Broiler Litter Production and Nutrient Content Characteristics

Management and disposal of poultry litter are two of the greatest challenges that poultry producers face. Improper litter management can result in serious flock health and welfare issues and can lead to odors, fly breeding, and excess nutrients in soil and water resources. Commercial **broiler litter is commonly recycled for several flocks** before an entire clean-out is performed and new bedding material placed on the broiler house floor.

In some regions (Mississippi and Delmarva, for example), it may have been **10 years or more** since many broiler houses were totally cleaned out. A portion of litter may be removed when the litter gets too deep (more than 6 inches), but enough is left to leave at least 3 inches on the floor, and this litter is leveled back out for future flocks. Removal and replacement of broiler litter varies widely across the poultry industry and can range from two flocks to many years of production (Chamblee and Todd, 2002; Malone, 1992; Tabler et al., 2015).

Litter Production and Nutrient Content

Litter exists in two forms:

- caked litter (typically greater than 35 percent moisture), often found under and near drinkers and near evaporative cooling pads
- loose litter

Caked litter is commonly **removed from the house after each flock is harvested**. The remaining loose litter is **reused multiple times** to grow future flocks of birds. This results in production of two types of waste materials with potentially different characteristics and nutrient content (Coufal et al., 2006). The Natural Resource, Agriculture, and Engineering Service (NRAES, 1999) reported whole **litter production from broilers to be 1.25 tons per 1,000 birds**, with cake production at 0.4 tons per 1,000 birds. Thus, according to NRAES (1999), cake represented 30–35 percent of the total litter. Depending on clean-out frequency, Malone et al. (1992) reported that cake accounted for 35–40 percent of total litter production. Tabler (2000) found cake was 28 percent of total litter production on a commercial broiler farm in Arkansas. In experimental pens, Coufal et al. (2006) found cake as a percentage of all litter produced per flock averaged 39.8 percent on an as-is basis.

While the fertilizer value of litter is well recognized, **nutrient content of litter can be extremely variable** (VanDevender et al., 2000). Litter nutrient content and the rate of litter production can be affected by numerous factors, including the number of flocks grown on the same litter material, initial type and amount of bedding material used, type of housing, litter management practices, feed formulation, flock health, ventilation rate, drinker management (height and water pressure), performance parameters, stocking density, and flock age at harvest (Malone, 1992). As a result, estimates of litter production and nutrient content vary greatly.

Litter production rates are most commonly reported as tons of litter on an as-is basis per 1,000 broilers. Patterson et al. (1998) reported different rates of litter production from two companies growing birds to different body weights in commercial broiler houses in Pennsylvania. Farms growing smaller birds produced litter at a rate of 1.07 tons per 1,000 birds, and farms growing larger birds produced litter at a rate of 1.65 tons per 1,000 birds. On a commercial broiler farm in Arkansas, Tabler (1999) found that smaller birds produced litter at a rate of 1.11 tons per 1,000 birds (unpublished data). Malone (1992) estimated average broiler litter production rate to be 1.0 dry metric tons per 1,000 broilers per flock, with a range of 0.7 to 2.0. Chamblee and Todd (2002) estimated broiler litter production from broilers in Mississippi to be 1.6 tons per 1,000 birds if houses were cleaned out annually, and 1.0 ton per 1,000 birds if houses were cleaned out completely at the end of 2 years.

Variation in Nutrient Content and Production

There is a **wide range of variation regarding litter nutrient content** in the literature. Tabler and Berry (2003) followed nine flocks of broilers on the same litter at a commercial broiler farm in Arkansas and found nitrogen (N) increased from 33.8 (1.69 percent) to 60.3 (3.02 percent) pounds per ton, phosphorus (P_2O_5) increased from 42.5 (2.13 percent) to 69.3 (3.47 percent) pounds per ton, and potassium (K_2O) increased from 36.6 (1.83 percent) to 58.3 (2.92 percent) pounds per ton on an as-is basis (Table 1). Litter moisture ranged from a low of 22.3 percent (Flock 9; August 1996) to a high of 26.0 percent (Flock 5; February

1996). Berry (1997) reported the 4-year average N, P_2O_5, and K_2O content of litter from an Arkansas commercial broiler farm cleaned out completely on an annual basis was 57.3 (2.87 percent), 64.9 (3.25 percent), and 50.0 (2.50 percent) pounds per ton, respectively, on an as-is basis (Table 2). Moisture content of the litter over the 4-year period ranged from 23.09 to 28.13 percent.

