Water Quality

Focus Area
Nutrients
and
Bacterial
Wastes

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# Spreading Dairy Waste Without 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 lead to adverse impacts on water quality. 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, however, is to provide guidance for application of waste without the benefit of a lab analysis but with data from 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."

If a laboratory analysis is not available, average values of manure nutrients in similar waste management systems as reported in the literature must be used. MU Publication WQ 201 gives average nutrient values for typical swine, dairy, and poultry manure

**Table 1.** Average nutrient levels in dairy waste.

| | Nitrogen | | | | |
|---|---|---|---|---|---|
| Waste Type | Total | Organic | Ammonia | $P_2O_5$ | $K_2O$ |
| Solid[1] w/ bedding | 9 | 4 | 5 | 4 | 10 |
| Solid[2] w/o bedding | 9 | 5 | 4 | 4 | 10 |
| Lagoon[3] | 69 | 23 | 46 | 79 | 144 |
| Liquid (Slurry)[4] | 26 | 16 | 10 | 14 | 26 |

[1]pounds/ton (21% dry matter, Source: MWPS-18, Table 10-6)
[2]pounds/ton (18% dry matter, Source: MWPS-18, Table 10-6)
[3]pounds/acre-inch (Source: MU Publication WQ 201)
[4]pounds/1,000 gallons (Source: MU Publication WQ 201)
(Note: $P_2O_5 = 2.27 \times P$; $K_2O = 1.2 \times K$)
Actual values are highly dependent on dilution, bedding, and other factors. Variations of 50% from average values are not uncommon.

management systems. Table 1 lists values for dairy waste.

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 2 shows the available ammonia nitrogen as a function of time until incorporation into the soil. 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 after application.

This publication details a procedure for estimating the amount of manure to apply to meet the soil test recommendations for nitrogen, using a dairy manure of unknown nutrient analysis. The soil test may call for more than 100 pounds of nitrogen per acre to be added to satisfy crop needs, thus exceeding the 100 pounds per acre allowed under the "conservative management approach." However, one may wish to use this worksheet with 100 pounds of N/acre applied (conservative approach) to see what happens with P and K. Blank worksheets are included for actual applications.

**Note:** This approach can not be used (to apply more than 100 pounds of N per acre 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.

**Table 2.** Manure Ammonia-Nitrogen Available 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 3.** 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 4.** Other minerals and micronutrients available in manure.

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

# Examples

A fescue hayfield (soil-plant filter) is available for receiving dairy waste. No laboratory analysis of the manure to be applied is available. The accompanying soil test 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, 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?

Since no laboratory analysis of the manure is available, the average values from Table 1 will be used. 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

For the application of solid manure with no bedding, complete the worksheet on page 4 to determine the proper application rate. Assume the soil-plant filter area has not received manure from any source the past three years. See Table 1 for average nutrients per unit of manure applied.

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# 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 Conductvity | mmho/cm | Sodium (Na) | lbs/a |
| Nitrate ($NO_3$-N) Topsoil | ppm | Subsoil ppm | Sampling Depth Top | Inches Subsoil | inches |

NUTRIENT REQUIREMENTS

| Cropping options | Yield goal | Pounds per acre N | $P_2O_5$ | $K_2O$ | Zn | S |
|---|---|---|---|---|---|---|
| 18 COOL SEASON GRASS HAY | 3 T/A | 120 | 75 | 140 | | |
| 19 COOL SEASON GR PAST | 200 CD/A | 120 | 55 | 75 | | |
| 1 ALFALFA, ALF-GRASS EST | 0 | 30 | 100 | 55 | | |
| 10 ALFALFA, ALF-GR HAY | 4 T/A | 0 | 85 | 235 | | |

LIMESTONE SUGGESTIONS

| | |
|---|---|
| Effective neutralizing material (ENM) | 1520 |
| Effective magnesium (EMg) | 0 |

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 (____) _____ _____

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

S

University of Missouri, Lincoln University, U.S. Department of Agriculture & Local University Extension Councils Cooperating
equal opportunity institutions

**A soil test report obtained from University Extension's Soil Testing Laboratory.**

# 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 in Table 2)
   4 lb/ton x 0.2 avail. = 0.8 lb/ton

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

   lb N/ton x % available = lb N/ton
   (Percent available first year from Table 3)

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

4. Since no manure was applied in any of the previous three years, no residual nitrogen is available.

5. Manure application rate to supply nitrogen.

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

$$= \frac{120 - 0}{0.8 + 2.5}$$

= application rate

= 36.4 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 1 = 4, % available from Table 4)
   36.4 tons/acre x 4 lb/ton x 0.8 = 116.5 lb/ac
   (**Note:** 116.5 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 1 = 10, % available from Table 4)
   36.4 tons/ac x 10 lb/ton x 1.0 = 364 lb/ac
   **(Note:** 364 lb/ac of $K_2O$ is applied versus 140 lb/ac recommended by the soil test.)

