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MACRONUTRIENT CONCENTRATIONS OF POULTRY LITTER AS AFFECTED BY FLOCK MANAGEMENT REGIMES

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ABSTRACT

Poultry litter is generally surface applied to cropland as a fertilizer. However, alternative marketing strategies could potentially been developed if nutrient concentrations were determined as influenced by flock management. Macronutrient (N, P, K, Ca, Mg, S) concentrations will be presented in this poster. Sampling occurred at cleanout following one through six flocks. Areas of sampling in each house included the middle, feed strip, and near the wall. Samples from these areas were further subdivided into three particle sizes by diameter: coarse > 3.2 mm, fine < 1.0 mm, and medium > 1.0 mm, and < 3.2 mm. All nutrient concentrations were significantly higher in the fine fraction with the exception of K, which was lower. N concentration was higher in the feed strip area while P, Ca, and Mg were lower. K concentration was higher in the middle of the house. S concentration declined as number of flocks increased.

INTRODUCTION

In 1991, Arkansas produced approximately 986 million broilers (Arkansas Agricultural Statistics Service, 1991). Van Dyne and Gilbertson (1978) estimated that approximately 1 kg of dry broiler litter was produced per bird during a production cycle (one flock). As a result, a house with 20,000 broilers per growout will produce approximately 120 Mg of litter per year. A tremendous amount of broiler litter must be utilized in Arkansas and other broiler producing states. Considering that most of the litter is currently applied to pastureland as a source of fertilizer, the objectives of this research were to analyze the major and secondary nutrient concentrations as affected by: 1) number of flocks grown, 2) brood vs. non-brood end of the house, 3) location in the house, and 4) particle size after sieving. The results of this research will be used to develop alternative products such as potting soil blends and/or mulch materials.

MATERIALS & METHODS

The study was initiated in the spring of 1992, and broiler litter was collected from Hudson Farms poultry complexes near Hope in southwest Arkansas. Company farms were used rather than private farms since feed rations were the same in the company houses. Samples were collected immediately following the production of one through six flocks from five houses (replications). A typical broiler house measures approximately 10 m X 100 m in floor space. Each house is generally divided in the middle (10 m X 50 m) to allow for a brood vs. non-brood end. At the initiation of each production cycle, chicks are placed in the brood end for approximately two weeks. Following the initial two-week period, the curtain is raised and birds have access to the entire house for approximately five additional weeks.

Sampling was conducted where the brood vs. nonbrood comparisons could be made. Within the brood or nonbrood end, samples were collected in the three distinct areas of the house: water/feed area, middle of the house, and wall area. Three samples were collected from each area (0.2 X 3 m) using a square-pointed shovel. Each sample was collected in the center of the area represented and parallel to the outside wall of the house. The three samples were mixed thoroughly, combined into a bulk sample (20 kg), and transported to the laboratory for sieving into three particle sizes. Approximately 1 kg of the bulk sample was separated into three fractions using stainless steel screens. Particles larger than standard No. 6 mesh screen (>3.2-mm openings) represented the coarse texture. Particles smaller than a standard No. 20 mesh screen (<1.0-mm openings) represented the fine texture. Particles in between the two screens represented the medium fraction (>1.0 mm and <3.2-mm openings).

Following fractionation, the samples were weighed and dried in a forced air oven at 65°C for 72 h for moisture determination. After drying, samples were weighed, placed into polypropylene containers, and analyzed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S).

For N determination, a 0.20 g sample was digested in 3.0 mL of sulfuric acid (H_2SO_4) at 250 to 300°C until clear. After cooling, 25 mL of deionized water was added. Steam distillation was conducted using a Tecator Kjeltec Model 1030 Auto Analyzer.

Phosphorus, K, Ca, Mg, and S were analyzed using a rapid perchloric acid ($HClO_4$) digestion method (Adler and Wilcox, 1985). A 0.25 g sample was digested in 1.0 mL of hydrogen peroxide (H_2O_2), followed by 3.0 mL of $HClO_4$ until clear. After cooling, 1.0 mL of nitric acid (HNO_3) was added. Following digestion, the sample was diluted to 25 mL with deionized water. Samples were analyzed using a simultaneous inductively-coupled plasma spectrophotometer. All data were statistically analyzed by utilizing the PROC GLM procedure and calculating least-squares means with PC SAS (1985).

