 4, 6 and 8. The pH levels decreases with increasing levels of Alum in week 4 and 6 (P<0.05). The result of total nitrogen levels of alum treated and untreated litter at two week intervals during the research period is presented in Figure 2. The result shows significantly (P<0.05) higher nitrogen content in all the alum treated litters (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter) for 2, 4, 6 and 8.

The fortnightly soluble reactive phosphorus levels of alum treated and untreated litter is presented in Figure 3. The result shows significantly (P<0.05) lower soluble reactive phosphorus level in all the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control group (0% alum treated litter). Figure 4 shows the fortnightly total volatile fatty acid levels of alum treated and untreated litter. The result shows significantly (P<0.05) lower total volatile fatty acid levels in all alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control(0% alum treated litter).The fortnightly ammonium ion ($NH_4^+$) concentrations of alum treated and untreated litter is presented in Figure 5. The result shows significantly (P<0.05) higher ammonium ion concentration in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter).

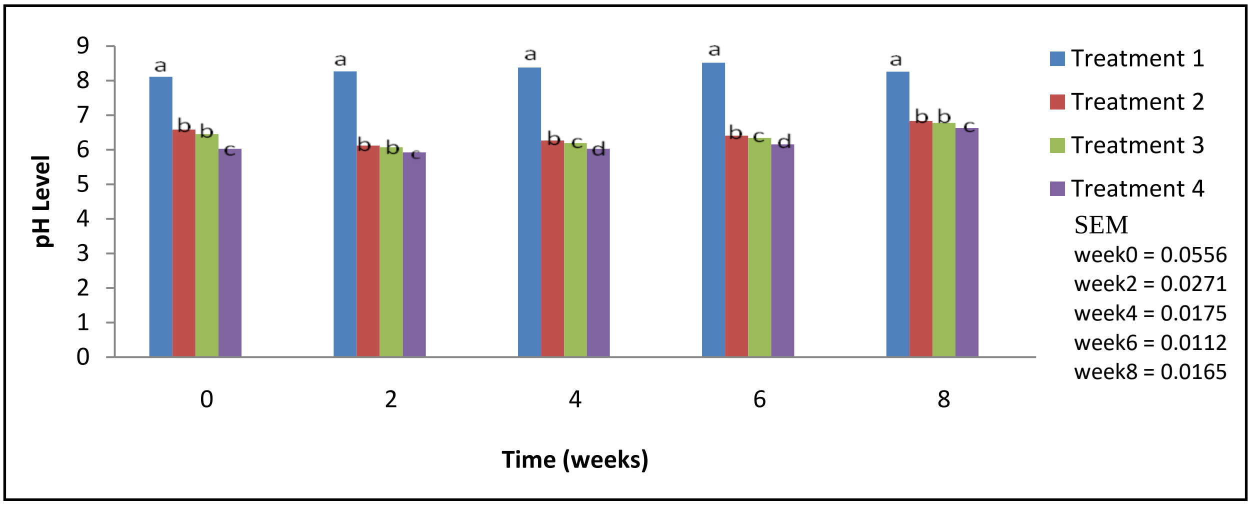


*Figure 1:* pH Levels of Alum Treated and Untreated Litter

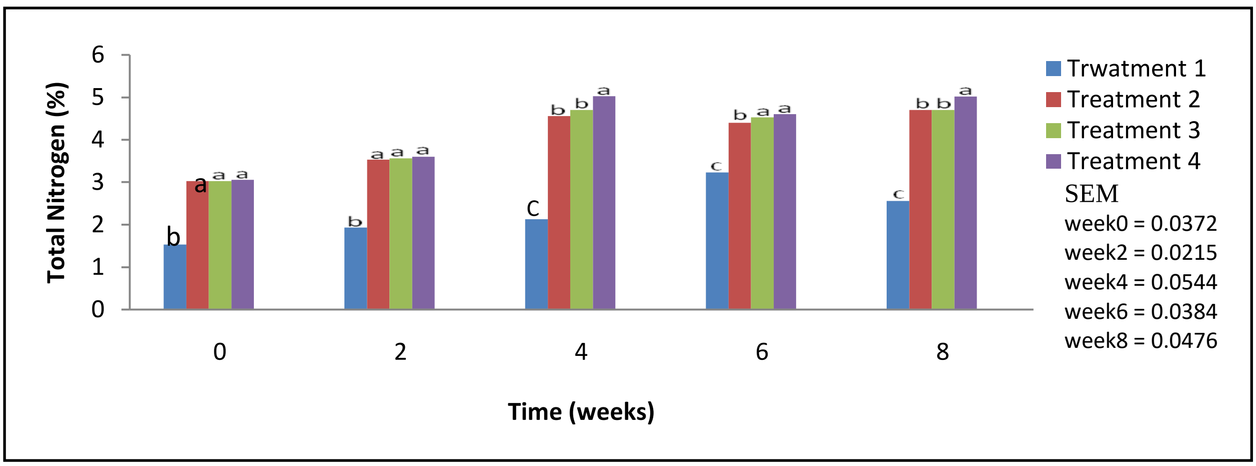


*Figure 2:* Total Nitrogen Levels of Alum Treated and Untreated Litter

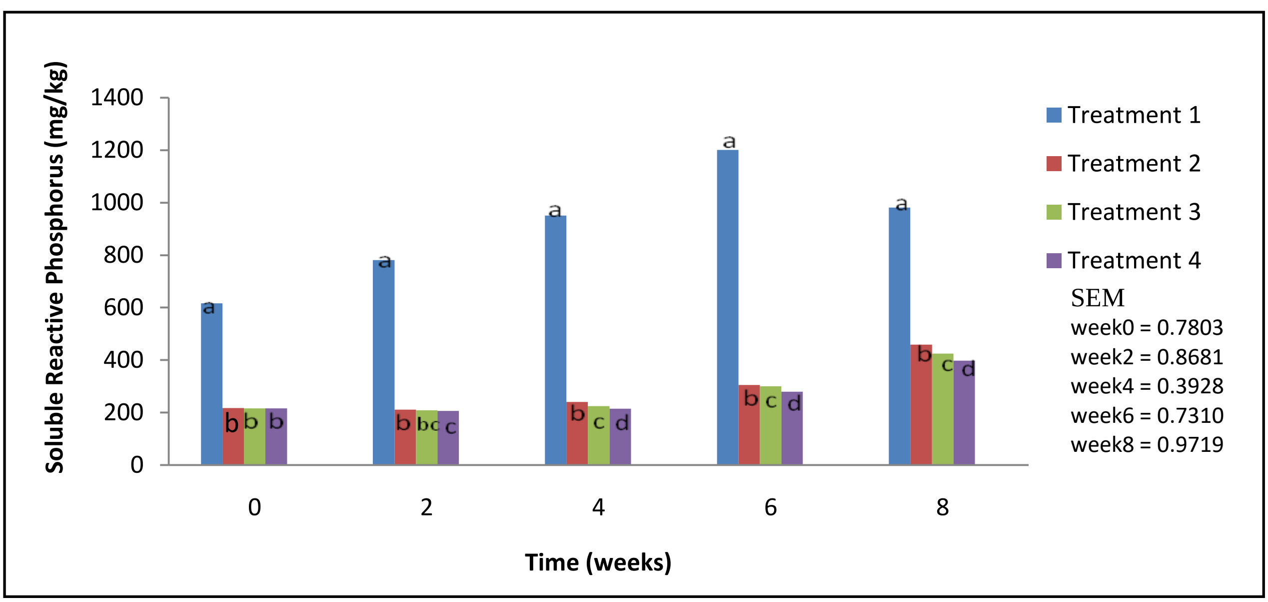


*Figure 3:* Soluble Reactive Phosphorus Levels of Alum Treated and Untreated Litter

