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Evaluation of a Novel Poultry Litter Amendment on Greenhouse Gas Emissions

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Abstract: Gaseous emissions from poultry litter causes production problems for producers as well as the environment, by contributing to climate change and reducing air quality. Novel methods of reducing ammonia (NH_3) and greenhouse gas (GHG) emissions in poultry facilities are needed. As such, our research evaluated GHG emissions over a 42 d period. Three separate flocks of 1000 broilers were used for this study. The first flock was used only to produce litter needed for the experiment. The second and third flocks were allocated to 20 pens in a randomized block design with four replicated of five treatments. The management practices studied included an unamended control; a conventional practice of incorporating aluminum sulfate (referred to as alum) at 98 kg/100 m^2); a novel litter amendment made from alum mud, bauxite, and sulfuric acid (alum mud litter amendment, AMLA) applied at different rates (49 and 98 kg/100 m^2) and methods (surface applied or incorporated). Nitrous oxide emissions were low for all treatments in flocks 2 and 3 (0.40 and 0.37 mg m^2 hr^{-1}, respectively). The formation of caked litter (due to excessive moisture) during day 35 and 42 caused high variability in CH_4 and CO_2 emissions. Alum mud litter amendment and alum did not significantly affect GHGs emissions from litter, regardless of the amendment rate or application method. In fact, litter amendments such as alum and AMLA typically lower GHG emissions from poultry facilities by reducing ventilation requirements to maintain air quality in cooler months due to lower NH_3 levels, resulting in less propane use and concomitant reductions in CO_2 emissions.

Keywords: alum; alum mud litter amendment (AMLA); poultry; litter; greenhouse gas (GHG); methane emissions; nitrous oxide emissions

1. Introduction

Poultry farms have been implicated as having a negative impact on air quality and the environment due to large amounts of atmospheric ammonia (NH_3) being emitted from poultry litter (combination of bedding material, feces, and urine; [1]) during production. It is believed that NH_3 emissions from poultry litter account for 27% of the total atmospheric NH_3 emissions in the U.S from animal husbandry. [2]. Although NH_3 is the largest atmospheric contaminant with respect to poultry production, poultry farms are also a source of greenhouse gas (GHG) emissions such as nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4), which contribute to global climate change [3].

According to the latest report by the U.S. Environmental Protection Agency (USEPA), the Agriculture sector accounts for 9.3% of the total GHG emissions in the U.S. [4]. Greenhouse gases in agriculture are mainly emitted from animal waste, in housing facilities, in storage faculties, during animal grazing through enteric fermentation, or during manure spreading [5]. Methane and N_2O have high global warming potentials, which are 28 and 265 times greater than CO_2, respectively [6]. According to USEPA [4], in 2018, CH_4 emissions from manure management and enteric fermentation represent approximately 10 and 28% of total anthropogenic activities, respectively. The largest contributors of N_2O emissions in the agriculture sector are livestock manure, application of synthetic and organic fertilizers, and growing N-fixing plants [4].

In the poultry industry, litter management during and after production contributes to GHG emissions. Given the assumption that 1.05 kg of litter is produced per bird [7], nearly 13 million Mg (14 million tons) of broiler litter is produced on U.S. poultry farms [1]. In contrast to NH_3 emissions, fewer studies have researched GHG emissions from poultry houses [8–10]. The data from these studies show that poultry production is responsible for a relativity small percentage of GHG emissions [8–10]. Broilers have monogastric digestive systems, and therefore do not produce a significant amount of CH_4 through enteric fermentation compared to cattle; instead, the main source of CH_4 being emitted is through poultry litter [9,11]. The formation of CH_4 occurs through anaerobic decomposition of poultry litter where oxygen, water contents, pH levels, and nutrient availability play a key role in CH_4 production. Methane emission from the surface of poultry litter is often reported as being very minimal [8,10]. Since the majority of poultry litter within poultry houses is in a solid state, aerobic conditions lead to only minimal CH_4 emissions being formed form the surface of the litter [9]. Nitrous oxide emissions mainly occur after poultry production, during storage and field application, through the process of nitrification and denitrification [12]. The storage of poultry litter under aerobic conditions with pockets of anaerobic conditions leads to N_2O volatilization while poultry litter stored in predominantly anaerobic conditions leads to the production of methane causing a trade-off between the two GHG emissions [13]. Carbon dioxide emissions from poultry litter occurs from the aerobic break down of uric acid as well as other organic compounds [14]. Calvet et al. [15] conducted a study on CO_2 balances in broiler production and reported that broiler litter accounted for 20% of the total CO_2 produced from a broiler facility.

