Poultry Manure as a Fertilizer Source

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Poultry manure is an excellent source of nutrients and can be incorporated into most fertilizer programs. Those using manures must practice sound soil fertility management to prevent nutrient imbalances and associated animal health risks, as well as surface-water and groundwater contamination. The key to successful management is to match the nutritional requirements of the crop with nutrients available in the manure. The value of poultry manure varies not only with its nutrient composition and availability, but also with management and handling costs.

Nutrient Composition and Sampling Procedure

The nutrient composition of poultry manure varies with the type of bird, the feed ration, the proportion of litter to droppings, the manure handling system, and the type of litter. Consequently, all manures should be sampled and analyzed for specific nutrient content before you apply them to the land. Waste samples can be analyzed for $4 by the North Carolina Department of Agriculture (NCDA), Agronomic Division, Plant Analysis Lab, P.O. Box 27647, Blue Ridge Road Center, Raleigh, NC 27611. Other qualified private laboratories can also perform the analysis (fees vary).

Collecting a representative manure sample is essential to reliable nutrient analysis. The nutrient value of litter varies greatly within the poultry house. To reduce sample variability, collect subsamples of broiler, turkey, and duck litter in 6 to 12 areas of the house. Samples taken around waterers, feeders, and brooders should be proportionate to the space these areas occupy in the house. At each location, collect litter by digging an area down to the earth; be careful, however, not to include soil. Place the subsamples in a plastic bucket, mix thoroughly, and put 2 to 3 pounds of the mixture in a sample container. Samples from stockpiled litter should be taken from at least 6 locations around thepile, all at depths of at least 18 inches. Subsamples should be mixed and submitted as suggested for litter from poultry houses.

To increase sample uniformity in poultry manure slurries and lagoon sludges, stir them before sampling. Within an anaerobic lagoon, liquids are relatively uniform above the sludge zone; nevertheless, take several subsamples and combine them.

If you cannot have the manure analyzed, use the mean nutrient values for your specific type of poultry manure found in Tables 1 through 4. Table 5 gives t he average values for the secondary and micronutrients ordinarily listed in the manure analysis report.

When using mean values for manure nutrient composition, exercise caution to avoid over- or underfertilization. Also, after several years, elements such as copper or zinc may accumulate and reach very high levels. To avoid these problems, take an annual plant tissue and a biennial soil sample to monitor nutrient levels.

Table 1. Average Nutrient Composition of Broiler Manures

Manure Type	Total N	Ammonium NH4	Phosphorus P2O5	Potassium K2O
	--------------------	lb/ton	--------------------	
Fresh (no litter)	26	10	17	11
Broiler house litter1	72	11	78	46
Roaster house litter1	73	12	75	45
Breeder house litter1	31	7	54	31
Stockpiled litter1	36	8	80	34

1Annual manure and litter accummulation; typical litter base is sawdust, wood shavings, or peanut hulls.
Source: Biological and Agricultural Engineering Department, NCSU.

Table 2. Average Nutrient Composition of Layer Manures

Manure Type	Total N	Ammonium NH4- N	Phosphorus P2O5	Potassium K20
	--------------------	lb/ton	--------------------	
Fresh (no litter)	26	6	22	11
Undercage scraped1	28	14	31	20
Highrise stored2	38	18	56	30
	--------------	lb/1,000 gallons	---------------	
Liquid slurry3	62	42	59	37
Anaerobic				

lagoon sludge	26	8	92	13
	----------------lb/acre-inch----------------			
Anaerobic lagoon liquid	179	154	46	266

1Manure collected within two days.
2Annual manure accummulation on unpaved surfaces.
3Six-12 months' accummulation of manure, excess water usage, and storage-surface rainfall surplus; does not include fresh water for flushing.
Source: Biological and Agricultural Engineering Department, NCSU.

Nutrient Availabilities

Except for nitrogen, the availability of most nutrients in poultry manures is fairly consistent. Nitrogen can occur in several forms, each of which can be lost when subjected to different management or environmental conditions.

Nitrogen in poultry wastes comes from uric acid, ammonia salts, and organic (fecal) matter. The predominant form is uric acid, which readily transforms to ammonia (NH_3), a gaseous form of nitrogen that can evaporate if not mixed into the soil. When it is thoroughly mixed, the ammonia changes to ammonium (NH_4^+), which can be temporarily held on clay particles and organic matter. Thus, soil mixing can reduce nitrogen losses and increase the amount available to plants.

