Water Quality

Focus Area
Nutrients & Bacterial Waste

Published by University Extension, University of Missouri-System

Spreading Poultry Litter without Lab Analysis or Soil Tests

Charles Fulhage and Donald Pfost, Department of Agricultural Engineering

A primary need and concern for most poultry producers is managing litter to protect groundwater and surface water and meet regulatory requirements. Meet the goals be applying litter to the land in such a way that the potential polluting nutrients (nitrogen, phosphorus, potash and organic matter) are used by the soil/plant complex and are not allowed to enter the ground water and surface water.

Litter as fertilizer

Litter should be viewed as fertilizer and managed like commercial fertilizer in your fertility program. The occasional practice of meeting fertility requirements with commercial fertilizer, then applying additional litter can damage water quality easily.

In general, Missouri waste application regulations are based on the rate of nitrogen application. With this plan, the phosphate (P_2O_5) and potash (K) applied may greatly exceed crop needs. Therefore, the best use of plant nutrients may apply less nitrogen (N) from waste than the crop needs and buy extra N to balance the needs. Applying phosphorous to fields with a Bray 1-P test level of more than 800 pounds per acre may aggravate surface water quality problems.

It is highly recommended that you analyze a representative sample of litter for nutrient values immediately before spreading. Also, test the soil before determining the land application rate. (See other publications in this series for more application plans.)

Managing litter as a fertilizer

Unlike commercial fertilizers, litter is a highly variable substance. Even within an animal species, test samples can vary 50 percent. Management styles for poultry operations, such as cleaning buildings on a certain schedule, dictate different techniques than commercial fertilizer that can be ordered and spread.

If a laboratory analysis is not available, use average values of manure nutrients in similar waste management systems. MU Publication WQ 201, *Reduce Environmental Problems with Proper Land Application of Animal Wastes*, gives average nutrient values for typical poultry manure management systems. Table 1 lists values for poultry litter.

	Nutrients (lb./ton)				
	N	N	NH_4-N	P_2O_5	K_2O
Broiler litter	54	46	8	59	38
Turkey litter	54	47	7	55	34

Note: P_2O_5 = 2.27 x P. K_2O = 1.2 x K
Actual values are highly dependent on dilution, bedding, etc.

Table 1. Average nutrient levels in turkey and broiler litter.

Days until incorporated	Percent of ammonia N available for crops
0-2	80
2-4	60
4-7	40
more than 7	20

Table 2. Manure ammonia N loss by days until incorporated into the soil. Unavailable portion is lost to the atmosphere.

In contrast to commercial fertilizer, litter has the potential for losing nutrients (primarily ammonia nitrogen) to the atmosphere after field spreading (see Table 2). For a discussion of manure nutrient losses, see MU Publication WQ 202, *Land Application Considerations for Animal Waste.*

Table 3 lists the percent of available organic nitrogen available with time. Table 4 gives the percent of various nutrients available in the growing season

Printed with soy ink on recycled paper

after application. Table 5 provides a basis for estimating the expected nitrogen release from soil organic matter for major annual crops in instead of a soil test. Table 6 lists N credits for crops following legumes.

If soil tests are not available for nutrient application rates, use a standard rate of 100 pounds of N per acre per year. This application rate would conform to the regulatory guideline for sizing soil/plant filters under the conservative management approach. However, this publication estimates the amount of manure to apply to satisfy the projected crop needs for nitrogen. It may exceed the 100 pounds per acre allowed under the conservative management approach. You may wish to use this worksheet with 100 pounds of N per acre applied to see what happens with P and K. Two blank worksheets are included for actual applications.

You cannot apply more than 100 pounds of nitrogen per year if the Department of Natural Resources has issued a letter of approval based on the conservative approach of applying not more than 100 pounds of nitrogen per year, regardless of the crop and the production level of the crop.

Manure applied	Percent organic matter available during current year
Current Year	40-60
1 year ago	10
2 years ago	5
3 years ago	5

Table 3. Manure organic nitrogen available by year.