Chemical amendments such as aluminum sulfate ($Al_2(SO_4)_3 \cdot 14H_2O$)), otherwise referred to as alum, are used to reduce NH_3 emission from poultry litter, but only one study has evaluated the effects of alum on GHG concentrations and emissions in poultry houses. In the study, Eugene et al. [16] found no differences in CH_4 and N_2O emissions from alum-treated and untreated litter. However, Eugene et al. [16] did report significantly lower CO_2 emissions from broiler houses treated with alum compared to untreated litter, which was due to less propane use during winter months because of lower NH_3 levels which allowed reduced ventilation rates.

The substantial price increase of alum over recent decades has created a need for a cheaper litter amendment to control NH_3 levels in poultry houses. One cheaper alternative that was patented by Moore [17] is alum mud litter amendment (AMLA). Alum mud litter amendment is a mixture of bauxite, sulfuric acid, and alum mud, which is an acidic solid residue formed as a byproduct during the manufacturing of alum [18,19]. Alum mud litter amendment, also called Al+Clear Plus, was manufactured by Chemtrade logistics INC. (Toronto, Ontario; Canada). Laboratory studies conducted on this new amendment showed that it was comparable to alum in reducing NH_3 emissions [17,19]. A pen trial conducted by Anderson et al. [20] on the effects of AMLA on NH_3 emissions from poultry litter showed AMLA reduced cumulative NH_3 from litter as much as, and in some cases more than alum applied at the same rate. Since this amendment is manufactured mainly using alum mud (a waste product that is normally landfilled at \$32 USD ton^{-1}), it should be much more cost-effective than alum. The effect of AMLA on GHG emissions has not previously been studied; therefore, the main objective of this study was to evaluate GHG emissions from poultry litter treated with AMLA in comparison to alum and untreated litter.

2. Materials and Methods

2.1. Design and Treatments

Pen trials were conducted at the poultry farm at the University of Arkansas Agricultural Research Station in Fayetteville, Arkansas. Three separate flocks of five hundred male and five hundred female 1-day-old Cobb x Cobb broiler chicks were randomly allocated to 20 pens at a density of 0.08 m^2 bird^{-1}. The pens (2.1 × 1.8 m; 50 birds per pen) were in a single room where the atmosphere was mixed. The chicks were reared with an automatically controlled light, temperature, and ventilation (0.85 m^3 h^{-1} per bird)

system that had two fans producing negative pressure. The lights in the room were on for twenty-three hours and off for one hour during the night. The temperature of the room followed industry standards, starting at 32.2 °C at the beginning of the flock and was lowered over time to 22.2 °C at six weeks. Heat lamps were used during the first 7 days to provide the chicks with warmer temperatures. The pens had concrete floors and were equipped with one tube feeder and an automatic bell drinker and started with 5 cm of clean pine wood shaving for bedding (17.2 kg per pen). Each flock of birds was raised for 42 d. Chicks were fed starter diets during the first two weeks (0 to 14 d), grower diets during the next three weeks (14 to 35 d), and finisher diets the last week (35 to 42 d). The diets contained corn (64.2%), soybean meal (27.7%), 50% meat and bone meal (2.5%), poultry oil (2.65%), sodium chloride (0.31%), sodium bicarbonate (0.05%) limestone (0.74%), dicalcium phosphate (1%), along with vitamins, amino acids, trace metals, xylanase and phytase. Unlike the European poultry industry, where litter is cleaned out and replaced with each flock of birds, the United States poultry industry reuses litter for several flocks of birds. Due to biosecurity protocols, litter from outside sources was not allowed to be brought into the facility, and therefore the purpose of the first flock of 1000 birds was to produce the poultry litter needed for the experiment. The second flock of 1000 birds was placed one week after the first flock was removed. The third flock of 1000 birds was placed one year after the removal of the second flock (due to the longest government shutdown in U.S. history and the fear of another shutdown). The litter was tilled between each flock to break up any cake that may have formed and to enhance drying.

