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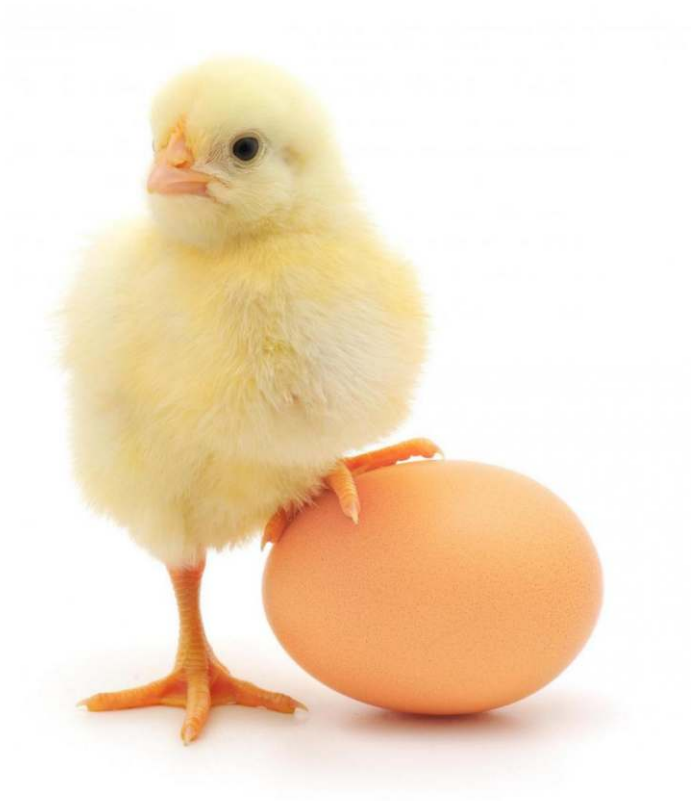

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Research Article
Poultry Production Management on the Buildup of Nutrients in Litter

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Abstract
Background and Objectives: It is believed that the poultry litter's nutrient composition is influenced by management. However, limited information exists on whether current poultry litter management strategies influence litter nutrients. To fill this knowledge gap, Alabama poultry producers were surveyed to evaluate their management strategies and asked to submit a litter sample to determine how their production practices impacts poultry litter and its nutrient composition. Specifically, this study assessed the frequency of cleanout, the depth of sampling, the size of birds reared and the number of flocks raised on the bedding to determine how it influenced macro and micro nutrient concentrations of the litter. **Materials and Methods:** The influence of poultry rearing facility (broiler, breeder, or pullet) and whether the litter was collected from a poultry house, composter or dry stack barn was also evaluated. A total of 188 L samples submitted by producers were used for this study. **Results:** Averaging across all samples collected, the litter on an as-is basis had a fertilizer grade close to that of 3-3-2 for N, P_2O_5 and K_2O, respectively. Litter collected from broiler production facilities had the highest overall macro- and micronutrient concentrations, while litter from composters had slightly higher N, P and Ca and lower C than litter taken directly from houses or drystack barns. The depth sampled, frequency of cleanout and number of flocks on the litter also influenced nutrient composition. Nutrients tended to be higher in caked litter than from sampling the entire six-inch depth. Litter nutrients tended to increase with flocks and decrease with frequency of cleanout. **Conclusion:** This study shows that differences in management may influence litter nutrient concentrations.

Key words: Litter management, macro and micro nutrient concentrations, nitrogen, phosphorus, potassium

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Poultry is the largest agricultural commodity (excluding forestry) in Alabama, generating 66% of the state's commodity receipts and 48% of agricultural exports[1]. Heavily influenced by broiler production, Alabama's poultry industry is ranked second in the nation[2]. Estimates of more than a 1 billion broilers are produced annually in Alabama, generating large amounts of poultry litter[2]. Until recently, poultry litter was viewed as a waste product that has historically been applied to nearby pastures as a means of disposal. With steady increases in fertilizer prices observed during the last two decades, poultry litter is now being viewed as valuable nutrient source for row crop production systems.

