Water Quality

Focus Area
Nutrients &
Bacterial
Waste

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Spreading Dairy Waste with Lab Analysis and with Soil Tests

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General information

A primary need and concern for most confinement livestock producers is managing manure so that groundwater and surface water are protected, and regulatory requirements are fulfilled. This objective is usually accomplished by applying manure to the land in such a manner that the potential polluting nutrients (N, P, K and organic matter) are utilized by the soil-plant complex, and are not allowed to enter the ground/surface water infrastructure.

Manure is a fertilizer resource

Manure should be viewed as a fertilizer resource and managed similarly to commercial fertilizer in the fertility program. The occasional practice of meeting fertility requirements with commercial fertilizer, then applying manure in addition "for a good measure," can easily impact water quality adversely. In general, Missouri waste application regulations are based on the rate of nitrogen application. With this scenario, the phosphorous and potash applied may greatly exceed crop needs. Therefore, optimum utilization of plant nutrients may necessitate applying less nitrogen from waste than the crop needs and buying supplemental nitrogen to balance crop needs. Applying phosphorous to fields with a Bray 1-P test level exceeding 800 pounds/acre may aggravate surface water quality problems.

It is highly recommended that a representative sample of dairy waste be analyzed for nutrient values immediately prior to spreading, in addition to soil tests, before determining the land application rate. The purpose of this publication is to provide guidance for application of waste with the benefit of a lab analysis and a soil test. Other publications in this series address application of dairy waste with other scenarios.

Managing manure as a fertilizer

Unlike commercial fertilizers, manure is a highly variable substance, even within a given animal specie, and variations of 50 percent to 100 percent among test samples are not unusual. Other management considerations peculiar to livestock operations, such as lagoon pumping in the fall to provide storage during winter and spring months, or manure storage tank emptying at whatever intervals are required to prevent overflow, dictate different management than commercial fertilizer which can just be "ordered and spread."

In contrast to commercial fertilizer, manure has the potential for nutrients (primarily nitrogen in the form of ammonia) to be lost to the atmosphere after field spreading. See MU Publication WQ 202 for a discussion of manure nutrient losses. Table 1 shows the available ammonia nitrogen as a function of time until incorporation into the soil. Table 2 lists the percent of available organic nitrogen available with time. Table 3 gives the percent of various nutrients avail-

Table 1. Manure Ammonia-Nitrogen Loss by Days Until Incorporated into the Soil (unavailable portion is lost to the atmosphere)

Days until Incorporation	Percent of Ammonia-N Available for Crops
0-2	80
2-4	60
4-7	40
>7	20

Table 2. Manure Organic Nitrogen Available by Year.

Manure Applied	Percent of Organic-N Available during Current Year
Current Year	40-60
1 year ago	10
2 years ago	5
3 years ago	5

Table 3. Other minerals and micronutrients available in manure.

Nutrient	Percent of Ammonia-N % available in growing season
P	80
K	100
S, Mn, Cu, Zn	80
Ca, Mg	100

able in the growing season after application.

The following soil test report gives the recommended nutrient application rates for a yield goal of 3 tons/acre of fescue hay. This publication details a procedure for estimating the amount of manure to apply to meet the soil test recommendations for nitrogen by applying dairy waste with a known nutrient analysis. A blank worksheet is included (on page 6)

University Extension
UNIVERSITY OF MISSOURI COLUMBIA

Soil Test Report

Soil Testing Laboratory
23 Mumford Hall, MU
Columbia, MO 65211
Phone. (314) 882-0623

or

Soil Testing Laboratory
P.O. Box 160
Portageville, MO 63873
Phone: (314) 379-5431

FIELD INFORMATION			
Field ID 1/4		Sample no. 1	
Acres 35	Last Limed 1-5	Irrigated	NO
Last crop *** NOT GIVEN ***			

This report is for:

Serial no. N2583		Lab no. 30000	
Area 80	County 801	Region	
Submitted 04/08/93		Processed 04/09/93	

Soil sample submitted by:

SOIL TEST INFORMATION			RATING					
			Very low	Low	Medium	High	Very High	Excess
pH_s	(salt pH)	4.8	**********					
Phosphorus	(P)	9 lbs/a	*******					
Potassium	(K)	110 lbs/a	**********					
Calcium	(Ca)	1800 lbs/a	**********					
Magnesium	(Mg)	350 lbs/a	**********					
Sulfur	(SO_4-S)	ppm						
Zinc	(Zn)	ppm						
Manganese	(Mn)	ppm						
Iron	(Fe)	ppm						
Copper	(Cu)	ppm						

Organic matter	1.8 %	Neutralizable acidity	4.5 meq/100g	Cation Exch. Capacity	10.6 meq/100g
pH in water		Electrical Conductivity	mmho/cm	Sodium (Na)	lbs/a
Nitrate (NO_3-N) Topsoil	ppm	Subsoil ppm	Sampling Depth Top	inches	Subsoil inches

NUTRIENT REQUIREMENTS								LIMESTONE SUGGESTIONS	
		Pounds per acre							
Cropping options	Yield goal	N	P_2O_5	K_2O	Zn	S			
18 COOL SEASON GRASS HAY	3 T/A	120	75	140				Effective neutralizing material (ENM)	1520
19 COOL SEASON GR PAST	200 CD/A	120	55	75					
1 ALFALFA, ALF-GRASS EST	0	30	100	55				Effective magnesium (EMg)	0
10 ALFALFA, ALF-GR HAY	4 T/A	0	85	235					

Some herbicide labels list restrictions based on soil pH in water. Your sample has an estimated pH in water of 5.3. Use this value as a guide to the label. If you wish to have soil pH in water analyzed, contact your dealer or local Extension specialist listed below.
To determine limestone needed in tons/acre, divide your ENM requirement by the guarantee of your limestone dealer.
When N requirement for cool season grass exceeds 90 pounds per acre apply two-thirds in the period December through February and the remainder in August.
Do not use nitrogen on spring seedings of legumes after May 1st, because of potential weed competition.
For alfalfa production, apply 1 lb of boron per acre annually.

Area Agronomy Specialist _____ Phone (___) _____ _____
Signature

White - Farmer *Yellow* - ASCS, *Blue* - Firm, *Pink* - Extension MP 189 Revised 8/91

University of Missouri, Lincoln University, U.S. Department of Agriculture & Local University Extension Councils Cooperating
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A soil test report obtained from University Extension's Soil Testing Laboratory.

Table 4. Laboratory Analysis for Solid Manure and Rate of Past Application

Nutrient	Nutrient Level, lbs/ton			
	this yr	1 yr ago	2 yrs ago	3 yrs ago
Total N	10	8	11	7
NH_4-N	5	4	5	3
Organic N	5	4	6	4
P_2O_5 (Phosphate)	4	3	5	4
K_2O (Potash)	11	8	12	9
Application, tons	?	21	19	22

Table 5. Laboratory Analysis for Liquid Manure and Rate of Past Application

Nutrient	Nutrient Level, lb/K-gallons			
	this yr	1 yr ago	2 yrs ago	3 yrs ago
Total N	30	24	33	21
NH_4-N	10	8	10	7
Organic N	20	16	23	14
P_2O_5 (Phosphate)	14	11	13	14
K_2O (Potash)	28	21	31	23
Application, K-gal[1]	?	7	6	7

[1]K-gal = 1,000 gallons, e.g., 6 K-gal = 6,000 gallons

for actual applications.

Note: This approach can not be used 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.

Examples

A fescue hayfield (soil-plant filter) is available for receiving dairy waste. The accompanying soil test

Worksheet for solid dairy manure

1. Crop nutrient requirements (from soil test).
   Crop Fescue Yield 3 tons/acre
   N,lb/acre 120 P_2O_5, lb/acre 75
   K_2O, lb/acre 140

2. Available ammonia (NH_4-N) nitrogen.

   lb NH_4-N/ton x % available = lb NH_4-N/ton
   (Percent available from Table 1)
   5 lb/ton x 0.2 avail. = 1.0 lb/ton

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

   lb N/ton x % available = available lb N/ton
   (Percent available first year from Table 2)

   5 lb/ton x 0.5 avail. = 2.5 lb/ton

4. Residual nitrogen available from previous years' organic fraction.
   (From Table 4: One year ago, 21 tons of dairy waste were applied to the field, 19 tons were applied two years ago, and 22 tons were applied three years ago.)