There were four replicates of five experimental treatments laid out in a randomized complete block design. Each of the 20 pens contained only one treatment. The five treatments used in this study were: (1) control (untreated litter), (2) 49 kg AMLA/100 m^2 incorporated, (3) 98 kg AMLA/100 m^2 incorporated, (4) 98 kg AMLA/100 m^2 surface applied, and (5) 98 kg alum/100 m^2 incorporated. Three days prior to the placement of birds for flocks two and three, litter amendments were added to the designated pens. All litter amendments were evenly spread on the litter surface. The surface applied treatments were left untouched, while the incorporated amendments had the top 2 to 3 cm of the litter homogenized using a pitchfork.

2.2. Flux Measurements and Litter Analyses

Nitrous oxide, CH_4, and CO_2 flux measurements and litter samples were collected from each pen at days 0, 7, 14, 21, 28, 35, and 42, during the second and third flocks. A plastic flux chamber attached to an Innova 1512 Photo-acoustic Multi-gas Analyzer (Innova Air Tech Instruments, Ballerup, Denmark) was used to measure NH_3 and GHG gas emissions from the litter at three random locations within each of the pens; NH_3 emissions were reported by Anderson et al. [20]. The static flux chamber was a cylindrical plastic container, 35 cm high with a 14.5 cm radius; with a small battery powered fan mounted inside the container to stir the air within the flux chamber. Although a static flux chamber was used it was only on the litter for a very short period where changes in gas concentrations were linear, hence, it is unlikely that the static chamber was significantly affecting the concentration gradients of the gases being measured. Greenhouse gases were measured above the litter surface at time zero. The flux chamber was then placed on the litter surface and gas measurements were recorded at 60 s as was done by Choi and Moore [21]. The difference between the concentration at time zero and 60 s was used along with the ideal gas law to estimate the gas flux for each GHG being emitted from the litter. The flux measurements were then converted to an aerial basis (mg m^{-2} hr^{-1}). Cumulative fluxes were calculated by multiplying hourly fluxes by 168 to convert to a weekly flux, then successively adding each weekly flux. A litter sample was collected using clean gloves and a putty knife (used to cut through the cake layer) from the entire litter profile at each of the three locations where fluxes measurements were taken. The depth of the litter sample changed each week as more manure was added by the birds. The litter samples were thoroughly homogenized in a clean bucket, and a subsample was refrigerated for analysis;

the excess litter was returned to the pen. Litter samples were analyzed for moisture content, pH, electrical conductivity (EC), ammonium-N (NH_4-N), nitrate-N (NO_3-N), and total N (TN). Only moisture content and NO_3-N litter data will be reported in this paper. For all other litter parameter data, see Anderson et al. [20]. Moisture content was determined by oven drying a subsample of litter at 65 °C for 1 week. Fresh litter samples were extracted using a 1:10 (litter: water) ratio and filtered through a 0.45 um filter paper according to Self-Davis and Moore [22]. The litter extracts were analyzed for NO_3-N colorimetrically on a Skalar auto-analyzer (Skalar, Buford, GA); using the salicylate-nitroprusside USEPA Method 351.2 [23].

2.3. Data Analysis

Statistical analyses were conducted to evaluate the effect of litter amendments on GHG fluxes and litter characteristics using the GLIMMIX procedure in SAS 9.4 [24]. The experimental design was a randomized complete block design with a two-factor, factorially arranged treatment design. Analysis of variance (ANOVA) was conducted on main effects (litter amendments and sampling date), while blocks were considered random effects. Flocks 1 and 2 were analyzed separately. Differences in means were separated using Fisher's least significant difference (LSD) test at the 0.05 probability level.