Poultry litter, a mixture of excreta, feed, feathers and organic bedding material such as pine shavings, pine bark, sawdust, peanut hulls, or rice hulls, is regarded as the most valuable manure source[3]. Poultry litter's relatively high nutrient content makes it an economically competitive N source to commercial inorganic fertilizers. The bedding portion of the litter also makes the poultry waste a highly carbonaceous material which can be used to increase soil organic matter. In addition, increasing concentrations of P, K, Ca, Mg, Cu and Zn have been observed in soils receiving poultry litter[4], which can potentially improve yields[5]. Thus, poultry litter can serve as a relatively inexpensive source of nutrients for row crop and forage production systems.

Like Alabama, poultry litter is an abundant resource in many regions of the southeastern US. In 2017, the southeastern US[6] produced more than two-thirds (6.23 billion) of the nation's 8.91 billion broilers generating approximately 9.35 million U.S. tons of broiler litter (1.5 kg litter/broiler[2,7]). In recent years, broiler producers have changed the way litter is being managed to decrease costs and increase their bottom line. For instance, there has been a tendency for producers to reuse litter in their poultry houses for one, two, or more years. This process has become necessary to expedite subsequent flock replacement, reduce bedding cost and labor, decrease storage space and minimize the need for land application. Instead of total cleanout, partial removal of the cake from areas where litter has become saturated and dense has become a common practice. This allows for reuse of the old litter as a base while only top dressing it with a thin layer of new material when needed to minimize cost. As a result, producers have been presented with a new challenge to reduce high ammonia concentrations. This has resulted in the use of chemical amendments (primarily acidifiers) to reduce ammonia and bacterial populations, further facilitating the life of the litter[8]. The practice of in-house windrowing litter between flocks has also gained acceptance in the industry as an alternative management practice to prolong the useful life of litter. These management practices are believed to have influence on nutrient concentrations of the litter. However, the impact of these poultry litter management practices have on plant nutrient content is largely unknown.

There is insufficient scientific data published on the nutrient content of poultry litter relative to recent management practices in most poultry houses. Also, concerns for disposal of poultry litter has become an important issue for producers, the industry, land managers and the general public because of growing threat that its nutrients pose to water quality[9]. It has been previously reported that poultry litter has a fertilizer grade of 3-3-2 ($N-P_2O_5-K_2O$)[10]. However, there have been some recent testimonies from producers observing poultry litter nutrient content as high as 5%. Thus, given that book values for the composition of poultry litter was developed from sources 20 -25 years ago and because poultry production practices and animal diets have changed, investigating the influence of management on poultry litter may lead to a better understand of how these practices may impact nutrients building up in litter?. This study was conducted to assess the frequency of cleanout, the depth of sampling, the size of birds reared and the number of flocks raised on the bedding to determine how it influenced macro- and micro nutrient concentrations of the litter.

MATERIALS AND METHODS

Representative poultry litter samples were collected from commercial growers in regions of Alabama where the industry is concentrated. Achieved with the help of Alabama Agriculture and Industry and Alabama Agricultural Cooperative Extension System Personnel, a total of 188 L samples were collected from 2009-2011 from poultry producers. The samples were classified into different categories based on the litter source collected and management. Litter samples were collected at random from the poultry facilities by taking multiple grab samples using a wedge probe and composited. Samples from litter heaps in dry stack barns or composters were collected by taken multiple small samplings and also compositing it. After collection, the samples were mixed thoroughly, placed in polythene bags and shipped to Auburn University Soil Testing Laboratory for analysis. The overall intent was to ascertain the influence poultry management practices have on the nutrient content of litter being removed from production facilities.

Survey analysis: At the time of poultry litter sampling, producers were solicited to complete a questionnaire querying them to describe their management. The questionnaire consisted of 2 pages containing 20 questions, each with a series of responses and an "other" option in some cases, which included detailed information on farm operations and management practices from where the litter was collected. The comprehensive questionnaire was developed by the authors of this manuscript. Prior to implementing survey, the questionnaire was submitted to the Alabama Interagency Waste Management Team which is made of personnel from the USDA-NRCS, Alabama Cooperative Extension System, Alabama Department of Agriculture and Industries, Alabama Farmers Federation, Alabama Poultry and Egg Association, Alabama Department of Environmental Management and Alabama Department of Public Health and researchers from Auburn University and the USDA-ARS for suggestions and comments. Revisions were made following review and the final version of the questionnaire used for this study is illustrated in Fig. 1. A free poultry litter analysis was given to each producer as an incentive for completing the questionnaire. Interviewees represented poultry producers with diverse management operations being practiced within the state. Surveys were conducted until adequate sampling was received. Upon receiving the questionnaires from the survey, responses were checked for clarity and accuracy. Clarification was sought from producers when needed and data discarded when believed to be erroneous. Each participant was guaranteed anonymity.