Nutrient	Percent available in growing season
P	80
K	100
S, Mn, Cu, Zn	80
Ca, Mg	100

Table 4. Minerals and micronutrients available in manure.

Expected nitrogen release	
Summer annuals (corn, etc.)	Winter annuals (wheat, etc.)
pounds nitrogen pe acre	pounds nitrogen per acre
40	20

Table 5. Expected nitrogen release form soil organic matter for major annual crops when a current soil test is not available. Assumes a cation exchange capacity from 10.1 to 18 meq/100g and organic matter less than or equal to 2 percent. No nitrogen credit given for nitrogen released with perennial crops, such as fescue.

Legume crop	Nitrogen added (pounds per acre) Next year
Alfalfa:	
80-100 percent stand	120-140
40-60percent stand	40-60
less than 50 percent	0-20
Sweet clover (green manure)	100-120
Red clover (pure stand)	40-60
Soybeans (add about 1 pound per bushel)	15-60

Table 6. Nitrogen supplied by legumes for following crops.

Crop	Units	Pounds removed per unit production N	P_2O_5	K_2O
Corn, grain	bushel	1.0	0.4	0.3
Corn, stover	ton	20.6	7.5	37.2
Corn, silage	ton	7.4	2.9	8.9
Soybeans, grain	bushel	3.4	1.0	1.5
Soybeans, residue	ton	15	6.5	15.8
Wheat, grain	bushel	1.3	0.5	0.3
Wheat, straw	ton	13.0	3.6	24.6
Oats, grain	bushel	0.7	0.3	0.2
Oats, straw	ton	12.4	4.6	32.9
Barley, grain	bushel	1.0	0.4	0.3
Barley, straw	ton	13.5	4.7	31.0
Sorghum, grain	bushel	1.1	0.4	0.3
Sorghum, silage	ton	7.0	2.6	10.0
Rye, grain	bushel	1.0	0.5	0.3
Rye, straw	ton	10.0	6.0	16.9
Alfalfa	ton	49.0	11.0	50.0
Reed canary grass	ton	60.0	13.4	49.0
Orchard grass	ton	50.0	16.6	62.5
Brome grass	ton	33.2	13.2	50.8
Tall fescue	ton	55.0	18.6	52.9
Blue grass	ton	25.8	18.3	60.0
Clover grass	ton	41.0	13.3	38.9
Timothy	ton	37.5	13.8	62.5
Sorghum sudan grass	ton	39.9	15.3	55.9

Six sources listing nutrient removal for a given yield were averaged to estimate removal for a unit of production.

About 70 percent of the above nitrogen in inoculated legumes is fixed from the air. The percentage goes down when adequate nitrogen is available from the soil.

Table 7. Nitrogen, phosphate and potash removal from soil by various crops.

Example 1.

A fescue hayfield soil/plant filter is available for receiving litter from a turkey operation. No lab analysis of the litter is available. No soil tests have been performed on the soil/plant filter area. The yield goal is 3 tons of hay per acre. How many tons per acre of turkey litter should be applied?

Since no soil data is available, use the nitrogen requirement for fescue found in Table 7. Manure will be applied to supply nitrogen. Fescue, a perennial, receives no credit of nitrogen release from soil organic matter or from a previous legume crop.

From Table 7, for a yield goal of 3 tons per acre per year, we calculate the following nutrient removal:

55 lb. N/ton x 3 tons/acre = 165 lb. N/acre
18.6 lb. P_2O_5/ton x 3 tons/acre = 56 lb. P_2O_5/acre
52.9 lb. K_2O/ton x 3 tons/acre - 159 lb. K_2O/acre

Because no laboratory analysis of the litter is available, use the average values from Table 1. Assume the litter is not incorporated into the soil, and the loss of ammonia nitrogen is 80 percent.