3. Results and Discussion

3.1. Nitrous Oxide Emissions and Litter Nitrate Concentrations

Nitrous oxide-N emissions ranged from 0.08 to 0.68 mg m^{-2} hr^{-1} during flock 2 and from −0.09 to 1.27 mg m^{-2} hr^{-1} during flock 3 (Table 1). There were no trends observed for average N_2O-N fluxes during either flock. These data are consistent with an emission study by Moore et al. [25] which reported low N_2O variation per flock. Average and cumulative N_2O-N emissions (Table 1 and Figure 1, respectively) from both flocks were not affected by the additions of AMLA or alum to poultry litter. The study conducted by Eugene et al. [16] on the effects of alum on GHG emissions, also found no significant differences in N_2O levels between alum and untreated litter. Nitrous oxide is produced during the denitrification portion of the N cycle. Denitrification is an anaerobic process where NO_3 is serially reduced to nitrite (NO_2), nitric oxide (NO), N_2O, and finally N gas. Bacteria play an essential role in the N cycle, since oxygen is excluded during denitrification, bacteria can use NO_3, NO_2, and NO as terminal electron acceptors for respiration [4]. For large levels of N_2O to be emitted, poultry litter must first be aerobic, which results in the mineralization of organic matter releasing NH_3, which is then converted to NO_3 through nitrification. Before the start of each flock and prior to the application of the treatments, litter was tilled to break up cake that formed during the previous flock, which likely created aerobic conditions within the litter. Such aerobic conditions are ideal for the formation of N_2O, however, under high litter moisture, denitrification is expected to form N_2 with little to no N_2O being produced [5]. There were no treatment effects on the moisture content of litter for either flock [20]. If the moisture content of the litter would have varied by treatment, then perhaps differences in N_2O emissions would have been observed.

Litter NO_3-N concentrations as a function of time for flock 2 and 3 are shown in Figure 2a,b, respectively. The highest concentrations of NO_3-N were observed during the first 2 weeks (0 to 14 d) of flock 3. Chastain et al. [26] noted aerated poultry litter will result in a significant amount of NO_3-N. The increased aeration from tilling prior to the start of flock 3, along with the low moisture content (Table 2) of the litter, created perfect conditions for high NO_3-N levels in the litter. There were no significant differences in NO_3-N concentrations between untreated control litter and litter treated with AMLA or alum, during flock 2. However, during the first 2 weeks (0 to 14 d) of flock 3, high rates of incorporated and surface applied AMLA, and alum litter treatments resulted in significantly lower NO_3-N concentrations compared to the control litter. From day 0 to 14 of flock 3, litter treated with AMLA and alum reduced the pH of litter below pH 7 [20]. The optimal pH for nitrifying bacteria is between pH 7.0 and 8.0 [27]; therefore, the control litter,

which had a pH greater than 7, had higher NO_3-N levels. When the moisture content of the litter was greater than 30%, (Table 2), the NO_3-N within the litter was readily converted to N gas and was emitted into the air, thus explaining the near zero NO_3-N values observed for the majority of flock 3 (days 21 through 42).

Table 1. Average nitrous oxide flux (mg N_2O-N m^{-2} hr^{-1}) for flock 2 and 3 by treatment by day.

Treatment	Day							Avg.
	0	7	14	21	28	35	42	
Flock 2								
Control	0.43a†	0.28a	0.48a	0.50a	0.42a	0.68a	0.08a	0.41a
49 kg AMLA/100 m^2 incorporated	0.50a	0.44a	0.54a	0.62a	0.38a	0.19a	0.23a	0.41a
98 kg AMLA/100 m^2 incorporated	0.22a	0.32a	0.58a	0.56a	0.37a	0.46a	0.28a	0.40a
98 kg AMLA/100 m^2 surface applied	0.48a	0.44a	0.52a	0.59a	0.48a	0.16a	0.15a	0.40a
98 kg alum/100 m^2 incorporated	0.48a	0.47a	0.47a	0.50a	0.31a	0.22a	0.22a	0.38a
Flock 3								
Control	−0.05a	0.05a	0.59a	1.27a	0.79a	0.44a	0.10a	0.46a
49 kg AMLA/100 m^2 incorporated	0.05a	0.03a	0.39a	0.60a	0.91a	0.41a	0.13a	0.36a
98 kg AMLA/100 m^2 incorporated	0.05a	0.22a	0.37a	0.64a	0.67a	0.79a	0.29a	0.43a
98 kg AMLA/100 m^2 surface applied	0.08a	0.14a	0.40a	0.63a	0.72a	0.50a	0.06a	0.36a
98 kg alum/100 m^2 incorporated	−0.09a	0.13a	0.17a	0.67a	0.57a	0.38a	−0.06a	0.25a