Poultry litter analysis: Poultry litter samples were analyzed by Auburn University Soil Testing Laboratory for macro and micronutrients using procedures outlined by Hue and Evans[11].

The Soil Testing lab at Auburn University (http://www.aces.edu/anr/soillab/ is attempting to build a database that will allow a quick estimate of poultry litter quality. It would be greatly appreciated if you could provide all the known information so we can be able to better serve you. If you fill this form and send in with the Chicken

Litter Information form found at: http://www.aces.edu/anr/soillab/ChickenLitterformRevised1.pdf.pdf, you will get free of charge for the L1 ($25.00) analysis for a one time deal. Your litter sample must be from Alabama to participate. Thank you.

1. Type of litter: **a)** layer **b)** broiler **c)** pullet **d)** breeder **e)** other ______________?
2. When was this manure collected (time, date) ______________?
3. Is the sample a composite sample (taken from several locations) or a grab sample (taken from one location)? **a)** composite **b)** grab
4. When were the birds last on the litter (date) ______________?
5. County where your animal operation is located ______________?
6. Is the sample from a: **a)** poultry house **b)** drystack **c)** composter **d)** spreader truck **e)** field storage **f)** other ______________?
7. If from a poultry house, what is the size (length x width) of the poultry house______________?
8. If from a poultry house, was the litter composted in the house between flocks______________?
9. How many birds are placed in the house per flock______________?
10. How many flocks or batches of birds were raised on the litter sample______________?
11. This sample represents the portion of the litter removed? **a)** cake **b)** 2-4 inches **c)** 4-6 inches **d)** 6 inches or more
12. How often is the house cleaned out to the ground: **a)** less than six months **b)** every six months **c)** every year **d)** every two years **e)** every three years **f)** other______________?
13. Do you use litter treatment? yes no If yes, what type of liter treatment do you typically use? **a)** Alum **b)** PLT **c)** Gypsum **d)** Poultry guard **e)** other ______________?
14. If litter treatment is used, what fraction of the house is treated________________?
15. Total number of birds produced on the litter before cleaning out to the ground _______________?
16. What is the approximate market weight of the bird produced ______________?
17. Do you use a bedding material? Yes No
    If yes, what type of bedding do you typically use? **a)** sawdust **b)** shavings **c)** peanut hulls **d)** other______________?
18. How do plan to use the litter? Please circle all that apply: **a)** apply as fertilizer to pasture **b)** apply as fertilizer to cropland **c)** sell the litter based on its nutrient content **d)** other use (explain) _______________?
19. When was the last application of litter to the soil? ____
20. What amount was spread? ____

Farm Information

Name: ____

Address: ____

____

County: ___________________ Phone No: _______________________ GPS: ____________________________

Fig. 1: Poultry litter sample questionnaire submission form

Statistics: Data were analyzed as a completely randomized design. Results from nutrient analysis were subjected to an analysis of variance (one-way ANOVA) using the GLM procedure of SAS®[12]. Differences were considered significant at $p \leq 0.05$ and separated using the Fisher's Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

