Water Quality

Focus Area
Nutrients
and
Bacterial
Wastes

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Spreading Dairy Waste Without Lab Analysis or 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, however, is to provide guidance for application of waste without the benefit of a lab analysis or 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 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

Table 1. Average nutrient levels in dairy waste.

Waste type	Nitrogen Total	Nitrogen Organic	Nitrogen 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 x P; K_2O = 1.2 x K)
Actual values are highly dependent on dilution, bedding, and other factors. Variations of 50 percent from average values are not uncommon.

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field spreading. See MU Publication WQ 202 for a discussion of manure nutrient losses. Table 2 shows the loss of ammonia nitrogen before incorporation. 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. Table 5 provides a basis for estimating the expected nitrogen release from soil organic matter for major annual crops in lieu of a soil test. Table 6 lists nitrogen credits for crops following various legumes.

If soil tests are not available for guidance on nutrient application rates, a standard rate of 100 pounds of N per acre per year might be used. This application rate would conform to the regulatory

Table 2. 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 3. Manure Organic Nitrogen Available by Year. Percent of Organic-N

Manure Applied	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

Table 5. Expected N release from soil organic matter for major annual crops when a current soil test is not available (assumes a cation exchange capacity from 10.1 to 18.0 meq/100g and organic matter content ≤ 2% (no credit given for N released with perennial crops).

Expected Nitrogen Release	
Summer Annuals lbs. N/ac	Winter Annuals lbs. N/ac
40	20

Table 6. Nitrogen supplied by legumes for succeeding crops (optimum).

Legume Crop	Nitrogen Added (lbs. N/Acre) 1st. year after
Alfalfa	
80-100% stand	120-140
40-60% stand	40-60
less than 50%	0-20
Sweet Clover (green manure)	100-120
Red Clover (pure stand)	40-60
Soybeans (add about 1 lb/bu)	15-60

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

	Pounds removed per unit production			
Crop	Units	N	P_2O_5	K_2O
Corn, grain	bu	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	bu	3.4	1.0	1.5
Soybeans, residue	ton	15	6.5	15.8
Wheat, grain	bu	1.3	0.5	0.3
Wheat, straw	ton	13.0	3.6	24.6
Oats, grain	bu	0.7	0.3	0.2
Oats, straw	ton	12.4	4.6	32.9
Barley, grain	bu	1.0	0.4	0.3
Barley, straw	ton	13.5	4.7	31.0
Sorghum, grain	bu	1.1	0.4	0.3
Sorghum, silage	ton	7.0	2.6	10.0
Rye, grain	bu	1.0	0.5	0.3
Rye, straw	ton	10.0	6.0	16.9
Alfalfa	ton	49.0	11.0	50.0
Reed Canarygrass	ton	60.0	13.4	49.0
Orchardgrass	ton	50.0	16.6	62.5
Bromegrass	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-sudangrass	ton	39.9	15.3	55.9

Sources: 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.

guideline for sizing soil-plant filters under the conservative management approach. This publication, however, details a procedure for estimating the amount of manure to apply to satisfy the projected crop needs for nitrogen, which may exceed 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. A blank worksheet is 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.

Examples

A fescue hayfield (soil-plant filter) is available for receiving dairy waste. No laboratory analysis of the manure to be applied is available and no soil tests have been performed on the soil-plant filter area. A yield goal of 3 tons of hay per acre is assumed. Given this information, how many inches of lagoon effluent, how many gallons per acre of slurry and how many tons per acre of solid manure can be applied?

Since no soil test is available, the nitrogen requirement for fescue production found in Table 7 will be used and manure will be applied to supply adequate nitrogen for the desired yield goal. For fescue (a perennial), no credit is given for 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 by fescue hay:

55 lbs of N/ton x 3 tons/acre = 165 lbs of N/acre

18.6 lbs of P_2O_5/ton x 3 tons/acre = 56 lbs of P_2O_5/acre

52.9 lbs of K_2O/ton x 3 tons/acre = 159 lbs of K_2O /acre

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

Worksheet for solid dairy manure

1. Crop nutrient requirements (calculated from Table 7 data).
   Crop Fescue Yield 3 tons/acre
   N, lb/acre 165 P_2O_5, lb/acre 56
   K_2O, lb/acre 159

2. Available ammonia (NH_4-N) nitrogen.

   lb NH_4-N/ton x % available = lb NH_4-N/ton
   (Find 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.

$$\frac{\text{(crop N requirement) - (residual N) - (N, OM) - (N, leg)}}{\text{(available NH4-N) + (available organic fraction)}}$$

= application rate

$$= \frac{165 - 0 - 0 - 0}{0.8 + 2.5}$$

= 50 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)
   50 tons/acre x 4 lb/ton x 0.8 = 160 lb/ac

   (**Note:** 160 lb/ac of P_2O_5 is applied versus 56 lb/ac removed by crop.)