   Tons/acre x N/ton x % available = lb N/acre
   (Percent available from Table 2)

1 yr ago:	21 tons	x 4 lb/ton	x 0.10	= 8.4 lb/ac
2 yrs ago:	19 tons	x 6 lb/ton	x 0.05	= 5.7 lb/ac
3 yrs ago:	22 tons	x 4 lb/ton	x 0.05	= 4.4 lb/ac
			Total	= 18.5 lb/ac

5. Manure application rate to supply nitrogen.

   $$\frac{\text{(crop N requirement) − (residual N)}}{\text{(available NH}_4\text{-N) + (available organic fraction)}}$$

   = application rate

   $$= \frac{120 - 18.5}{1.0 + 2.5}$$

   = 29.0 tons/acre

6. Phosphate available at calculated application rate for nitrogen.

   tons/acre x lb P_2O_5/ton x % available = lb P_2O_5/acre
   (P_2O_5/ton from Table 5 = 4, % available from Table 3)
   29.0 tons/acre x 4 lb/ton x 0.8 = 92.8 lb/ac

   (**Note**: 92.8 lb/ac of P_2O_5 is applied versus 75 lb/ac recommended by the soil test.)

7. Potash available at calculated application rate for nitrogen.

   tons/acre x lb K_2O/ton x % available = lb K_2O/ac
   (K_2O/ton from Table 4 = 11, % available from Table 3)
   29.0 tons/ac x 11 lb/ton x 1.0 = 319 lb/ac

   (**Note:** 319 lb/ac of K_2O is applied versus 140 lb/ac recommended by the soil test.)

Table 6. Laboratory Analysis for Lagoon Effluent and the Rate of Past Application.

	Nutrient Level, lb/K-gallons			
Nutrient	this yr	1 yr ago	2 yrs ago	3 yrs ago
Total N	78	66	70	55
NH4-N	52	44	45	30
Organic N	26	22	25	25
P_2O_5 (Phosphate)	41	33	39	31
K_2O (Potash)	130	110	122	106
Application, inches[1]	?	2.0	2.5	3.1

[1]One acre-inch = 27,154 gallons

contains fertilizer recommendations for a yield goal of 3 tons of fescue hay per year from the soil-plant filter area. From the soil test, the following nutrient applications are recommended:

120 lb/acre of N
75 lb/acre of P_2O_5
140 lb/acre of K_2O

Given this information and the laboratory analysis of the dairy waste, how many inches of lagoon effluent, how many gallons per acre of liquid manure (slurry) and how many tons per acre of solid manure should be applied to meet the nitrogen needs of the fescue?

Tables 4, 5 and 6 outline previous years application rates and analyses for solid, liquid and lagoon effluent.

Assume that the waste applied as solid or liquid will not be incorporated into the soil, therefore the loss of ammonia-nitrogen will be 80 percent. Assume that the waste applied as lagoon effluent will be incorporated into the soil within two days after application (by infiltration into the soil), therefore the loss of ammonia-nitrogen will be only 20 percent.

Solid manure

The laboratory analysis (see Table 4) for solid manure is available for present and past years with the rate of application for the past three years. Given this information, complete the solid manure work-

Worksheet for liquid dairy manure

1. Crop nutrient requirements (from soil test).
   Crop Fescue Yield 3 tons/acre
   N, lb/acre 120 P_2O_5, lb/acre 75
   K_2O, lb/acre 140

2. Available ammonia (NH_4-N) nitrogen.

   lb NH_4-N/K-gal x % available = lb NH_4-N/K-gal
   (Percent available from Table 1)
   10 lb/K-gal x 0.2 avail. = 2 lb/K-gal

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

   lb N/K-gal x % available = lb N/K-gal
   (Percent available first year from Table 2)
   20 lb/K-gal x 0.5 avail. = 10 lb/K-gal

4. Residual nitrogen available from previous years' organic fraction.

   [From Table 5: One year ago, 7,000 gallons of dairy waste were applied to the field, 6,000 gallons were applied two years ago and 7,000 gallons were applied three years ago.]