† Values in columns followed by different letters indicate significant *(p < 0.05)* differences in means within each date and flock.
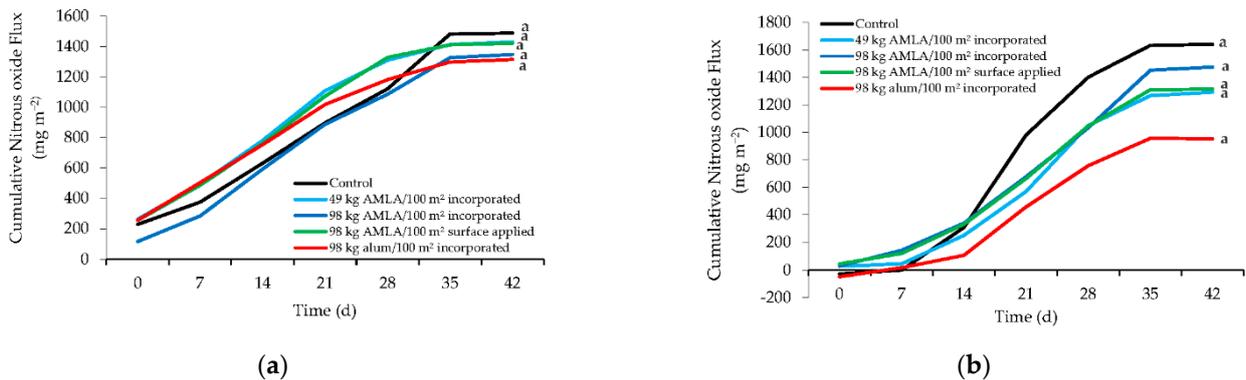

(**a**)   (**b**)

Figure 1. Cumulative nitrous oxide flux (mg N_2O-N m^{-2}) for (**a**) flock 2 and (**b**) flock 3 as a function of time. Treatments on day 42 not sharing a common letter are significantly different (*p < 0.05*).
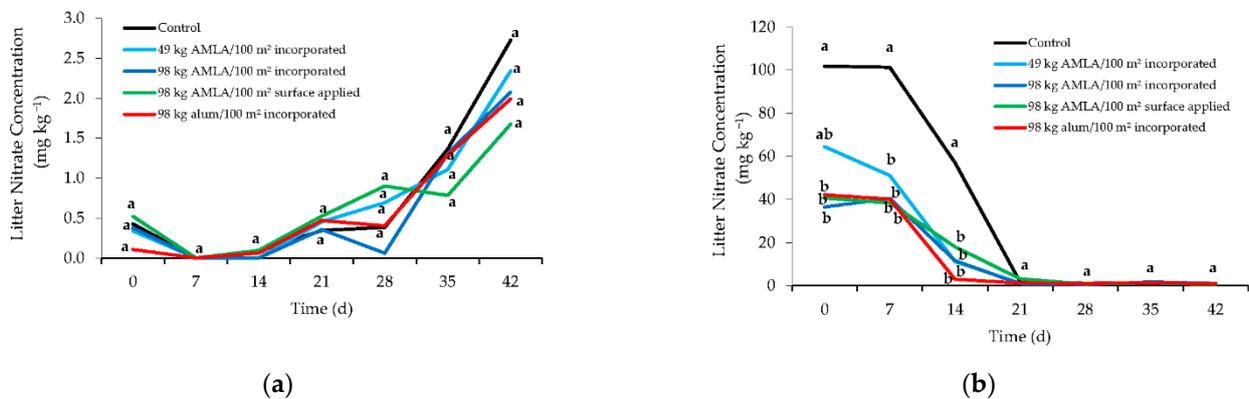

(**a**)   (**b**)

Figure 2. Average nitrate litter concentrations (mg NO_3-N kg^{-1}) for (**a**) flock 2 and (**b**) flock 3 as a function of time. Treatments not sharing a common letter are significantly different (*p < 0.05*).

Table 2. Average litter moisture (%) flock 2 and 3 by treatment by day.