RESULTS & DISCUSSION

Nitrogen

Statistical analysis of the data indicated no differences for N concentration in the brood vs. nonbrood end of the house. While the grand mean for N concentration was 37269 mg N/kg litter, both the flock X area and flock X sieve size were significant ($p < .05$). Nitrogen concentrations were higher in the water/feed area of the house following each flock produced (Table 1). In most cases, N concentration from the middle or wall areas were similar, but less than N concentrations from the water/feed area. This indicates that wasted feed is likely contributing to higher N concentrations in the water/feed areas. Upon sieving, much higher N concentrations were observed in the fine fraction. Most of the material passing the fine screen resembled either cottonseed meal and/or soybean meal.

Phosphorus

The concentration of P in the nonbrood end of the house was higher ($p > .0086$) than the brood end at concentrations of 18505 and 18221 mg/kg, respectively. Given that these differences were minimal in practical terms, the data were pooled and flock X area and flock X sieve interactions were analyzed. The grand mean for P concentration was 18363 mg/kg. In all cases, P concentration was always higher in the middle of the house, and also from the wall area except after flocks 1 and 3 (Table 2). Higher P concentrations were in the fine fraction through flock 5.

Potassium

Differences ($p > .0001$) were detected in K concentration between the brood (24249 mg/kg) and nonbrood (25776 mg/kg) end of the house. With only two exceptions, K was always higher in the middle of the house (Table 3). While K concentrations tended to be higher in the coarse fractions of litter, sieving had no real impact on K concentrations.

Calcium

Calcium concentrations differed (p > .0001) between the brood (31984 mg/kg) and nonbrood end (28657 mg/kg) of the house. Calcium concentrations were generally higher in the wall and middle areas of the house with the water/feed areas being lowest (Table 4). After sieving, Ca concentrations were greatly impacted in that higher Ca concentrations were observed in the fine fraction.

Magnesium

Concentrations were greater (p > .0001) in the non brood (6026 mg/kg) vs. brood (5711 mg/kg) end of the house. When evaluating the flock X sieve interaction (Table 5), higher Mg concentrations were generally found in the fine fraction. The flock X area interaction was not significant (p > .05), but area of the house was significant. The middle of the house contained higher Mg concentrations (6209 mg/kg) than that of the wall area (5994 mg/kg) or the water/feed area (5403 mg/kg).

Sulfur

Sulfur concentrations from the brood and nonbrood ends of the house were not different. However, it was evident that S concentration rapidly declined with an increase in flocks grown (Table 6). One possible explanation for this finding is that elemental S is applied in conjunction with diesel fuel to the litter (shavings or rice hulls) after cleanout when fresh litter is applied to the pad. The reason for this mixture is to reduce disease incidence in the house by lowering the litter pH. Within each flock, the area of the house did not greatly impact S concentration. The finely sieved fraction, in most cases, had higher S concentrations.

SUMMARY

These data suggest that N is more concentrated in the water/feed areas of a broiler house, and especially where fractionated into the fine fraction. Higher concentrations of Ca, P, and S also tended to be in the fine fraction. Potassium concentrations tended to be very erratic in that no differences or trends of practical value were defined. It seems that if high and reliable N concentrations are desired for the production of a specific material, it would be collected from the water/feed area of the house and fractionated into a fine fraction (< 1.0-mm openings). It is hopeful that these data will aid in defining new potential markets for broiler litter.

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Table 1. Nitrogen concentration of poultry litter as affected by number of flocks grown, area in the house, and sieve size.

Area in House	Number of Flocks Grown 1	2	3	4	5	6
	nitrogen (mg/kg)					
Wall	28847[c*†]	35343[b]	32723[c]	32343[c]	40060[b]	34870[b]
Water/Feed	40597[a]	43927[a]	39830[a]	40543[a]	44620[a]	42720[a]
Middle	31443[b]	35733[b]	36340[b]	35557[b]	39070[b]	36283[b]
Sieve Size						
Coarse	31177[b*†]	35040[b]	33583[b]	34967[b]	37050[b]	35197[b]
Medium	29430[b]	34380[b]	34007[b]	33430[b]	36980[b]	33170[b]
Fine	40280[a]	45583[a]	41303[a]	40047[a]	49720[a]	45507[a]

Pooled SE = 822 mg/kg

[*] Values in a column with different letters are different at $P < 0.05$.

[†] Least-squares mean.

Table 2. Phosphorus concentration of poultry litter as affected by number of flocks grown, area in the house, and sieve size.