Table 6 lists the first-year nutrient availability coefficients for various poultry manures. Determine the available nutrients by multiplying these values by the nutrient composition values listed on the waste analysis report or in Tables 1 through 4. The NCDA's Agronomic Division calculates available nutrients and lists them in its report.

Table 3. Average Nutrient Composition of Turkey Manures

Manure Type	**Total N**	**Ammonium NH4- N**	**Phosphorus P2O5**	**Potassium K2O**
	-------------------lb/ton-------------------			
Fresh (no litter)	27	8	25	12
Brooder house litter1	45	9	52	32
Grower house litter2	57	16	72	40
Stockpiled litter3	36	8	72	33

1Based on cleanout after each flock.
2Based on annual cleanout after full production.
3Based on annual house accummulation removed to uncovered stockpile to be spread within six months.
Source: Biological and Agricultural Engineering Department, NCSU.

Table 4. Average Nutrient Composition of Duck Manures

Manure Type	Total N	Ammonium NH4- N	Phosphorus P2O5	Potassium K2O
	lb/ton			
Fresh (no litter)	28	5	23	17
House litter1	19	3	17	14
Stockpiled litter2	24	5	42	22

1Annual manure and litter accummulation; typical litter base is wood shavings.
2Annual house accummulation removed to uncovered stockpile to be spread within six months.
Source: Biological and Agricultural Engineering Department, NCSU.

Table 5. Average Secondary and Micronutrient Content of Poultry Manures

Manure Type	Ca	Mg	S	Na	Fe	Mn	B	Mo	Zn	Cu
	lb/ton									
Layer										
Undercage scraped	43.0	6.1	7.1	4.5	0.52	0.27	0.050	0.00390	0.32	0.036
Highrise stored	86.0	6.0	8.8	5.0	1.8	0.52	0.046	0.00038	0.37	0.043
Broiler Litter										
Broiler house	41.0	8.0	15.0	13.0	1.3	0.67	0.054	0.00085	0.63	0.45
Roaster house	43.0	8.5	14.0	13.0	1.6	0.74	0.049	0.00082	0.68	0.51
Breeder house	94.0	6.8	8.5	8.6	1.3	0.57	0.035	0.00048	0.52	0.21
Stockpiled	54.0	8.0	12.0	6.2	1.5	0.59	0.041	0.00069	0.55	0.27
Turkey Litter										
Brooder house	28.0	5.7	7.6	5.9	1.4	0.52	0.047	0.00081	0.46	0.36
Grower house	42.0	7.0	10.0	8.4	1.3	0.65	0.048	0.00092	0.64	0.51
Stockpiled	42.0	6.8	9.5	6.4	1.5	0.62	0.047	0.00095	0.56	0.34
Duck Litter										
Duck house	22.0	2.7	3.1	2.8	.98	0.31	0.021	0.00040	0.26	.056
Stockpiled	27.0	4.4	5.6	8.8	1.2	0.47	0.030	0.00030	0.47	.050
	lb/1,000 gallons									
Layer										
Liquid slurry	35.0	6.8	8.2	5.3	2.9	0.42	0.040	0.018	0.43	0.080

Lagoon sludge	71.0	7.2	12.0	4.2	2.2	2.3	0.082	0.014	0.80	0.14
	----------lb/acre-inch----------									
Layer										
Lagoon liquid	25.0	7.4	52.0	51.0	2.0	0.24	0.37	0.020	0.70	0.19

Application Rate

Land application rates are generally determined by matching the available nitrogen or phosphorus content of the waste to the nutrient requirements of the crop. In most cases, nitrogen requirements determine the application rate, unless the area is designated "nutrient sensitive" and indicates that phosphorus movement off-site can lead to eutrophication of surface waters. In nondesignated areas, phosphorus movement can be adequately controlled with conservation measures such as grass field borders, grassed waterways, contour planting, and reduced tillage, which minimize soil and residual manure movement. Leaching of phosphorus is extremely limited on mineral soils and should not contribute to groundwater contamination.