Worksheet 1. Turkey litter on fescue

1. Crop nutrient requirements (data from Table 7)
   Crop _Fescue_ Yield _3_ tons/acre Nitrogen _165_ lb./acre
   P_2O_5 _56_ lb./acre K_2O _159_ lb./acre
2. Available ammonia nitrogen (NH_4-N)
   NH_4-N lb./ton x percent available = NH_4-N lb./ton (percent from Table 2, NH_4-N from Table 1)
   _7_ lb./ton x _0.2_ = _1.4_ lb./ton
3. Nitrogen available from this year's organic fraction.
   N lb./ton x percent available = N lb./ton (percent from Table 3, organic N from Table 1)
   _47_ lb./ton x _0.5_ = _23.5_ lb./ton
4. Because no litter was applied in the last three years, no residual nitrogen is available.
5. Litter application rate to supply nitrogen.

$$\frac{\text{(Crop N (line 1))- (residual N (line 4))- (N from O.M. (Table 5))- (legume N (Table 6))}}{\text{(Available } NH_4\text{-N (line 2)) + (available organic nitrogen (line 3))}} = \text{application rate tons/acre}$$

$$\frac{165 - 0 - 0 - 0}{1.4 + 23.5} = 6.6 \text{ tons/acre}$$

6. Phosphate available at calculated application rate for nitrogen.
   Tons/acre x P_2O_5 lb./ton x percent available = P_2O_5 lb./acre
   (P_2O_5/ton from Table 1, percent from Table 4)
   _6.6_ tons/acre x _55_ lb./ton x _0.8_ = _290*_ lb./acre
   *290 lb./acre P_2O_5 is applied vs. 56 lb./acre removed by crop.
7. Potash available at calculated application rate for nitrogen.
   Tons/acre x K_2O lb./ton x percent available = K_2O lb./acre
   (K_2O/ton from Table 1, percent from Table 4)
   _6.6_ tons/acre x _34_ lb./ton x _1_ = _224*_ lb./acre
   *224 lb./acre of K_2O is applied vs. 159 lb./acre removed by crop.

Example 2.

Turkey litter is to be spread on a fescue hayfield soil/plant filter, as in Example 1. However, in this example, assume that litter was spread at the rate of 3 tons/acre on the hayfield the previous two years. No lab analysis or soil test is available. Yield goal and nutrient requirements are the same as in Example 1.

Worksheet 2. Turkey litter on fescue

1. Crop nutrient requirements (data from Table 7)

Crop _Fescue_ Yield _3_ tons/acre Nitrogen _165_ lb./acre

P_2O_5 _56_ lb./acre K_2O _159_ lb./acre

2. Available ammonia nitrogen (NH_4-N)

NH_4-N lb./ton x percent available = NH_4-N lb./ton (percent from Table 2, NH_4-N from Table 1)

_7_ lb./ton x _0.2_ = _1.4_ lb./ton

3. Nitrogen available from this year's organic fraction.

N lb./ton x percent available = N lb./ton (percent from Table 3, organic N from Table 1)

_47_ lb./ton x _0.5_ = _23.5_ lb./ton

4. Residual nitrogen available from past year's organic fraction.

Tons/acre x N lb./ton x percent available = N lb./acre
(percent from Table 3)

One year ago: _3_ tons/acre x _47_ lb./ton x _0.10_ = _14.1_ lb./acre

Two years ago: _3_ tons/acre x _47_ lb./ton x _0.05_ = _7.1_ lb./acre

Total = _21.2_ lb./acre

5. Litter application rate to supply nitrogen.

$$\frac{\text{(Crop N (line 1))- (residual N (line 4))- (N from O.M. (Table 5))- (legume N (Table 6))}}{\text{(Available } NH_4\text{-N (line 2)) + (available organic nitrogen (line 3))}} = \text{application rate tons/acre}$$

$$\frac{165 - 21.2 - 0 - 0}{1.4 + 23.5} = 5.8 \text{ tons/acre}$$

6. Phosphate available at calculated application rate for nitrogen.

Tons/acre x P_2O_5 lb./ton x percent available = P_2O_5 lb./acre

(P_2O_5/ton from Table 1, percent from Table 4.)