Flock	Day							Avg.
	0	7	14	21	28	35	42	
Flock 2	36.0	30.6	30.1	30.0	37.9	43.0	43.4	35.9
Flock 3	16.4	15.4	26.8	37.4	40.9	47.7	50.2	33.5

3.2. Methane Emissions

Methane emissions, like N_2O-N emission, were also low, ranging from -7.84 to 81.8 mg m^{-2} hr^{-1} during flock 2 and from -167.2 to 178.9 mg m^{-2} hr^{-1} during flock 3 (Table 3). These low CH_4 emissions are consistent with emission studies by Wathes et al. [10], Miles et al. [8], and Burns et al. [28], who also reported low levels of CH_4 being emitted from poultry litter. Since CH_4 is produced by an anaerobic process and poultry litter is typically aerobic, high CH_4 emissions are not expected. An increase in CH_4 emissions was observed during the first 3 weeks (0 to 14 d) of flock 2 and during the first 5 weeks (0 to 35 d) for most treatments of flock 3. The increase in the moisture of the litter (Table 2) played a role in the increase in CH_4 emissions, especially during the third flock (Table 3). Miles et al. [8] also saw an increase in CH_4 from placement of chicks until mid growout, corresponding to increased moisture. The negative CH_4 fluxes observed during day 42 for both flocks was likely caused by a thick layer of cake that started forming during week 5. The layer of cake acted as a barrier creating lower emissions of CH_4 from the litter surface. Large variability in CH_4 flux measurement within pens were also observed during this period since the cake did not cover the entire pen, and therefore, the CH_4 flux was very much dependent on the placement of the flux chamber. There was no significant difference in average (Table 3) or cumulative CH_4 (Figure 3) emissions observed between treatments for either flock. Eugene et al. [16] also did not report any significant differences in CH_4 flux between untreated and alum-treated litter.

Table 3. Average methane flux (mg CH_4 m^{-2} hr^{-1}) for flock 2 and 3 by treatment and sampling date.

Treatment	Day							Avg.
	0	7	14	21	28	35	42	
Flock 2								
Control	32.0a†	44.4a	81.8a	38.1a	22.2a	20.4a	-7.48b	33.1a
49 kg AMLA/100 m^2 incorporated	25.7a	34.5ab	55.5a	47.1a	32.3a	24.4a	17.5a	33.9a
98 kg AMLA/100 m^2 incorporated	10.8a	36.1ab	73.9a	44.3a	23.9a	23.6a	8.12a	31.5a
98 kg AMLA/100 m^2 surface applied	14.8a	29.3b	82.0a	41.3a	22.5a	27.2a	19.3a	33.9a
98 kg alum/100 m^2 incorporated	18.9a	28.3b	78.4a	42.7a	27.0a	13.6a	14.2a	31.9a
Flock 3								
Control	-7.15b	19.0a	25.5a	35.5a	29.7a	94.1a	-167.2a	4.21a
49 kg AMLA/100 m^2 incorporated	-2.04ab	15.7a	21.4a	31.6a	46.4a	94.1a	-8.81a	28.3a
98 kg AMLA/100 m^2 incorporated	4.03a	21.8a	19.5a	33.7a	42.6a	178.9a	3.97a	43.5a
98 kg AMLA/100 m^2 surface applied	6.47a	20.8a	20.5a	28.0a	55.3a	131.7a	72.4a	47.9a
98 kg alum/100 m^2 incorporated	-7.00b	24.1a	26.0a	47.7a	31.1a	87.7a	-1.98a	29.7a

† Values in columns followed by different letters indicate significant ($p < 0.05$) differences in means within each date and flock.

3.3. Carbon Dioxide Emissions

Carbon dioxide emissions were the highest of the three GHGs measured in this study, ranging from 10.1 to 47.3 g m^{-2} h^{-1} during flock 2 and from 0.18 to 50.5 g m^{-2} h^{-1} during flock 3 (Table 4). At the start of flock 2 (0 d), CO_2 emissions were still elevated from the previous flock (flock 1), which was removed only one week prior to the placement of flock 2 chicks. After the first week, CO_2 levels decreased by more than half and then started increasing over the next 4 weeks (14 to 35 d), corresponding to broiler growth. Average CO_2 emissions on day 0 (of flock 3) were much lower compared to day 0 of flock 2 since