   No. of K-gal/acre x lb N/K-gal x % available = lb N/acre
   (Percent available from Table 2)

   1 yr ago: 7 K-gal x 16 lb/K-gal x 0.10 = 11.2 lb
   2 yr ago: 6 K-gal x 23 lb/K-gal x 0.05 = 6.9 lb
   3 yr ago: 7 K-gal x 14 lb/K-gal x 0.05 = 4.9 lb
   Total = 23.0 lb

5. Manure application rate to supply nitrogen.

$$\frac{\text{(crop N requirement) - (residual N)}}{\text{(available } NH_4\text{-N) + (available organic fraction)}}$$

   = application rate

$$= \frac{120 - 23}{2 + 10}$$

   = 8.1 (K-gal/acre) = 8,100 gallons/acre

6. Phosphate available at calculated application rate for nitrogen.

   No. of (K-gal/acre) x lb P_2O_5/K-gal x % available = lb P_2O_5/acre
   (P_2O_5/ton from Table 5 = 14, % available from Table 3)
   8.1 (K-gal/acre) x 14 lb/K-gal x 0.8 = 90.7 lb/ac

   (**Note:** 90.7 lb/ac of P_2O_5 is applied versus 75 lb/ac recommended by the soil test.)

7. Potash available at calculated application rate for nitrogen.

   No. of (K-gal/acre) x lb K_2O/K-gal x % available = lb K_2O/acre
   (K_2O/ton from Table 5 = 28, % available from Table 3)
   8.1 (K-gal/acre) x 28 lb/K-gal x 1.0 = 226.8 lb/ac

   (**Note:** 226.8 lb/ac of K_2O is applied versus 140 lb/ac recommended by the soil test.)

sheet on page 3 to determine the proper application rate.

Liquid manure (slurry)

The following laboratory analysis (in Table 5) for liquid manure (slurry) is available for present and past years with the rate of application for the past three years. Complete the worksheet on page 4 to determine the proper application rate.

Lagoon effluent

The laboratory analysis for lagoon effluent, appearing in Table 6, for is available for present and past years with the rate of application for the past three years. Complete the lagoon effluent worksheet to determine the proper application rate.

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.

Worksheet for lagoon effluent

1. Crop nutrient requirements (from soil test).
   Crop Fescue Yield 3 tons/acre
   N, lb/acre 120 P_2O_5, lb/acre 75
   K_2O, lb/acre 140

2. Available ammonia (NH_4-N) nitrogen.

   lb NH_4-N/acre-inch x % available = lb NH_4-N/acre-in
   (Percent available from Table 1)
   52 lb/acre-inch x 0.8 avail. = 41.6 lb/acre-in

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

   lb N/acre-inch x % available = lb N/acre-inch
   (Percent available first year from Table 2)
   26 lb/acre-inch x 0.5 avail. = 13.0 lb/acre-inch

4. Residual nitrogen available from previous years' organic fraction. [From Table 6: One year ago, 2.0 inches of dairy lagoon waste water were applied to the field, 2.5 inches were applied two years ago and 3.1 inches were applied three years ago.]

   inches x lb N/acre-inch x % available = lb N/acre
   (Percent available from Table 2)

   1 yr ago: 2.0 inch x 22 lb/ac-in x 0.10 = 4.4 lb/ac
   2 yrs ago: 2.5 inch x 25 lb/ac-in x 0.05 = 3.1 lb/ac
   3 yrs ago: 3.1 inch x 25 lb/ac-in x 0.05 = 3.9 lb/ac
   Total = 11.4 lb/ac

5. Manure application rate to supply nitrogen.

$$\frac{\text{(crop N requirement) - (residual N)}}{\text{(available } NH_4\text{-N) + (available organic fraction)}}$$

= application rate

$$= \frac{120 - 11.4}{41.6 + 13.0}$$

= 2 inches

6. Phosphate available at calculated application rate for nitrogen.

   No. of inches applied x lb P_2O_5/acre-inch x % available = lb P_2O_5/ac
   (lb P_2O_5/acre-inch from Table 6 = 41, % available from Table 3)

   2 inches x 41 lb/acre-inch x 0.8 = 65.6 lb/ac
   (**Note:** 65.6 lb/ac of P_2O_5 is applied versus 75 lb/ac recommended by the soil test.)