# Worksheet for liquid 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/1,000 gal x % available = lb $NH_4$–N/1,000 gal
   (Percent available from Table 2)
   10 lb/1,000 gal x 0.2 avail. = 2 lb/1,000 gal

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

   lb N/1,000 gal x % available = lb N/1,000 gal
   (Percent available first year from Table 3)
   16 lb/1,000 gal x 0.5 avail. = 8 lb/1,000 gal

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

   No. of K–gal/acre x lb N/K–gal x % available = lb N/acre
   (**Note:** K–gal = 1,000 gallons, e.g., 5 K–gal = 5,000 gallons)
   (Percent available from Table 3)

   2 yr ago: 3.8 K–gal x 16 lb/K–gal x 0.05 = 3.0 lb

5. Manure application rate to supply nitrogen.

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

$$= \frac{120 - 3}{2 + 8}$$

= application rate

= 11.7 (K–gal/acre) = 11,700 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
   ($P_2O_5$/1,000 gal from Table 1 = 14, % available from Table 4)
   11.7 (K–gal/acre) x 14 lb/K–gal x 0.8 = 131.0 lb/ac
   (**Note:** 131.0 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
   ($K_2O$/1,000 gal from Table 1 = 26, % available from Table 4)
   11.7 (K–gal/acre) x 26 lb/K–gal x 1.0 = 304.2 lb/ac
   (**Note:** 304.2 lb/ac of $K_2O$ is applied versus 140 lb/ac recommended by the soil test.)

# Liquid manure (slurry)

For the application of liquid manure (slurry) with no bedding, complete the worksheet on page 4 to determine the proper application rate. The soil-plant filter area received 3,800 gallons of liquid dairy manure per acre two years ago. See Table 1 for average nutrients per unit of manure applied.

# Lagoon effluent

For the application of waste from a lagoon , complete the worksheet below to determine the proper application rate. The soil-plant filter area has received 1.45 inches of dairy lagoon effluent each of the past six years. See Table 1 for average nutrients per unit of manure applied.

# 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–inch
   (% available from Table 2)
   46 lb/acre–inch x 0.8 avail. = 36.8 lb/acre–inch

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

   lb N/acre–inch x % available = lb N/acre–inch
   (% available first year from Table 3)
   23 lb/acre–inch x 0.5 avail. = 11.5 lb/acre–inch

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

   inches x lb N/acre–inch x % available = lb N/acre
   (Percent available from Table 3)

   1 yr ago: 1.45 inch x 23 lb/ac–in x 0.10 = 3.3 lb/ac
   2 yrs ago: 1.45 inch x 23 lb/ac–in x 0.05 = 1.7 lb/ac
   3 yrs ago: 1.45 inch x 23 lb/ac–in x 0.05 = 1.7 lb/ac
   Total = 6.7 lb/ac

5. Manure application rate to supply nitrogen.

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

   $$= \frac{120 - 6.7}{36.8 + 11.5}$$

   = 2.35 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

   ($P_2O_5$/acre–inch from Table 1 = 79, % available from Table 4)

   2.35 inches x 79 lb/acre–inch x 0.8 = 148.5 lb/ac

   (**Note:** 148.5 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 $K_2O$/acre

   ($K_2O$/acre–inch from Table 1 = 144, % available from Table 4)

   2.35 inches x 144 lb/acre–inch x 1.0 = 338.4 lb/ac

   (**Note:** 338.4 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.

   **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 2)

   _____ x _____ = _____

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

   **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 3)

   _____ 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 3)

   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 4)

   _____ 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 avail. from Table 4)

   _____ x _____ x _____ = _____

   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

This guide was 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 resources, contact the Missouri Department of Natural Resources, P. O. Box 176, Jefferson City, MO 65102. Toll free 1-800-334-7046.

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