Approximately, 200 poultry litter samples (188 actual number) accompanying litter surveys were submitted for this study. The samples were taken from poultry houses at the end of a rearing cycle. Most of these samples came from the Sand Mountain Region of North East Alabama (Dekalb, Jackson, St Clair and Calhoun County) and the Wiregrass Region of South East Alabama (Crenshaw, Lowndes, Butler, Coffee and Geneva), which are representative of the largest poultry producing areas in Alabama. Majority of the samples submitted were composite samples taken directly from poultry houses followed by dry-stack barns. Average poultry house size was 40×400 or 40×500, which raised approximately 23,000 birds ranging from 4.0-7.5 pounds. Litter samples primarily originated from broiler houses (ex. samples from dry-stacks or composters originated from broiler houses) which are a reflection of the large broiler industry in Alabama. The number of flocks raised on the litter being evaluated ranged from 1-70 plus flocks. While there were some producers cleaning out the house to the ground every year (every year ~31%, every two years 32%, every three years ~10%, more than three years or never ~22%) a large number of producers are just removing the cake or top 2-4 inches of litter and not cleaning out to the ground. Also, a majority of the producers submitting poultry litter samples used some form of litter treatment (72%) for ammonia control, primarily to the brooding half of the house. A majority of the litter treatments used were PLT® [Poultry Litter Treatment, sodium bisulfate (38%)] followed by Al+Clear® [Alum, aluminum sulfate (28%)], Poultry Guard™ [Acidified Clay (8%)], Al+Clear®+PLT (18%) and PLT®+Al+Clear (6%). Producers not using a litter treatment composted their litter inside the house between flocks (in-house windrowing). Approximately, 80% of the producers planned on using the poultry litter to fertilizer their pasture (average application rate 2 t acre^{-1}), while 20% were selling the litter for its nutrient content. Litter nutrient content varied depending on the type of poultry operation and management. The following discussion is an in-depth look at how poultry management operations influence nutrient concentrations of the litter. Data presented in the succeeding text is expressed on a dry-matter basis.

Nutrient concentrations based on production facility: Poultry litter nutrient concentrations based on bird production facility are presented in Table 1. Differences in litter nutrient composition were observed depending on the type of bird produced. Concentrations of C, N, P, Ca, B, Cu, Fe, Mn and Zn were significantly affected. Generally, broiler litter had the highest C, N, B, Cu and Zn concentrations, while pullet litter had the highest P and the breeder litter had the highest Ca and Mn. Difference in observed litter nutrient concentrations among the different types of poultry production facilities are most likely attributed to differences in the feed formulation and house management practices. It is also noteworthy mentioning that there was limited litter data collect from pullet and breeder houses for this study.

Nutrient concentration differences between poultry houses, composter and drystack: Minimal differences were observed in nutrient concentrations of litter taken from the poultry house, composter, or drystacks (Table 2). Phosphorus was the only nutrient significantly influenced between these litter management practices, with litter taken from the composter being highest. It is also important to note that N concentration of litter collected from the composter was numerically higher (although not significant at $p<0.05$) than litter from the house and drystack. It is believed that while N is lost to volatilization during composting, C is also lost in the form of CO_2. Numerically, the composted litter also had a lower C concentration and higher amounts of Ca but not significant. A number of state Agricultural Extension Publications from the southeast have suggested that composting PL decreases C and N concentrations in poultry litter and increases P, K, Ca, Cu, Zn and other micro and macro nutrient concentrations. This was not observed with this study.

Nutrient concentrations based on cleanout frequency: When the same litter is used for multiple growouts, the cake which is normally the 5-10 cm thick crusted layer on the surface is removed after each flock, leaving behind the fine material to be reused as bedding. Table 3 shows the influence of growing successive flocks on nutrient composition changes of the remaining fine material (litter) reused for bedding. Nutrient concentrations of the litter observed from this study tended to increase with the number of flocks regardless of the macro- or micro nutrient being evaluated, except for C. However, significant increases were only found for concentrations of N, K, Ca and Mg, with increasing flocks on the litter. Phosphorus tended to increased linearly with the number of flocks but was not significant from the yearly

Table 1: Nutrient concentration of litter based on the type of production facility

	Percentage							mg kg^{-1}					
	Ash	C	N	P	K	Ca	Mg	AL	B	Cu	Fe	Mn	Zn
Broiler (159)†	22 28.9 (9.02)	33.6 (4.64)^a	3.7 (0.56)^a	1.7 (0.50)^a	2.3 (0.7)^a	2.7 (0.7)^c	0.8 (0.50)^a	2779.2 (1695)^a	73.5 (38.60)^b	559.4 (267.2)^a	2794.8 (1257)^a	558.0 (154.1)^b	588.1 (148.27)^b
Breeder (16)	46.7 (13.9)	27.9 (7.10)^b	2.0 (0.64)^c	1.4 (0.47)^b	2.1 (1.28)^a	6.5 (1.9)^a	0.8 (0.27)^a	3083.9 (3973)^a	32.1 (10.35)^a	199.9 (201.9)^b	3868.1 (3226)^a	1569.9 (2419)^a	323.8 (103.11)^a
Pullet (13)	34.7 (15.3)	31.2 (7.11)^b	2.8 (0.67)^b	2.1 (0.71)^a	2.0 (0.31)^a	3.5 (1.3)^b	0.8 (0.23)^a	4745.7 (2568)^a	45.8 (15.51)^a	467.5 (218.4)^a	6301.6 (4574)^b	1109.3 (563.6)^b	513.2 (121.41)^b