Nitrogen recommendations for various crops are listed in Table 7. Use these rates as guidelines with realistic yield capabilities for the crop and field. With feed and forage crops, excessive manure application can produce high nitrate concentrations, which can harm livestock (through nitrate poisoning) and promote nutrient imbalances that may lead to grass tetany. If loading rates are to be based on phosphorus, apply the amount suggested by soil-test recommendations. Because the manure may not supply adequate amounts of all the other nutrients required by the crop, be sure to take a soil test and, if necessary, supplement with commercial fertilizer.

In addition to monitoring nutrients, be sure to maintain an adequate soil pH, which will help to maximize crop yields and nutrient availability and promote the decomposition of organic matter. The biological conversion of organic matter to nitrate is an acid-forming process. Take annual or biennial soil samples to monitor pH changes. When livestock wastes are applied at agronomic rates, high salinity (excess salt) has not been a problem, given normal amounts of rainfall in North Carolina.

A worksheet to help you determine land application rates is included at the end of the text.

Table 6. First-Year Nitrogen Availability Coefficients for Different Poultry Manures

Manure **Type**	**Injection**[1]	**Soil Incorporation**[2]	**Broadcast**[3]	**Irrigation**[4]
	--------P_2O_5 and K_2O availability coefficients--------			
All manure types	0.8	0.8	0.7	0.7
	--------------N availability coefficient--------------			
All poultry litters[5]	-	0.6	0.5	— -

Layers (no litter)	--	0.6	0.4	- -
Layer anaerobic lagoon sludge	0.6	0.6	0.4	0.4
Layer anaerobic liquid slurry	0.8	0.7	0.4	0.3
Layer liquid lagoon	0.9	0.8	0.5	0.5

1Manure injected directly into soil and covered immediately.
2Surface-spread manure plowed or disked into soil within two days.
3Surface-spread manure uncovered for one month or longer.
4Sprinkler-irrigated liquid uncovered for one month or longer.
5Includes in-house and stockpiled litters.

Table 7. Nitrogen Fertilization Guidelines

Commodity	**lb N/RYE1**
Corn (grain)	1.0 - 1.25 lb N/bu
Corn (silage)	10 - 20 lb N/ton
Cotton	0.06 - 0.12 lb N/lb lint
Sorghum (grain)	2.0 - 2.5 lb N/cwt
Wheat (grain)	1.7 - 2.4 lb N/bu
Rye (grain)	1.7 - 2.4 lb N/bu
Barley (grain)	1.4 - 1.6 lb N/bu
Triticale (grain)	1.4 - 1.6 lb N/bu
Oats	1.0 - 1.3 lb N/bu
Bermudagrass (hay2,3)	40 - 50 lb N/dry ton
Tall fescue (hay2,3)	40 - 50 lb N/dry ton
Orchardgrass (hay2,3)	40 - 50 lb N/dry ton
Small grain(hay2,3)	50 - 60 lb N/dry ton
Sorghum-sudangrass (hay2,3)	45 - 55 lb N/dry ton
Millet (hay2,3)	45 - 55 lb N/dry ton
Pine and hardwood trees4	40 60 lb N/acre/year

1RYE = Realistic Yield Expectation
2Annual maintenance guidelines
3Reduce N rate by 25 percent when grazing.
4On trees less than 5 feet tall, N will stimulate undergrowth competition.

Timing and Uniformity of Manure Applications

To minimize nitrogen losses, apply manure as near as possible to planting time or to the crop growth stage during which nitrogen is most needed. Surfacewater and groundwater contaminations are greater in areas of high rainfall and when manures for spring crops are applied in fall or winter. For coarse-textured soils, manures should be applied frequently and at low rates throughout the growing season because such soils have a high water infiltration rate and a low ability to hold nutrients. Unused nitrogen can therefore be lost by leaching.

Exercise caution when applying lagoon liquid by irrigation on crops undergoing stress (for example, corn during an extended drought). A heavy coating of manure solids on the leafy vegetation can cause ammonia burn. Except in extreme cases, this damage is usually short term and does not significantly reduce yields. With concentrated lagoon liquids, use several small applications rather than one large dose.

Whether poultry waste is applied by manure spreaders or irrigation systems, you must apply it uniformly. A lack of uniformity leads to nutrient excesses and deficiencies, lower yields, and variable crop moisture at harvest time.

Acreage Requirements for New Facilities

Whenever manure or lagoon liquid samples are available for analysis, they should be used to determine application rates and acreage requirements. When you are planning new facilities, however, the average values can help determine approximate acreage requirements for a poultry operation of a given size. Table 8 gives minimum acreage requirements for various nitrogen fertilization rates. This table can be used to estimate the minimum acreage required to use all of the manure.