7. Potash available at calculated application rate for nitrogen.

   tons/acre x lb K_2O/ton x % available = lb K_2O/acre
   (K_2O/ton from Table 1 = 10, % available from Table 4)
   50 tons/acre x 10 lb/ton x 1.0 = 500 lb/ac

   (**Note:** 500 lb/ac of K_2O is applied versus 159 lb/ac removed by crop.)

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 previous worksheet (on page 3) 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.

Liquid manure (slurry)

For the application of liquid manure (slurry) with no bedding, complete the worksheet below (page 4) to determine the proper application rate. Assume 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 on the following page (see page 5) to determine the proper application rate. Assume 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.

Worksheet for liquid dairy manure

1. Crop nutrient requirements (calculated from Table 7 data).
   Crop Fescue Yield 3 tons/acre
   N, lb/acre 165 P_2O_5, lb/acre 56
   K_2O, lb/acre 159

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.

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

= application rate

$$= \frac{165 - 3 - 0 - 0}{2 + 8}$$

= 16.2 K-gal/acre = 16,200 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)
   16.2 (K-gal/acre) x 14 lb/K-gal x 0.8 = 181.4 lb/ac

   (**Note:** 181.4 lb/ac of P_2O_5 is applied versus 56 lb/ac removed by crop.)

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)
   16.2 (K-gal/acre) x 26 lb/K-gal x 1.0 = 421.2 lb/ac

   (**Note:** 421.2 lb/acre of K_2O is applied versus 159 lb/ac removed by crop.)

Worksheet for lagoon effluent

1. Crop nutrient requirements (calculated from Table 7 data).
   Crop Fescue Yield 3 tons/acre
   N, lb/acre 165 P_2O_5, lb/acre 56
   K_2O, lb/acre 159

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.

$$\frac{\text{(crop N requirement) - (residual N) - (N, OM) - (N, leg)}}{\text{(available } NH_4\text{-N) + (available organic fraction)}} = \text{application rate}$$

$$= \frac{165 - 6.7 - 0 - 0}{36.8 + 11.5}$$

= 3.28 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/acre
   (P_2O_5/acre-inch from Table 1 = 79, % available from Table 4)
   3.28 inches x 79 lb/acre-inch x 0.8 = 207.3 lb/ac

   (**Note:** 207.3 lb/ac of P_2O_5 is applied versus 56 lb/ac removed by crop.)

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)
   3.28 inches x 144 lb/acre-inch x 1.0 = 472.3 lb/ac

   (**Note:** 472.3 lb/ac of K_2O is applied versus 159 lb/ac removed by crop.)

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

Manure fertility worksheet

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

Crop ______________ Yield ______________
N, lb/acre ______________ P_20_5, lb/acre ______________
K_20, 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.

$$\frac{\text{(crop N reqmt., line 1) - (residual N, line 4) - (N from O.M., Table 5) - (N from legumes, Table 6)}}{\text{(avail. } NH_4\text{-N, line 2) + (avail. organic fraction, line 3)}}$$

= application rate

$$\frac{(\_\_\_\_) - (\_\_\_\_) - (\_\_\_\_) - (\_\_\_\_)}{(\_\_\_\_) + (\_\_\_\_)} = \_\_\_\_\_\_ \text{ lb N/ac}$$

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

lb P/ac x 2.27 = lb P_20_5/ac

Note: Do not perform the conversion from P to P_20_5 if lab results are given in units of P_20_5.

______________ x 2.27 = ______________ lb P_20_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 4)

________ x ________ x ________ = ________ lb K/ac

lb K/ac x 1.2 = lb K_20/a

Note: Do not perform the conversion from K to K_20 if lab results are given in units of K_20.

______________ x 1.2 = ______________ lb K_20/ac

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