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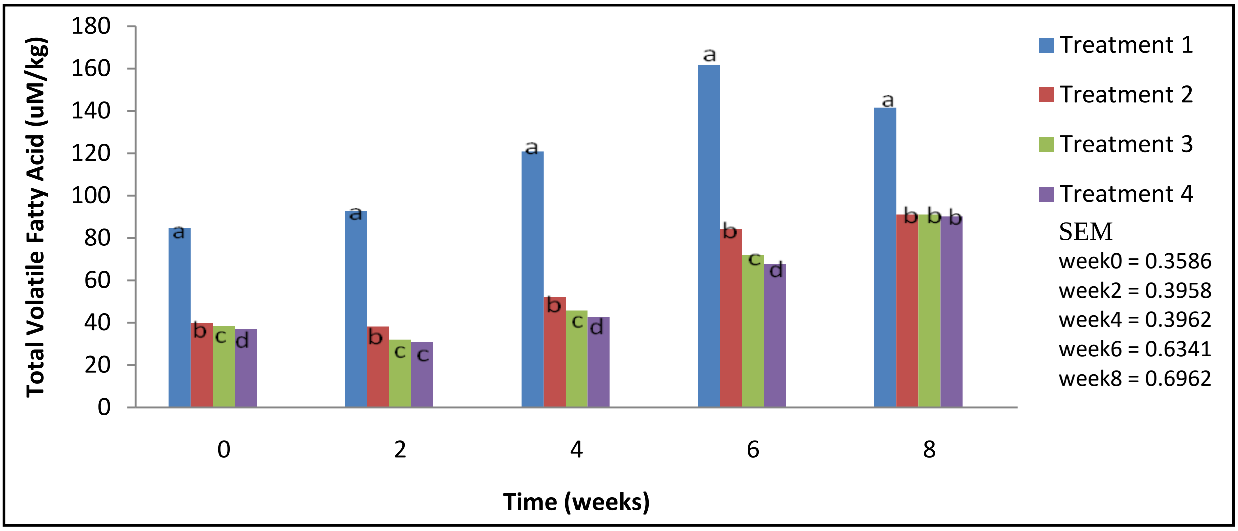


*Figure 4:* Total Volatile Fatty Acid Levels of Alum Treated and Untreated Litter