	Number of Flocks Grown					
Area in House	1	2	3	4	5	6
	---------------------------- phosphorus (mg/kg) --------------------------					
Wall	16083^{b*†}	17877^{a}	19013^{b}	19439^{a}	19652^{a}	19622^{a}
Water/Feed	16283^{b}	16260^{b}	17901^{c}	18282^{b}	17149^{b}	17096^{b}
Middle	18732^{c}	17842^{a}	21013^{a}	20126^{a}	18758^{b}	19404^{a}
Sieve Size						
Coarse	14996^{c*†}	16821^{b}	18288^{b}	20044^{a}	17964^{b}	18076^{b}
Medium	17177^{b}	16723^{b}	17889^{b}	18212^{b}	17677^{b}	19300^{a}
Fine	18926^{a}	18346^{a}	21751^{a}	19591^{a}	19918^{a}	18746^{b}
Pooled SE = 382 mg/kg						

* Values in a column with different letters are different at $P < 0.05$.

† Least-squares mean.

Table 3. Potassium concentration of poultry litter as affected by number of flocks grown, area in the house, and sieve size.

	Number of Flocks Grown					
Area in House	1	2	3	4	5	6
	potassium (mg/kg)					
Wall	20837^{b*†}	24957^{a}	25647^{b}	26116^{b}	26671^{a}	23833^{b}
Water/Feed	21239^{b}	22777^{b}	24767^{b}	24592^{c}	23847^{b}	22277^{c}
Middle	24629^{a}	25774^{a}	29847^{a}	27890^{a}	27563^{a}	26959^{a}
Sieve Size						
Coarse	22407^{ab*†}	25816^{a}	26709^{a}	28294^{a}	26774^{a}	23490^{b}
Medium	23147^{a}	24149^{b}	26750^{a}	26476^{b}	25467^{b}	25810^{a}
Fine	21151^{b}	23544^{c}	26802^{a}	23827^{c}	25840^{ab}	23768^{b}

Pooled SE = 467 mg/kg

[*] Values in a column with different letters are different at $P < 0.05$.

[†] Least-squares mean.

Table 4. Calcium concentration of poultry litter as affected by number of flocks grown, area in the house, and sieve size.

	Number of Flocks Grown					
Area in House	1	2	3	4	5	6
	calcium (mg/kg)					
Wall	28066[b*†]	29401[a]	31431[b]	32595[ab]	32414[a]	31170[a]
Water/Feed	28361[b]	27142[b]	30081[b]	30685[b]	27867[b]	27679[b]
Middle	30924[a]	28871[ab]	34217[a]	33618[a]	30737[a]	30503[a]
Sieve Size						
Coarse	24253[c*†]	26075[b]	28194[b]	30410[b]	27921[b]	27745[b]
Medium	27091[b]	26279[b]	27636[b]	29070[b]	27685[b]	29143[b]
Fine	36007[a]	33061[a]	39900[a]	37419[a]	35412[a]	32464[a]

Pooled SE = 797 mg/kg

[*] Values in a column with different letters are different at $P < 0.05$.

[†] Least-squares mean.

Table 5. Magnesium concentration of poultry litter as affected by number of flocks grown and sieve size.

Sieve Size	Number of Flocks Grown 1	2	3	4	5	6
	magnesium (mg/kg)					
Coarse	5246[c*†]	5512[b]	6152[b]	6115[a]	5625[b]	6154[a]
Medium	5594[b]	5167[c]	5579[c]	5288[b]	4829[c]	6052[a]
Fine	6628[a]	6032[a]	7157[a]	6308[a]	6157[a]	6035[a]

Pooled SE = 120 mg/kg

[*] Values in a column with different letters are different at $P < 0.05$.

[†] Least-squares mean.

Table 6. Sulfur concentration of poultry litter as affected by number of flocks grown, area in the house, and sieve size.

	Number of Flocks Grown					
Area in House	1	2	3	4	5	6
	sulfur (mg/kg)					
Wall	14062^{c*†}	9848^{ab}	10193^{a}	9130^{a}	8367^{a}	8748^{a}
Water/Feed	15504^{b}	9671^{b}	10090^{a}	8495^{a}	7484^{b}	7764^{b}
Middle	16948^{a}	10527^{a}	10759^{a}	9262^{a}	7918^{ab}	8520^{ab}
Sieve Size						
Coarse	12627^{c*†}	9169^{b}	9782^{b}	8890^{ab}	7715^{b}	7791^{b}
Medium	14911^{b}	9483^{b}	9697^{b}	8587^{b}	7472^{b}	8944^{a}
Fine	18977^{a}	11396^{a}	11564^{a}	9410^{a}	8582^{a}	8297^{ab}
Pooled SE = 290 mg/kg						

* Values in a column with different letters are different at $P < 0.05$.

† Least-squares mean.