†No. of samples used for analysis, ‡mean followed by the standard deviation

Table 2: Nutrient concentration of litter taken directly from house, composted, or stored in a drystack barn

	Percentage							mg kg^{-1}					
Management	Ash	C	N	P	K	Ca	Mg	AL	B	Cu	Fe	Mn	Zn
Poultry house (88)	29.4 (11.46)	34.1 (5.48)^a	3.45 (0.62)^a	1.59 (0.54)^b	2.29 (0.94)^a	2.57 (0.77)^a	0.70 (0.40)^a	3165 (3684)^a	64.90 (30.6)^b	567 (334.0)^a	2876 (2909)^a	524 (145)^a	575.0 (183)^a
Compost (19)	32.9 (8.09)	33.1 (4.56)^a	3.73 (0.69)^a	1.83 (0.61)^a	2.15 (0.50)^a	3.10 (1.13)^a	0.72 (0.41)^a	2970 (3017)^a	77.02 (51.7)^a	466 (2316.0)^a	2701 (1823)^a	541 (174)^a	557.0 (170)^a
Drystack (49)	29.5 (11.59)	33.6 (5.71)^a	3.56 (0.91)^a	1.68 (0.43)^{ab}	2.39 (0.66)^a	2.94 (0.94)^a	0.88 (0.47)^a	2756 (2978)^a	77.77 (36.9)^a	551 (342.4)^a	2857 (2874)^a	718 (1026)^a	569.1(177)^a

†No. of samples used for analysis, ‡mean followed by the standard deviation

Table 3: Nutrient concentration of litter based on cleanout frequency

	Percentage							mg kg^{-1}					
Management	Ash	C	N	P	K	Ca	Mg	AL	B	Cu	Fe	Mn	Zn
Every year (48)	28.9 (9.81)	34.4 (4.46)^a	3.46 (0.67)^b	1.58(0.42)^a	2.18 (0.60)^b	2.57 (0.62)^b	0.65 (0.28)^b	2775 (2894)^a	65.4 (23.4)^a	465 (314)^a	2112 (1143)^a	532 (164)^a	555 (177.0)^a
Every two years (31)	29.3 (0.83)	34.5 (4.72)^a	3.56 (0.69)^b	1.58 (0.52)^a	2.22 (0.78)^b	2.56 (0.80)^b	0.77 (0.53)^a	3246 (4546)^a	78.3 (50.8)^a	597 (370)^a	2260 (1994)^a	527 (158)^a	561 (199.0)^a
Every three years (17)	30.6 (15.05)	33.4 (7.43)^a	3.84 (0.55)^a	1.69 (0.20)^a	2.24 (0.37)^b	2.61 (0.40)^b	0.76(0.30)^{ab}	1970 (1633)^a	85.2 (43.6)^a	653 (281)^a	2243 (1462)^a	556 (107)^a	623 (81.5)^a
More than three (20)	26.2 (4.86)	34.3 (3.16)^a	3.89 (0.52)^a	1.70(0.37)^a	2.76 (0.73)^a	3.14 (0.74)^a	1.01 (0.53)^a	2012 (1886)^a	83.1 (33.2)^a	608 (203)^a	2549 (1011)^a	606 (140)^a	591 (85.4)^a

†No. of samples used for analysis, ‡mean followed by the standard deviation

cleanout. These finding are in accordance with other studies who have observed nutrient increases over time when the litter is recycled[13,14].