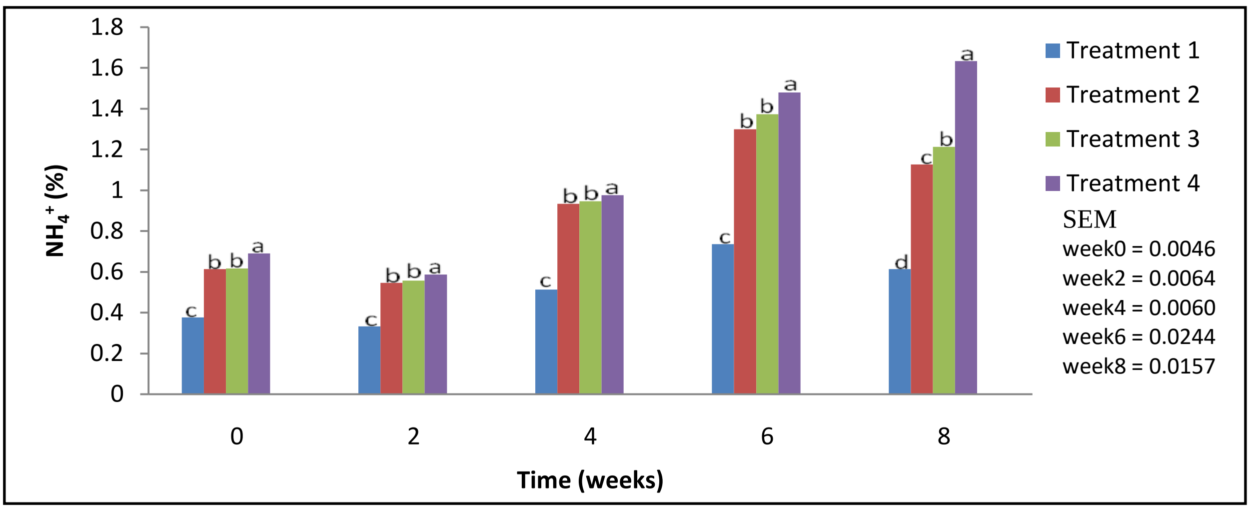


*Figure 5:* Ammonium ion ($NH_4^+$) Concentrations of alum Treated and Untreated Litter

## IV. Discussion

*a) Performance of Broiler Chickens Raised on Alum Treated and Untreated Litter*

The improved final weight, feed intake, FCR and cost/kg gain in the alum treated litter groups (5%, 10% and 15% alum treated litter) is in agreement with that obtained by Moore *et al*. (2000), who reported that alum treatment to poultry litter resulted in increased weight gains and improved feed conversion. This significant difference observed between the alum treated litter groups (5%, 10% and 15% alum treated litter) and the untreated litter (0% alum treated litter) can be attributed to the haematological parameters of the birds in this groups, hence indicating immune challenge condition of birds in the control group. The significantly higher final weight and weight gain observed in 5% and 10% alum treated litter compared to 15% alum treated litter may be due to the high alum concentration in the litter in 15% alum treated litter, which is similar to the result obtained by Choi and Moore (2008), who reported significantly higher weight gain in lower aluminium chloride compared to the high aluminium chloride treatment. Birds in 15% alum treated litter were observed to be limping during the study period. In general, alum treatment to broiler litter improves feed conversion, increased weight gains and resulted in fewer mortalities (Forbes and Robert, 2012).

*b) Carcass Characteristics of Broiler Chickens Raised on Alum Treated and Untreated Litter*

The significantly higher live weight, dressed weight, carcass weight, dressing percentage and percent breast, thigh and drum stick in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the untreated litter group (0% alum treated litter) and the significantly higher percent wings and back can be attributed to the health status of the birds as shown from the haematological parameters of the birds which agree with the result of Chinrasri and

Aengwanich (2007) indicating that the birds in the control (0% alum treated litter)group may behaving immune challenges, while the significantly higher Spleen, heart, liver and kidney observed in the untreated litter group compared to the alum treated litter groups can be also attributed to the disease condition of the birds as reported by Abeke*et al.* (2008), who reported that hypertrophy of organs may occur as a result of the body's attempt to increase protein availability or in the process of detoxifying toxic substances taking in or secreted by pathogens in the body.

*c) Chemical analysis of recycled litter treated with graded levels of Alum*

The significant decrease in pH levels of alum treated and untreated litter showed a significant decrease in litter pH between alum treated litter groups (5%, 10% and 15% alum treated litter) compared to control (0% alum treated litter), is in agreement with the result obtained by Choi and Moore (2008), who reported pH values to be 8.04 and 7.42 in the control and $AlCl_3$ treated litter respectively. The reduction in pH level observed in the alum treated litter can be attributed to the reaction of alum with $H_2PO_4$ in the litter resulting in the generation of acidity in the litter as reported by Penn and Zhang (2013). This reduced pH level in the litter agree with the result obtained by Moore *et al*. (1998) and Moore *et al*. (2000), who reported thatalum addition to poultry litter significantly reduces the pH of the litter. The significant increase in the total nitrogen content of the litter in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter) is in agreement with the report by Penn and Zhang (2013) who reported 4.24 % nitrogen in alum treated litter compared to the control untreated litter with 3.97% nitrogen at week 6.This significantly higher nitrogen level observed in the alum treated litter may be due to conversion ability of alum (aluminium sulphate) for nitrogen from gas form to a more stable solid form in the litter i.e. through the conversion of $NH_3$ gas to $(NH_4)_2SO_4$ by the reaction of sulphate with $NH_3$ in the litter as reported by Charles (2005). The significant higher nitrogen level in the litter is also similar to the report of Moore *et al*. (1998) and Moore *et al*. (2000) who reported the average total nitrogen contents of alum treated litter to be significantly higher compared to untreated litter. This nitrogen availability, indicate that crop yields could be higher when litter treated with alum is used as manure as reported by Shreve *et al*. (1995) and Moore and Edwards(2005).