Malone (1992) reported an average (as-is basis) of 2.94, 3.22, and 2.03 percent for N, P_2O_5, and K_2O, respectively, from several U.S. sources. Chamblee and Todd (2002) reported Mississippi broiler litter contained 2.85, 1.45, and 2.95 percent N, P_2O_5, and K_2O, respectively. Patterson et al. (1998) reported broiler litter in Pennsylvania to have an average N, P_2O_5, and K_2O content of 3.73, 3.11, and 2.18 percent, respectively. Sharpley et al. (2009) reported N, P_2O_5, K_2O, and water-extractable phosphorus (WEP) levels of 62 (3.10 percent), 68.7 (3.44 percent), 62.4 (3.12 percent), and 1.9 pounds per ton, respectively (Table 3).

Espinoza et al. (2005) reported broiler litter samples analyzed by the University of Arkansas Agricultural Diagnostic Laboratory between 1993 and 2001 had an average N, P_2O_5, and K_2O content of 60, 57, and 52 pounds per ton, respectively (Table 4). Tabler et al. (2015) reported that Mississippi broiler litter contained 47.44, 69.39, 61.37, and 9.22 pounds per ton of N, P_2O_5, K_2O, and WEP, respectively (Table 5). Based on the number of flocks grown on the same litter, Tabler et al. (2015) indicated that nutrient concentrations of N, P_2O_5, K_2O, and WEP in broiler litter tended to **increase until approximately 15 flocks had been grown** and then tended to stabilize, regardless of how many additional flocks were grown. Figure 1 illustrates the effect of number of flocks on pounds of N per ton of litter. Similar results were seen for P_2O_5, K_2O, and WEP.

Patterson et al. (1999) reported as-is litter production to be 0.558 and 0.488 pound per pound (lb/lb) of live weight for litter that was used for two to three flocks and one to two flocks, respectively. For litter used for six (1993), five (1994), seven (1995), and nine (1996) flocks, Tabler et al. (1997) reported as-is litter production to be 0.369, 0.466, 0.407, and 0.416 lb/lb of live weight, respectively (Table 2). Coufal et al. (2006) observed litter production to be 0.606 and 0.550 lb/lb of live weight for two flocks, respectively. Starting litter depth and density, litter moisture content, and broiler harvest weight could account for some of these differences.

Summary

Nutrient content characteristics of broiler litter can be extremely variable. This underscores the importance of **correctly sampling and analyzing litter** before it is spread because, otherwise, there is no way to know its fertilizer value. Broiler growers and integrators can use the information presented here to estimate the amount of litter material generated over a wide range of flocks grown on the same litter. Nutrient analysis of this litter material, when coupled with the estimated amounts, will allow broiler growers to estimate the total nutrient content available from their litter materials. This information will prove increasingly valuable as **land application of litter is being closely scrutinized** regarding short- and long-term environmental impacts, especially as it relates to phosphorus runoff and its potential role in accelerating eutrophication.