Nutrient concentrations based on depth of litter removed: Table 4 illustrates the nutrient concentrations of litter with depth. Nutrient compositions tended to decrease when litter was sampled at increasing depths, except for the C content. The carbon content in the litter was significantly lower than that observed from deeper depths. This is most likely a result of the cake having less bedding and a greater concentration of excrement. Although, minimal differences were observed, given the trend, it is important to mention that cake had the highest nutrient concentration. Previous, research has shown that nutrients accumulated more slowly in the rest of the litter than in the cake[13]. Moore et al.[15] reported that fresh chicken manure without bedding has higher concentrations of P, Ca, Mg and Zn compared to broiler litter. Thus, it was to be expected that the cake portion of the litter in this study tended to have higher nutrient concentrations. Sistani *et al*.[16] evaluated the influence of decaking vs. total cleanout on litter nutrients from three broiler houses over the course of four flocks. They reported that the cake removed had numerally higher N and P concentrations and significantly greater Ca, Mg, K, Cu, Fe, Mn and Zn than the entire litter.

Nutrient concentrations based on the size of bird: The influence of bird size on litter nutrient concentration is present in Table 5. Overall, numerical concentrations of P, K, Ca and B tended to decrease with bird size. However, this observation was not corroborated statistically. This trend could have resulted in the amount of P, K, Ca and B nutrients being higher in starter feed and lower in grower and finisher feed. For example, heavy broilers are provided grower feed for much longer periods than that of small or medium sized broilers. Further, heavy broilers are placed in broiler houses at much lower stocking densities than smaller or medium size broilers which may also influence the nutrient concentrations of the litter.

Nutrient concentrations based on the number of flocks: Nutrient concentrations observed for litter based on the number of flocks reared are displayed in Table 6. Numerically, concentrations of N, P, K, Ca and Mg tended to increase with increasing number of flocks being raised on the litter. However, nutrient concentrations of N, P, Ca, did not increase to a level that was significant when compared with flock 1. Concentrations of Mg and K were the only nutrients that

Table 4: Nutrient content of litter based on the depth of litter removed from house

	Percentage							mg kg^{-1}					
Depth	Ash	C	N	P	K	Ca	Mg	AL	B	Cu	Fe	Mn	Zn
Cake (35)	26.5 (6.45)	32.9 (5.34)^{a}	3.72 (0.53)^{a}	1.72 (0.30)^{a}	2.48 (0.61)^{a}	2.85 (0.61)^{a}	0.80 (0.49)^{a}	2824 (2809)^{a}	86.3 (37.5)^{a}	614 (323)^{a}	2935 (2458)^{a}	592 (139)^{a}	633(166)^{a}
2-4 inches (38)	28.7 (8.20)	35.0 (3.35)^{b}	3.42 (0.59)^{a}	1.54 (0.42)^{a}	2.31 (0.76)^{a}	2.58 (0.68)^{a}	0.78 (0.38)^{a}	3340 (3537)^{a}	73.4 (42.5)^{ab}	501 (285)^{a}	2735 (2679)^{a}	534 (157)^{a}	548(169)^{a}
4-6 inches (45)	29.0 (11.51)	34.6 (5.25)^{ab}	3.72 (0.72)^{a}	1.61 (0.51)^{a}	2.24 (0.75)^{a}	2.61 (0.82)^{a}	0.71 (0.40)^{a}	2946 (4349)^{a}	60.3 (24.8)^{b}	505 (321)^{a}	2509 (2616)^{a}	521 (139)^{a}	561(147)^{a}
6 inches (8)	29.6 (1.29)	35.1 (3.91)^{b}	3.65 (0.67)^{a}	1.49 (0.55)^{a}	2.03 (0.53)^{a}	2.55 (0.61)^{a}	0.69 (0.58)^{a}	1118 (726)^{a}	64.9 (45.7)^{ab}	375 (213)^{a}	1524 (1205)^{a}	512 (105)^{a}	530(238)^{a}