The soluble reactive phosphorous levels reduction of the litter for alum treated at week 8 by 53.25%, 56.70% and 59.46% for5%, 10% and 15% alum treated litter respectively compared to the control is similar to that obtained by Shreve *et al*. (1995) who reported that alum treated litter lowered phosphorus concentrations in runoff by 87% and 63% compared with alum untreated litter for the first and second runoff events respectively. The significantly lower soluble reactive phosphorus level observed in the alum treated litter may be due to the impact of alum (aluminium sulphate) on the water solubility of phosphorus in the litter, thereby making the Phosphorus in the litter less water soluble and hence reducing phosphorus runoff on land as reported by Moore *et al*. (1998) and Moore *et al*. (2000). This is also similar to the findings of Shreve *et al.* (1995, 1996) and Dao *et al*. (2001) who reported that Al, Ca, and Fe amendments reduced soluble phosphorus in animal manures. Smith *et al*. (2001) reported that alum and $AlCl_3$ treatments produced reduced soluble reactive phosphorus concentrations in runoff by as much as 84% compared with normal manure and were not statistically different from soluble reactive phosphorus concentrations in runoff from unfertilized control plots. Choi (2004) reported that concentrations of soluble reactive phosphorus were 83% lower for $AlCl_3$ (200 g/kg of rice hulls) treated litter. Moore *et al*. (1998, 1999) explained that one of the reasons alum was chosen for phosphorus control in poultry litter was because alum is stable over a very wide range of pH conditions. The reduction in the total volatile fatty acid concentration by 35.6%, 35.72% and 36.25% in the 5%, 10% and 15% alum treated litter respectively when compared to the 0% alum treated litter group is in line with the report ofChoi and Moore (2008), who reported 51% of total volatile fatty acid reduction with aluminium chloride treatment to poultry litter.

Wilson (2000), Line (2002) and Choi and Moore(2008) hypothesize that it was due to the pH effect of acidifiers, which would inhibit microbial growth and activity in poultry litter. Similar findings have been observed by Varel and Miller (2004) who reported that when eugenol was added to animal manure it reduced VFA production by 70% and 50% in cattle and swine manure, respectively. They suggested that eugenol suppressed microbial activity by lowering manure pH and inhibiting the production of VFA that are considered the predominant odour compounds emitted from livestock wastes. The ammonium ion concentrations of the litters were 23.89%, 23.95%, 25.81 and 32.53% of the total nitrogen content of the litter for 0%, 5%, 10% and 15% alum treated litter respectively. This result is similar to that obtained by Choi and Moore (2008), Sims (1986, 1987) and Chadwick *et al*. (2000) who reported ammonium nitrogen representing 11% to 66% of the total nitrogen contents from control and all liquid $AlCl_3$ treatments. The significantly higher ammonium ion concentration observed in the alum treated litter groups (5%, 10% and 15% alum treated litter) is due to the higher nitrogen content of the litter resulting from reduced $NH_3$ emission as reported by Moore and Watkins (2012).The content of $NH_4^+$ and mineralizable organic nitrogen fraction (plant available nitrogen) in manure and litter plays an important role in determining the value of animal wastes as nitrogen fertilizer (Choi and Moore, 2008).

## V. Conclusion

The study conclude that treating recycled poultry litter with alum can increase total nitrogen and ammonium ion concentration of the litter and reduce pH, total volatile fatty acid and soluble reactive phosphorus content of the litter, thereby making the litter to be a better manure for crop production and reduce odour in poultry houses.

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