_5.8_ tons/acre x _55_ lb./ton x _0.8_ = _255*_ lb./acre

*255 lb./acre P_2O_5 is applied vs. 56 lb./acre removed by crop.

7. Potash available at calculated application rate for nitrogen.

Tons/acre x K_2O lb./ton x percent available = K_2O lb./acre

(K_2O/ton from Table 1, percent from Table 4)

_5.8_ tons/acre x _34_ lb./ton x _1.0_ = _197*_ lb./acre

*Note: 197 lb./acre of K_2O is applied vs. 159 lb./acre removed by crop.

Example 3.

Turkey litter is spread on corn ground that was in soybeans last year, but no soil tests or litter lab analyses are available. Litter is not incorporated within 7 days. Ammonia nitrogen loss is 80 percent. Litter was spread on the area the last 3 years at 4 tons per acre. Yield goal for the corn is 150 bushel per acre. Because corn is a summer annual, nitrogen release is 40 pounds per acre, see Table 5.

Since soybeans were the last crop, expect about 30 pounds N/acre available from the legume, see Table 6.

From Table 7, we calculate the nutrient requirements as follows:

1 lb. N/bushel x 150 bushels/acre = 150 lb. N/acre

0.4 lb. P_2O_5/bushel x 150 bushel/acre = 60 lb. P_2O_5/acre

0.3 lb. K_2O/bushel x 150 bushels/acre = 45 lb. K_2O/acre

Worksheet 3. Turkey litter applied past three years on corn

1. Crop nutrient requirements (data from Table 7).
   Crop _Corn grain_ Yield _150_ tons/acre Nitrogen _150_ lb./acre
   P_2O_5 _60_ lb./acre K_2O _45_ lb./acre

2. Available ammonia nitrogen (NH_4-N).
   NH_4-N lb./ton x percent available = NH_4-N lb./ton (percent from Table 2, NH_4-N from Table 1)
   _7_ lb./ton x _0.2_ = _1.4_ lb./ton

3. Nitrogen available from this year's organic fraction.
   N lb./ton x percent available = N lb./ton (percent from Table 3, organic N from Table 1)
   _47_ lb./ton x _0.5_ = _23.5_ lb./ton

4. Residual nitrogen available from past years organic fraction.
   Tons/acre x N lb./ton x percent available = N lb./acre (percent from Table 3)
   One year ago: _4_ tons/acre x _47_ lb./ton x _0.10_ = _18.8_ lb./acre
   Two years ago: _4_ tons/acre x _47_ lb./ton x _0.05_ = _9.4_ lb./acre
   Three years ago: _4_ tons/acre x _47_ lb./ton x _0.0_ = _9.4_ lb./ton
   Total = _37.6_ lb./acre

5. Litter application rate to supply nitrogen.

$$\frac{\text{(Crop N (line 1))- (residual N (line 4))- (N from O.M. (Table 5))- (legume N (Table 6))}}{\text{(Available NH}_4\text{-N (line 2)) + (available organic nitrogen (line 3))}} = \text{application rate tons/acre}$$

$$\frac{150 - 37.6 - 40 - 30}{1.4 + 23.5} = 1.7 \text{ tons/acre}$$

6. Phosphate available at calculated application rate for nitrogen.
   Tons/acre x P_2O_5 lb./ton x percent available = P_2O_5 lb./acre
   (P_2O_5/ton from Table 1, percent from Table 4.)
   _1.7_ tons/acre x _55_ lb./ton x _0.8_ = _75*_ lb./acre
   *75 lb./acre P_2O_5 is applied vs. 60 lb./acre removed by crop.