†No. of samples used for analysis, ‡mean followed by the standard deviation

Table 5: Nutrient concentration of litter based on size of bird

	Percentage							mg kg^{-1}					
Bird size (lbs)	Ash	C	N	P	K	Ca	Mg	AL	B	Cu	Fe	Mn	Zn
3 - 3.9 (14)	26.2 (3.69)	35.3 (2.90)^a	3.54 (0.58)^a	1.79 (0.29)^a	2.68 (0.77)^a	2.80 (0.59)^a	0.65 (0.36)^a	2259 (1799)^a	85.6 (55.5)^a	676 (345)^b	2115 (806)^a	586(142)^a	620 (73.1)^a
4 - 4.9 (46)	29.4 (10.11)	34.4 (4.87)^a	3.62 (0.75)^a	1.72 (0.60)^a	2.43 (1.02)^a	2.69 (0.84)^a	0.78 (0.40)^a	3292 (3148)^a	75.0 (36.6)^a	548 (271)^b	2617 (1747)^a	567(260)^a	574 (167)^a
5 - 5.9 (3)	25.5 (1.37)	37.1 (1.17)^a	3.13 (0.31)^a	1.14 (0.66)^a	1.82(1.05)^b	1.95 (0.85)^a	0.74 (0.45)^a	1230 (1077)^a	45.0 (4.36)^a	132 (17.4)^a	1083 (703)^a	360(185)^a	306 (177)^b
6 - 6.9 (34)	30.3 (11.00)	32.8 (5.56)^a	3.81 (0.45)^a	1.66 (0.27)^a	2.22 (0.45)^a	2.69 (0.53)^a	0.61 (0.38)^a	2794 (3650)^a	73.3 (34.2)^a	519 (302)^b	2930 (3067)^a	569(116)^a	625 (169)^a
7 - 7.9 (25)	27.2 (8.93)	34.5 (4.43)^a	3.46 (0.59)^a	1.53 (0.42)^a	2.13 (0.43)^a	2.76 (0.59)^a	0.90 (0.51)^a	1432 (1052)^a	64.0 (25.9)^a	668 (326)^b	1920 (839)^a	510(116)^a	600 (193)^a
8 + (4)	32.2 (19.97)	36.5 (3.68)^a	3.53 (1.28)^a	1.52 (0.92)^a	2.08 (1.23)^a	2.49 (1.22)^a	0.74 (0.47)^a	5826 (7822)^a	50.6 (21.7)^a	264 (97.4)^a	2029 (317)^a	613(233)^a	527 (118)^a

†No. of samples used for analysis, ‡ mean followed by the standard deviation

Table 6: Nutrient concentration of litter based on the number of flocks on litter

	Percentage							mg kg^{-1}					
Flocks	Ash	C	N	P	K	Ca	Mg	AL	B	Cu	Fe	Mn	Zn
1 (5)	23.7 (8.03)	36.7 (4.52)^a	3.74 (1.01)^a	1.53 (0.71)^a	1.88 (1.08)^a	2.42 (1.02)^a	0.68 (0.65)^a	2436 (2656)^a	48.4 (16.4)^a	447 (335)^a	1934 (1177)^a	559 (226)^a	586 (202)^a
2 (8)	31.4 (18.06)	32.3 (8.38)^a	3.25 (0.79)^a	1.46 (0.32)^a	2.28 (0.48)^a	2.42 (0.46)^a	0.81 (0.08)^a	3051 (3099)^a	51.3 (12.4)^a	515 (295)^a	3566 (5188)^a	541 (151)^a	501 (92)^a
3 (13)	30.3 (7.06)	33.0 (3.66)^a	3.47 (0.57)^a	1.68 (0.17)^a	2.35 (0.66)^a	2.64 (0.25)^a	0.51 (0.27)^a	4035 (3301)^a	63.1 (15.9)^a	439 (207)^a	2542 (1341)^a	561 (160)^a	634 (131)^a
4 (14)	28.1 (7.68)	35.0 (4.14)^a	3.66 (0.79)^a	1.67 (0.47)^a	2.21 (0.36)^a	2.68 (0.54)^a	0.96 (0.45)^a	2188 (2504)^a	62.9 (15.3)^a	511 (273)^a	2614 (2164)^a	567 (102)^a	554 (124)^a
5 (17)	29.5 (11.53)	34.9 (5.79)^a	3.39 (0.87)^a	1.48 (0.42)^a	2.02 (0.42)^a	2.57 (0.71)^a	0.75 (0.33)^a	2136 (869)^a	76.4 (33.6)^a	525 (389)^a	2030 (704)^a	498 (175)^a	528 (245)^a
6 (18)	28.2 (10.69)	35.1 (4.62)^a	3.59 (0.57)^a	1.68 (0.78)^a	2.22 (1.35)^a	2.64 (0.91)^a	0.72 (0.52)^a	3341 (5072)^a	66.7 (24.8)^a	682 (356)^a	2780 (3830)^a	532 (170)^a	652 (221)^a
7 (5)	26.7 (4.54)	33.0 (3.92)^a	3.80 (0.36)^a	1.69 (0.26)^a	2.42 (0.69)^a	2.89 (0.67)^a	0.59 (0.50)^a	4115 (5197)^a	68.8 (9.7)^a	619 (555)^a	3230 (2819)^a	556 (110)^a	644 (153)^a
8 (8)	33.6 (12.82)	34.0 (4.51)^a	3.90 (0.85)^a	1.70 (0.44)^a	2.23 (0.96)^a	2.78 (0.92)^a	0.60 (0.38)^a	3922 (5543)^a	57.7 (10.2)^a	522 (218)^a	4341 (4872)^a	517 (146)^a	586 (119)^a
9 (4)	31.5 (10.28)	32.9 (4.86)^a	3.18 (0.47)^a	1.70 (0.21)^a	2.01 (0.10)^a	2.68 (0.16)^a	0.59 (0.34)^a	2551 (1054)^a	82.1 (6.7)^a	782 (358)^a	2366 (1149)^a	513 (25)^a	616 (154)^a
10 (25)	26.3 (4.72)	34.4 (3.04)^a	3.78 (0.47)^a	1.77 (0.34)^a	2.73 (0.75)^a	3.00 (0.69)^a	0.89 (0.36)^a	1820 (1819)^a	70.5 (40.1)^a	530 (204)^a	2173 (963)^a	559 (117)^a	556 (91)^a