Table 1. Litter nutrient analysis at the University of Arkansas Applied Broiler Research Unit over a nine-flock grow-out.[1,2,3]

Date	Flock length (days)	Flocks on same litter	pH	Moisture (%)	Ash (%)	lb/ton on as-is basis			
						N	P_2O_5	K_2O	Ca
Jun-95	41	1	7.4	33.1	19.6	33.8	42.5	36.6	36.2
Aug-95	41	2	7.6	31.5	22.5	43.6	47.9	44.1	43.0
Oct-95	41	3	7.6	28.7	26.2	51.8	57.7	45.6	46.1
Dec-95	40	4	7.2	33.8	24.6	51.0	51.0	44.2	42.6
Feb-96	45	5	6.9	36.0	24.4	55.3	52.9	48.4	43.2
Mar-96	41	6	7.5	34.7	24.9	53.0	52.8	45.6	41.2
May-96	42	7	7.8	27.3	24.0	62.9	58.2	52.9	47.4
Jun-96	42	8	7.3	28.7	26.0	49.5	59.3	54.2	47.3
Aug-96	43	9	7.8	22.3	22.6	60.3	69.3	58.3	53.5

[1]Adapted from Tabler and Berry (2003).

[2]Initial bedding material was 50:50 mix of rice hulls and pine shavings/sawdust.

[3]Figures are averages of four 40-by-400-foot houses on the farm.

Table 2. Litter production variables from 4 years of broiler production at the University of Arkansas Applied Broiler Research Unit.[1]

Date	Flock age (weeks)	# of flocks	pH	Moist (%)	Ash (%)	lb/ton on as-is basis				Depth (in)	Density (lb/ft^3)	lb litter[2]/ lb chicken
						N	P_2O_5	K_2O	Ca			
Apr-93	8	6	7.25	23.78		57.7	57.0	64.1	41.7	6.44	30.50	0.369
Apr-94	8	5	6.87	28.13	27.20	58.1	68.0	49.1	51.0	5.13	37.09	0.466
Apr-95	6	7	7.61	25.04	26.61	55.9	66.1	52.5	53.2	3.96	35.14	0.407
Aug-96	6	9	7.80	23.09	23.87	57.5	68.4	58.0	54.2	4.64	41.58	0.416
Average			7.38	25.01	25.89	57.3	64.9	55.9	50.0	5.04	36.08	0.415

[1]Adapted from Berry (1997).

[2]Weight is on as-is basis.

Table 3. Broiler litter analysis on an as-is basis over a 3-year period (2005–07) analyzed by the University of Arkansas Agricultural Diagnostic Laboratory.[1]

Factor	Sample size	Minimum	Maximum	Average
Moisture, %	297	13	67.2	30.8
pH	297	5.6	9.4	8.4
N, lb/ton	297	20	88	62
P_2O_5, lb/ton	297	27.5	119.1	68.7
K_2O, lb/ton	297	2.6	81.6	62.4
WEP[2], lb/ton	297	0.5	9.9	1.9

[1]Adapted from Sharpley et al. (2009).

[2]Water-extractable phosphorus.

Table 4. Nutrient and moisture levels of poultry litter from samples submitted to the University of Arkansas Agricultural Diagnostic Laboratory between 1993 and 2001.[1]

Factor	Minimum	Maximum	Average
Moisture, %	2	47	23
N, lb/ton	22	98	60
P_2O_5, lb/ton	18	96	57
K_2O, lb/ton	23	80	52

[1]Adapted from Espinoza et al. (2005).

Table 5. Effect of division on number of flocks, litter pH, litter moisture percent, nitrogen (N), phosphorus (P_2O_5), potassium (K_2O), and water-extractable phosphorus (WEP).[1]