7. Potash available at calculated application rate for nitrogen.
   Tons/acre x K_2O lb./ton x percent available = K_2O lb./acre
   (K_2O/ton from Table 1, percent from Table 4)
   _1.7_ tons/acre x _34_ lb./ton x _1_ = _58*_ lb./acre
   *58 lb./acre of K_2O is applied vs. 45 lb./acre removed by crop.

Litter fertility worksheet — without lab analysis or soil test

1. Crop nutrient requirements (from data in Table 7)

   Crop ________________ Yield ____________ Nitrogen ____________ lb./acre

   P_2O_5 ___________ lb./acre K_2O _________________ lb./acre

2. Available ammonia nitrogen (NH_4-N).

   NH_4-N lb./ton x percent available = NH_4-N lb./ton

   (Percent from Table 2, NH_4-N from Table 1)

   _______________ lb./ton x ________________ = ________________ lb./ton

3. Nitrogen available from this year's organic fraction.

   N lb./ton x percent available = N lb./ton

   (Percent from Table 3, organic N from lab tests)

   _______________ lb./ton x ________________ = ________________ lb./ton

4. Residual nitrogen available from past years organic fraction.

   Ton/acre x N lb./ton x percent available = N lb./acre

   (Percent available from Table 3, organic N from lab tests)

One year ago:	__________	tons/acre x	________	lb./ton x	________	lb./acre
Two years ago:	__________	tons/acre x	________	lb./ton x	________	lb./acre
Three years ago:	__________	tons/acre x	________	lb./ton x	________	lb./acre
				Total =	________	lb./acre

5. Litter application rate to supply oxygen.

$$\frac{\text{(Crop N (line 1))} - \text{(residual N (line 4))} - \text{(N from O.M (Table 5))} - \text{(legume N (Table 6))}}{\text{(Available } NH_4\text{-N (line 2))} + \text{(available organic nitrogen (line 3))}} = \text{application rate tons/acre}$$

$$\frac{\_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_}{\_\_\_\_\_ + \_\_\_\_\_} = \_\_\_\_\_\_ \text{ tons/acre}$$

6. Phosphate available at calculated application rate for nitrogen.

   Ton/acre x P_2O_5 lb./ton x percent available = P_2O_5 lb./acre

   (P_2O_5/ton from Table 1, percent from Table 4)

   _________ tons/acre x _________ lb./ton x ________ = _______ lb./acre

7. Potash available at calculated application rate for nitrogen.

   Ton/acre x K_2O lb./ton x percent available = K_2O lb./acre

   (K_2O/ton from Table 1, percent from Table 4)

   ________ tons/acre x _________ lb./ton x ________ = _______ lb./acre

References

1. MU Publication WQ 201. *Reduce Environmental Problems with Proper Land Application of Animal Wastes.* Extension Publications, University of Missouri, Columbia, MO 65211.

2. MU Publication WQ 202. *Land Application Considerations for Animal Wastes.* Extension Publications, University of Missouri,Columbia, MO 65211.

3. MWPS-18, *Livestock Waste Facilities Handbook.* 1985. Midwest Plan Service, Iowa State University, Ames, Iowa 50011

Published with funds provided to the Missouri Department of Natural Resources from the Environmental Protection Agency, Region VII. To learn more about water quality and other natural resource issues, contact the Missouri Department of Natural Resources, P.O. Box 176, Jefferson City, MO 65102. Toll free 1-800-334-6946.

University Extension

UNIVERSITY OF MISSOURI SYSTEM
LINCOLN UNIVERSITY

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Ronald J. Turner, Director, Cooperative Extension, University of Missouri and Lincoln University, Columbia, MO 65211. ■ University Extension does not discriminate on the basis of race, color, national origin, sex, religion, age, disability or status as a Vietnam era veteran in employment or programs. ■ If you have special needs as addressed by the Americans with Disabilities Act and need this publication in an alternative format, write ADA Officer, Extension and Agricultural Information, 1-98 Agriculture Building, Columbia, MO 65211, or call (314) 882-8237. Reasonable efforts will be made to accommodate your special needs.