†No. of samples used for analysis, ‡ mean followed by the standard deviation

became significantly different. The lack of significance observed from the present study could be a result of the difference in replication between submitted samples for the number of flocks raised on the litter. Intuitively it would seem, that nutrient concentrations would increase as the number of flocks increased. Others have reported that nutrient concentrations increased over time as the number of flocks raised on litter increased. For instance Kelly *et al.*[17] reported that nutrient concentration levels increased when pine shaving were used for multiple flocks. Bowers *et al.*[14] also reported that nutrient concentration in pine shavings litter and sand litter generally increased with the number of flocks.

Take home message: In summary, this poultry litter survey suggests that nutrient concentrations can change depending on the bedding management in rearing facilities. Averaged across all broiler litter samples submitted, on an as-is basis the broiler litter had a compositional value close to an equivalent fertilizer grade of 3-3-2 for N, P_2O_5 and K_2O. This is similar to that previously reported by Malone[18] and Mitchell and Donald[10]. However, it is also important to note that these nutrient composition values presented represent mean concentrations obtained from averaging across all litter management practices. There were large variations in the amount of nutrients among litter samples analyzed for this study. For example, N concentrations ranged from 0.9-4.3% N on an as-is basis. This variability could have huge economic implications on the producer's bottom line who is using the litter for crop production. For example, if the poultry litter has 1% N vs. 4% N, the producer would need to apply 4 times the amount of litter to satisfy crop nutrient requirements. Thus, it behooves the producer or end user to have their litter tested for its nutrient content before utilizing for fertility purposes.

CONCLUSION

It is important to note that samples from this study were taken from producers, thus the litter was not measured under control conditions. Also, when producers collected litter samples, care was not taken to determine whether the litter was taken from the brooding end of the house or near waterers or feeders. Based on data collected from this survey, the litter was influenced by poultry production and management. On average, poultry litter had a 3-3-2 fertilizer grade on as-is-bases; however, the nutrient concentration of the litter may change depending on the poultry rearing house. Litter nutrient were significantly influenced by type of production facility. Frequency of cleanout, depth of litter removed and nutrient content based on the size of the flock. The data generated from this study may also be used to determine general trends of nutrient buildup and nutrient concentrations. Significant variations in the nutrient values were observed.

It is noteworthy mentioning that nutrient concentrations of litter generated may be quite different from values derived in this survey, depending on the poultry unit or facility. To optimize utilization of nutrients from the litter, representative samples should be analyzed by a certified lab prior to land application.

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