a year had passed between the end of flock 2 and the beginning of flock 3. As with flock 2, flock 3 CO_2 emissions increased over the next 4 weeks (7 to 28 d) corresponding to broiler growth. A study by Miles et al. [8] also reported increased CO_2 levels in broiler houses over time with bird growth and respiration. The decrease in CO_2 emissions on day 42 of flock 2 and days 35 and 42 of flock 3, was likely a result of caking that also affected CH_4 emissions. During the 42-day broiler life cycle, averaged across flocks, CO_2 represented 95% of total GHG emissions, while CH_4-CO_2-equivlant emissions accounted for 3% with N_2O-CO_2-equivlant emissions making up the remaining 2%. Alum mud litter amendment and alum did not influence average (Table 4) or cumulative CO_2 flux (Figure 4) during either flock. Eugene et al. [16] found that adding alum to poultry litter significantly lowered CO_2 emissions from poultry houses. Unlike this study, Eugene et al. [16] did not measure fluxes from litter but measured emissions from poultry houses that were either controls or treated with alum treatments, which included CO_2 produced from propane heaters. The control poultry house had higher ventilation rates (because of high NH_3 levels) which resulted in more propane being used to maintain optimum temperatures for poultry production, resulting in higher CO_2 emissions compared to the poultry house with alum-treated litter [16].
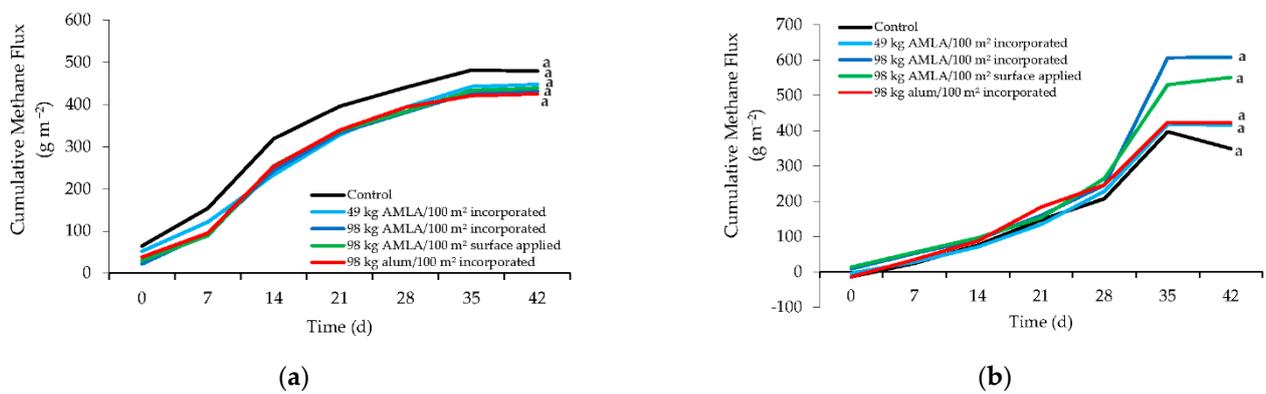

(a)

(b)

Figure 3. Cumulative methane flux (g CH_4 m^{-2}) for (**a**) flock 2 and (**b**) flock 3 as a function of time. Treatments on day 42 not sharing a common letter are significantly different ($p < 0.05$).

Table 4. Average carbon dioxide flux (g CO_2 m^{-2} hr^{-1}) for flock 2 and 3 by treatment and sampling date.

Treatment	Day							Avg.
	0	7	14	21	28	35	42	
Flock 2								
Control	29.1a†	12.6a	23.4a	19.8a	33.0a	47.3a	18.9a	26.3a
49 kg AMLA/100 m^2 incorporated	27.5a	13.2a	24.2a	21.9a	41.7a	41.0a	18.9a	26.9a
98 kg AMLA/100 m^2 incorporated	28.2a	11.3a	21.6a	22.8a	39.1a	35.4a	23.2a	26.0a
98 kg AMLA/100 m^2 surface applied	29.0a	10.1a	19.9a	21.7a	32.0a	37.1a	22.5a	25.0a
98 kg alum/100 m^2 incorporated	26.8a	10.2a	20.0a	18.5a	35.4a	41.1a	18.5a	24.4a
Flock 3								
Control	0.61a	1.25a	18.3a	42.9a	40.4a	29.7a	21.6a	22.1a
49 kg AMLA/100 m^2 incorporated	0.46a	0.69a	20.1a	39.8a	39.6a	25.7a	17.6a	20.6a
98 kg AMLA/100 m^2 incorporated	0.25a	0.50a	19.8a	45.0a	50.5a	25.5a	17.5a	22.7a
98 kg AMLA/100 m^2 surface applied	0.61a	0.46a	16.8a	36.0a	39.5a	22.4a	14.4a	18.6a
98 kg alum/100 m^2 incorporated	0.18a	0.79a	19.0a	35.5a	43.4a	25.3a	12.4a	19.5a