Division	# of farms	# of flocks	pH	Moisture %	lb/ton			
					N	P_2O_5	K_2O	WEP
1	18	7.28^{c}	7.48^{ab}	24.46^{efg}	44.08^{bc}	43.13^{c}	61.84^{ab}	9.58^{bcd}
2	20	7.95^{c}	6.67^{f}	25.35^{defg}	44.42^{bc}	50.78^{c}	61.94^{ab}	6.59^{ef}
3	18	5.94^{c}	7.61^{a}	23.85^{gf}	38.76^{c}	52.53^{c}	59.94^{ab}	4.95^{f}
4	20	8.05^{c}	7.19^{cd}	27.23^{bcd}	46.68^{b}	55.23^{c}	60.23^{ab}	13.38^{a}
5	4	11.25^{c}	7.27^{bc}	27.11^{def}	47.42^{b}	73.49^{b}	60.16^{ab}	9.40^{cd}
6	10	22.40^{b}	7.12^{cd}	26.39^{cde}	47.08^{b}	77.24^{ab}	57.37^{b}	8.00^{de}
7	10	10.50^{c}	6.84^{ef}	28.95^{ab}	49.46^{b}	74.78^{b}	59.19^{ab}	9.52^{bcd}
8	16	12.87^{c}	7.14^{cd}	25.73^{def}	45.52^{b}	75.82^{b}	66.86^{a}	10.83^{bc}
9	7	34.43^{a}	6.81^{ef}	26.71^{cd}	46.61^{b}	78.65^{ab}	57.02^{b}	10.45^{bc}
10	12	12.58^{c}	6.71^{f}	27.92^{ab}	49.84^{b}	85.99^{ab}	59.67^{ab}	10.47^{bc}
11	18	25.22^{b}	6.99^{de}	28.37^{g}	60.85^{a}	89.30^{a}	64.73^{ab}	11.29^{b}
12	5	6.20^{c}	7.10^{cd}	30.26^{a}	48.56^{b}	75.78^{b}	67.44^{a}	6.16^{f}
Average	13.72	13.72	7.08	26.86	47.44	69.39	61.37	9.22

[1]Adapted from Tabler et al. (2015).

[abcdefg]Means within a column not sharing a common subscript differ significantly ($P < 0.05$).

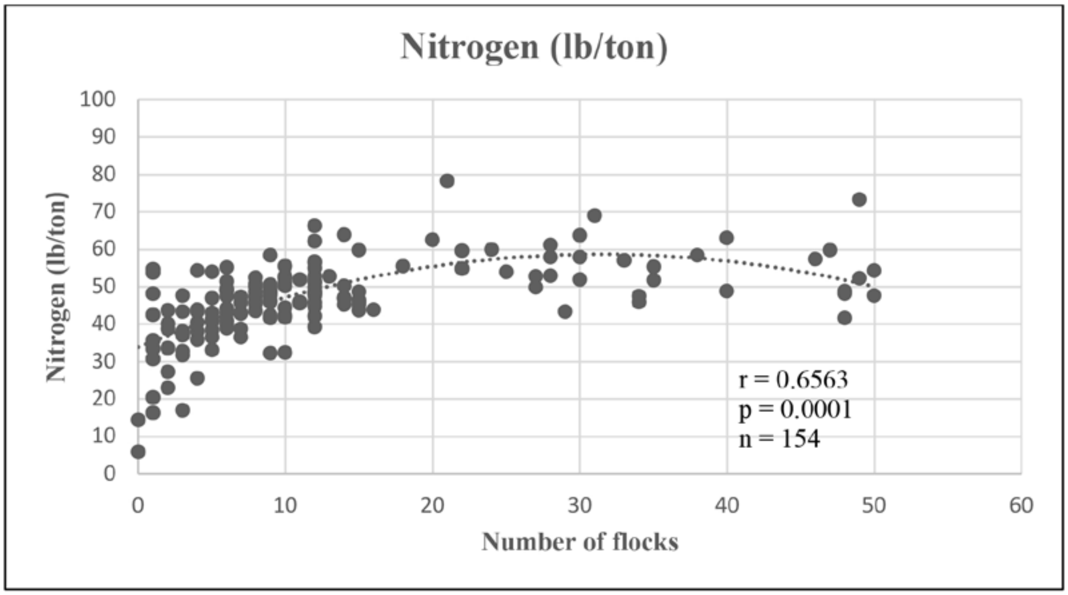

Figure 1. Effect of number of flocks on pounds of nitrogen per ton of litter. Adapted from Tabler et al. (2015).

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