7. Potash available at calculated application rate for nitrogen.

   No. of inches applied x lb K_2O/acre-inch x % available = lb K_2O/ac
   (K_2O/acre-inch from Table 6 = 130, % available from Table 3)
   2 inches x 130 lb/acre-inch x 1.0 = 260 lb/ac
   (**Note:** 260 lb/ac of K_2O is applied versus 140 lb/ac recommended by the soil test.)

Manure fertility worksheet

1. Crop nutrient requirements (from soil test).

   Crop _____ Yield _____

   N, lb/acre _____ P_2O_5, lb/acre _____

   K_2O, lb/acre _____

2. Available ammonia (NH_4-N) nitrogen (from lab test).

   Lagoon: lb NH_4-N/ac-in x % avail. = lb NH_4-N/ac-in
   Slurry: lb NH_4-N/K-gal x % avail. = lb NH_4-N/K-gal
   Solid: lb NH_4-N/ton x % avail. = lb NH_4-N/ton
   (Percent available from Table 1)

   _____ x _____ = _____

3. Nitrogen available from this year's organic fraction (from lab test).

   Lagoon: lb N/ac-in x % avail. = lb N/ac-in
   Slurry: lb N/K-gal x % avail. = lb N/K-gal
   Solid: lb N/ton x % avail. = lb N/ton
   (Percent available from Table 2)

   _____ x _____ = _____
   Note: K-gal = 1,000 gallons

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

   Lagoon: inches x lb N/ac-in. x % avail. = lb N/ac
   Slurry: K-gal/ac x lb N/K-gal x % avail. = lb N/ac
   Solid: ton/ac x lb N/ton x % avail. = lb N/ac
   (Percent available from Table 2)

   1 yr ago:_____ x _____ x _____ = _____
   2 yr ago:_____ x _____ x _____ = _____
   3 yr ago:_____ x _____ x _____ = _____
   TOTAL = _____

5. Manure application rate.

   $$\frac{\text{(crop N reqmt., line 1) - (residual N, line 4)}}{\text{(avail. } NH_4\text{-N, line 2) + (avail. organic fraction, line 3)}}$$

   = application rate

   $$\frac{(\quad) - (\quad)}{(\quad) + (\quad)} = \_\_\_\_\_$$

6. Phosphorus available at calculated application rate for nitrogen.

   Lagoon: inches x lb P/ac-in x % avail. = lb P/ac
   Slurry: K-gal/ac x lb P/K-gal x % avail. = lb P/ac
   Solid: ton/ac x lb P/ton x % avail. = lb P/ac
   (Percent available from Table 3)

   _____ x _____ x _____ = _____

   lb P/ac x 2.27 = lb P_2O_5/ac

   Note: Do not perform the conversion from P to P_2O_5 if lab results are given in units of P_2O_5.

   _____ x 2.27 = _____ lb P_2O_5/ac

7. Potassium available at calculated application rate for nitrogen.

   Lagoon: inches x lb K/ac-in x % avail. = lb K/ac
   Slurry: K-gal/ac x lb K/K-gal x % avail. = lb K/ac
   Solid: ton/ac x lb K/ton x % avail. = lb K/ac
   (Percent available from Table 3)

   _____ x _____ x _____ = _____ lb K/ac

   lb K/ac x 1.2 = lb K_2O/ac

   Note: Do not perform the conversion from K to K_2O if lab results are given in units of K_2O.

   _____ x 1.2 = _____ lb K_2O/ac

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