Suppose that a producer is interested in building two broiler houses with a combined 50,000 bird capacity/growout. The producer is planning to spread this litter on a bermudagrass hay field capable of producing 6 dry tons per acre. From Table 7, the bermudagrass will require 300 lb nitrogen per acre (6 tons x 50 lb N/dry ton). How many acres of bermudagrass would be needed for the entire year's waste? Using Table 8, under surface broadcast column 300, we find that each 1,000-bird capacity would require 0.65 acres for land application of broiler litter. For a 50,000-bird growout operation (0.65 x 50), the producer would need 32.5 acres for a year's worth of litter.

Table 8. Minimum Amount of Land Needed to Apply Poultry Manure as a Nitrogen Fertilizer Source (Based on the Nitrogen Rate Required by the Crop)

	Soil Incorporated1				Surface Broadcast2			
	lb N/acre/year							
	100	200	300	400	100	200	300	400
	Annual acres/1,000 bird single capacity							
Layer								
Undercaged scraped	4.80	2.40	1.60	1.20	3.00	1.50	1.00	0.75
Highrise scraped	4.30	2.15	1.43	1.07	2.60	1.30	0.87	0.65
Liquid manure/slurry	6.70	3.35	2.23	1.68	4.00	2.00	1.33	1.00

Anaerobic lagoon sludge	0.71	0.35	0.24	0.18	0.56	0.28	0.19	0.14
Anaerobic lagoon liquid	0.87	0.43	0.29	0.22	0.84	0.42	0.28	0.21
Broiler Litter								
Broiler house	2.40	1.20	0.80	0.60	1.96	0.98	0.65	0.49
Roaster house	4.30	2.15	1.43	1.08	3.60	1.80	1.20	0.90
Breeder house	4.70	2.35	1.57	1.18	3.20	1.60	1.07	0.80
Stockpiled	1.20	0.60	0.40	0.30	0.92	0.46	0.31	0.23
Turkey Litter								
Poult house	1.40	0.70	0.47	0.35	1.08	0.54	0.36	0.27
Brooder house	8.10	4.05	2.70	2.02	5.60	2.80	1.87	1.40
Grower hen house	5.70	2.85	1.90	1.43	4.00	2.00	1.33	1.00
Grower tom house	8.60	4.30	2.87	2.15	6.00	3.00	2.00	1.50
Stockpiled								
Poult	0.94	0.47	0.31	0.23	0.76	0.38	0.25	0.19
Hen	3.00	1.50	1.00	0.75	2.40	1.20	0.80	0.60
Tom	4.50	2.25	1.50	1.13	3.60	1.80	1.20	0.90
Duck Litter								
Duck house	3.00	1.50	1.00	0.75	2.20	1.10	0.73	0.55
Stockpiled	1.50	0.75	0.50	0.38	1.08	0.54	0.36	0.27

1Incorporated within two days
2Not incorporated for at least 1 month

Value of Manure

When comparing manure to commercial fertilizers, convert total manure nutrients to available nutrients by using the availability coefficients. Consider the following example. Analysis of the available nitrogen, phosphorus (P2O5), and potassium (K2O) content in a broiler litter sample that will be incorporated shows that it contains 43 pounds of nitrogen per ton, 62 pounds of phosphate per ton, and 37 pounds of potash per ton. The current fertilizer prices for nitrogen, phosphate, and potash are as follows: $0.23 per pound of nitrogen; $0.22 per pound of phosphate; and $0.12 per pound of potash as potassium chloride. One ton of broiler litter would be worth the following:

(43 x $0.23) + (62 x $0.22) + (37 x $0.12) = $27.97 per ton

This value does not cover hauling, handling, or application costs, nor does it include the value of other essential nutrients available in the manure. In addition, it assumes that the soil test has recommended each nutrient, when, in fact, many may not be needed. Nutrients not needed should not be considered when you assess the manure's value.

Land Application Worksheet

Farmer Jones is preparing to spread broiler litter on a field and incorporate it within two days to supply nutrients to his corn crop. Last year, he grew soybeans in the field.