† Values in columns followed by different letters indicate significant ($p < 0.05$) differences in means within each date and flock.
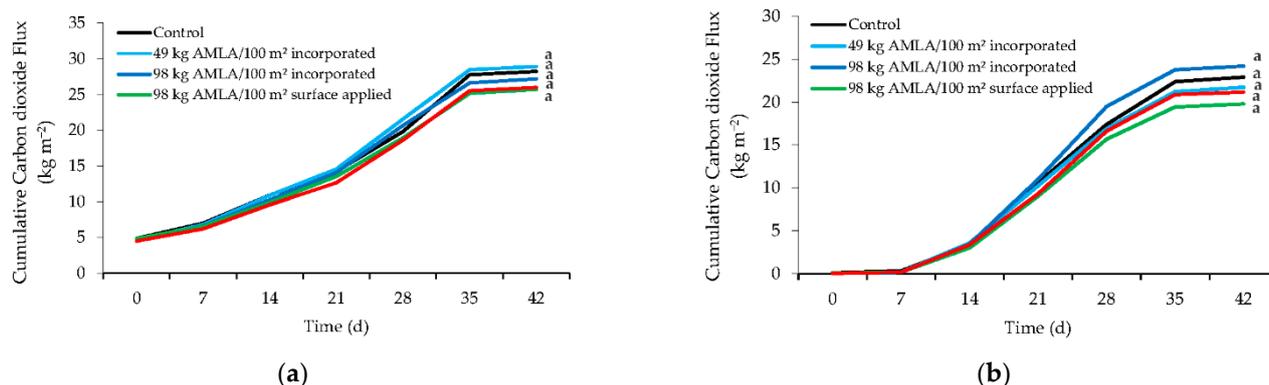
Figure 4. Cumulative carbon dioxide flux (kg CO_2 m^{-2}) for (**a**) flock 2 and (**b**) flock 3 as a function of time. Treatments on day 42 not sharing a common letter are significantly different ($p < 0.05$).

3.4. Effect of Litter Accumulation on Greenhouse Gas Emissions

In the United States, poultry litter is only cleaned out and replaced in poultry houses once a year, with some parts of the country cleaning out once every 3 to 5 years. The addition of fresh manure during new flocks affects GHG emissions in several ways. One of the primary ways is by adding organic compounds that are very labile, so there will be more microbial activity as they decompose the easily decomposable compounds. The rise in microbial activity will greatly increase CO_2 production. If the litter is dry enough, some of the NH_4 will be nitrified to NO_3. As more and more manure builds up and the moisture content of the litter gets higher, particularly in the cake, oxygen diffusion into the litter will be slower than oxygen demand by microbes, causing anaerobic microsites to develop in the litter. When this happens, bacteria will begin to use NO_3 as an electron acceptor, causing it to be denitrified ($NO_3 \rightarrow NO_2 \rightarrow NO \rightarrow N_2O \rightarrow N_2$), a process that will likely increase N_2O emissions. Under very reduced conditions, CO_2 can be used by microbes as an electron acceptor for respiration, resulting in methanogenesis, which would cause an increase CH_4 fluxes for the litter ($CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$).

4. Conclusions

The objective of this study was to evaluate the effect of a new litter amendment, AMLA, on GHG emissions from poultry litter. Both N_2O and CH_4 emissions from the surface of poultry litter were low. The moisture content of the litter played a role in NO_3 concentrations, with NO_3-N observed to be near zero when the litter moisture was greater than 30%. As the moisture increased during growout, CH_4 emissions also increased. As expected, CO_2 fluxes from the litter increased with broiler growth. The cake that formed during week 5 of both flocks caused greater variability in CH_4 and CO_2 emissions. Overall, the pen trial showed no significant differences in GHG emissions (N_2O-N, CH_4, and CO_2) being emitted from poultry litter treated with AMLA or alum compared to untreated litter. However, it is expected that the use of AMLA should reduce CO_2 emissions from poultry facilities, as do other ammonia-control chemicals, such as alum, by lowering atmospheric NH_3 levels in the houses, allowing lower ventilation rates during winter and concomitant decreases in propane use [16]. Since this novel poultry litter amendment was observed to have no significant impact on GHG emissions, addressing the concerns regarding the global warming potential of poultry production will require other strategies than those used to address air quality concerns.

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