His corn-yield goal is 140 bush-els per acre, and he has decided to apply the equivalent of 140 pounds of nitrogen per acre (Table 7). His land is not subject to erosion, is not in a nutrient-sensitive watershed, and has grassed borders and waterways to further reduce the potential of runoff.

Farmer Jones used a starter fer-tilizer on his corn crop at a rate to supply 10 pounds of nitrogen per acre and 34 pounds of phosphorus per acre. He intends to supply the rest of his nitrogen needs by applying broiler litter with a litter spreader (Figure 1) and incorporating it within two days.

How much litter does he need to spread in order to meet the nitrogen needs of his corn crop? Will he need to supplement the crop with additional potash or phosphate to satisfy his soil-test recommendations of 50 pounds per acre of each nutrient? The answers are given in the following worksheet. Use Table 9 to estimate available nitrogen carry-over from legumes.

Table 9. Estimated Residual Nitrogen Provided by Legumes Grown inRotation

Legume1	**Residual Nitrogen Available**
	----------lb/acre----------
Alfalfa2	80-100
Harry vetch2	80-100
Crimson clover2	60-75
Austrian winter pea2	50-60
Soybeans3 harvested for seed	15-30
Peanuts3 harvested for seed	20-40

1Assumes good stand.
2Killed before planting current spring crop.
3Legume planted in previous year or season. More nitrogen available if fall-planted crop immediately follows legume; less nitrogen available with spring-planted crop.

Worksheet: Determining the Nutrient Needs of Your Crop

	Example	**Your Farm**
1.Crop to be grown	corn	
2.Total nutrients required		
a.N (Table 7) (lb/acre)	140	
b.P_2O_5 (soil test) (lb/acre)	50	
c.K_2O (soil test) (lb/acre)	50	
3.Pounds of starter or preplant fertilizer used		
a.N (lb/acre)	10	
b.P_2O_5 (lb/acre)	34	
c.K_2O (lb/acre)	0	
4.Residual N credit from legumes (Table 9) (lb/acre)	20	
5.Net nutrient needs of crop (lb/acre)		
Nitrogen: total need (item 2a) minus additional N from starter (item 3a) minus legume residual (item 4)		
a.N: 140 –10 – 20 (lb/acre)	110	
Phosphorus and potassium: total need (items 2b and 2c) minus additional nutrients from starter (items 3b and 3c)		
b.P_2O_5: 50 – 34 (lb/acre)	16	
c.K_2O: 50 – 0 (lb/acre)	50	
6.Nutrient totals in manure. If analysis report already gives available nutrients, skip this item.		
a.Total N (Tables 1-4 or waste samples)(lb/ton)	72	
b.P_2O_5 (lb/ton)	78	
c.K_2O (lb/ton)	46	
7.Nutrients available to crop (items 6a, 6b, and 6c) times availability coefficients (Table 6). If analysis report already gives available nutrients, fill in those numbers.		
a.Available N: 72 x 0.6 (lb/ton)	43.2	
b.Available P_2O_5: 78 x 0.8 (lb/ton)	62.4	
c.Available K_2O: 46 x 0.8 (lb/ton)	36.8	
8.Application rate to supply priority nutrient		
a.Priority nutrient	nitrogen	
b.Amount of priority nutrient needed (lb/acre from item 5a)	110	
c.Rate of manure needed to supply priority nutrient (item 8b) divided by (item 7a): 110/43.2 (tons/acre)	2.55	
9.Pounds per acre of all nutrients supplied at the application rate required to meet the needs for the priority nutrient: for each nutrient, enter the available nutrients (items 7a, 7b,and 7c) times manure rate (item 8c)		
a.N supplied: 43.2 x 2.55 (lb/acre)	110	
b.P_2O_5 supplied: 62.4 x 2.55 (lb/acre)	159	
c.K_2O supplied: 36.8 x 2.55 (lb/acre)	94	
10.Nutrient balance: net nutrient need (–) or excess (+) after application of manure at calculated rate. Subtract the net nutrient needs of the crop (items 5a, 5b, and 5c) from the nutrient rate applied (items 9a, 9b, and 9c).		
a.N balance: 110 –110 (lb/acre)	0	
b.P_2O_5 balance: 159 –16 (lb/acre)	+143	
c.K_2O balance: 92 – 50 (lb/acre)	+44	

Note: Calculation format modified from Pennsylvania Department of Environmental Resources, Field Application of Manure,October 1986.

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