Ohio Livestock Manure And Wastewater Management Guide
Bulletin 604

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Manure Management Worksheet

Example 1

A swine producer has a farrow-to-finish operation in enclosed buildings with a capacity of 50 sows (avg. wt. 350 pounds), 12 gilts (avg. wt. 250 pounds), 5 boars (avg. wt. 350 pounds), and 500 growing-finishing pigs (avg. wt. 150 pounds). A liquid-manure system is used, and wastes are stored in a below-ground storage. Manure is typically land-applied in the spring and incorporated within 3 days. Determine a manure management plan including manure production, nutrients, application rates, and land required for land application.

A. Manure Production

Step I. Determine the average animal units (a.u.), expressed as 1,000-pound equivalents, for your farm based on a one-time capacity and average animal weights.

A.U. = AWT x ANA / 1000 lb

A.U. = Animal unit, 1,000-pound equivalent
AWT = Average weight per animal, pounds
ANA = Average one-time capacity of animals

Solution:

A.U. = 350 lb/sow x 50 sow/1,000 lb = 17.5 a.u.
= 250 lb/gilt x 12 gilts/ 1,000 lb = 3.0 a.u.
= 350 lb/boar x 5 boars/ 1,000 lb = 1.75 a.u.
= 150lb/pig x 500 pigs/l,000 lb = 75.0 a.u.

A.U.= 17.5 + 3.0 + 1.75 + 75.0
= 97.25 a.u.

Step II. Determine the annual manure production in tons or gallons.

AMP = A.U. x MPR

AMP = Annual manure production, tons per year or gallons per year
A.U. = Animal unit, 1,000-pound equivalent
MPR = Annual manure production rate, ton/yr or gal/yr (Table 4)

Solution:

AMP = 17.5 a.u. x 3,894 gal/a.u. = 68,145 gal/yr (sows)
= 3.0 a.u. x 1,425 gal/a.u. = 4,275 gal/yr (gilts)
= 1.75 a.u. x 1,425 gal/a.u. = 2,494 gal/yr (boars)
= 75.0a.u. x 3,008 gal/a.u. = 225,600 gal/yr(pigs)

AMP = 68,145 + 4,275 + 2,494 + 225,600

= 300,514 gal/yr

Step III. Determine approximate storage capacity required for desired storage length, expressed in cubic feet or gallons.
Typical storage periods are 90 days, 180 days, and 1 year. For liquid storages, include additional dilution volumes, such as wash water, runoff water, etc. For storages without runoff waters, plan for 10 percent to 25 percent dilution volume. For solid storages, include half the volume of bedding materials when estimating the storage volume.

MSV = AMP x SL / 365 day/yr x DF + RNF

MSV = Manure storage volume, cubic feet or gallons
AMP = Annual manure production volume, cubic feet per year or gallons per year. To convert ton/yr to cubic feet per year, multiply by 2,000 lb/ton and divide by the density, lb per cubic foot, found in Table 1.
SL = Storage length, days
DF = Dilution volume factor for wash water, etc. (1.10 - 1.25)
RNF = Runoff volume or bedding material, cubic feet or gallons

Solution:

Assume 180-day storage and a dilution volume of 25 percent for spilled and wash water.

The buildings are enclosed so no runoff is stored.

MSV = 300,514gal/yr x 180 days / 365 days/yr x 1.25 + 0
= 185,248 gallons

B. Nutrient Requirements and Availability

Step I. Determine the nutrients needed to grow the crop. Refer to the Ohio Agronomy Guide, Bulletin 472, and a current soil-test report for fields receiving manure to determine needed nutrients for the crop.

Solution:

The producer wants to apply manure to no-till corn.

Yield Goal = 150 bu/a

Previous Crop = Corn

Soil Test:
pH = 6.3
LTI = 68
P = 60 lb/a
K = 350 lb/a
Ca = 3000 lb/a
Mg = 640 lb/a
CEC = 11 meq/100 g

The fertilizer recommendation from the Ohio Agronomy Guide or The Ohio State University Research and Extension Analytical Laboratory (REAL) for this yield goal of no-till corn would be:

Lime = none

N = 200 lb/a
P2O5 = 60 lb/a
K20 = 40 lb/a

Step II. Determine the manure nutrient content per ton of solid manure or per 1,000 gallons of liquid manure. Nutrient values from a chemical analysis of manure are preferred. If nutrient contents are presented in percent, multiply the percent nutrient in manure by 20 for pounds nutrient per ton, or by 85 for pounds nutrient per 1,000 gallons. If an analysis is not available, use Tables 1 or 4 for fresh manure and Tables 6 or 7 for stored manure. Record values for total nitrogen, ammonium nitrogen (NH4), P2O5, and K20.

Solution:

A chemical analysis of the manure is not available. Use the values from Table 7 for liquid manure stored in a below-ground storage pit.

Total N = 36 lb/1,000 gal
NH4 = 26 lb/1,000 gal
P2O5 = 27 lb/1,000 gal
K20 = 22 lb/1,000 gal

C. Annual Manure-Application Rate

Step I. Considering existing soil-fertility levels, application method (surfaceapplied or incorporated), and site conditions (low or high runoff potential) determine the recommended manure-application strategy from Table 10.

Solution:

The soil-test P, value of 60 pounds per acre is an ideal level for corn production, and the Ohio Agronomy Guide recommends that enough phosphorus for crop removal be applied for this yield. The land available for manure application is considered a low-runoff-potential site. From Table 10, enough manure to meet the nitrogen requirement of the no-till corn can be applied based on a low-runoff-potential site and soil-test P, value of 60 pounds per acre.

Step II. Calculate the amount of plant-available nitrogen in the manure considering the organic nitrogen, ammonium nitrogen,and application method.

a. Determine amount of organic nitrogen in the manure.
Organic N = Total N - Ammonium N

b. Calculate the plant-available nitrogen.
Available N = 0rganic N x Efficiency factor + Ammonium N x Efficiency factor

Solution:

a. Amount of organic nitrogen in the manure.
Organic N = 36 lb/1,000 gal - 26 lb/1,000 gal = 10 lb/1,000 gal

b. Amount of plant-available nitrogen (Table 8). Manure was applied in the spring and incorporated in 3 days.
Available N = 1O lb/1,000 gal x 0.33 + 26 lb/1,000 gal x 0.50 = 16.3 lb/1,000 gal

Step III. Determine the amount of residual or carryover nitrogen that exists from previous years' manure applications. Use Table 9 to determine percent of residual nitrogen made available.

Solution:

Manure was added to this field at a rate of 3,000 gallons per acre for the past 3 years. All of the ammonium (NH_4) nitrogen is available the first year, so no residual remains. Only one-third of the organic nitrogen was available in the first year. Therefore, the only residual nitrogen will be from the organic nitrogen pool from previous manure applications.

Residual organic N = 0rganic N - Organic N x Efficiency factor
= 10 lb/1,000 gal - 10 lb/1,000 gal x 0.33
= 6.67 lb/1,000 gal

Use Table 9 to determine the amount of residual organic nitrogen available from each year's application.

Residual N = 6.67 lb/1,000 gal x [0.05 (1st yr) + 0.047 (2nd yr) + 0.045 (3rd yr)] x 3,000 gal/acre = 2.84 lb/acre

Step IV. Adjust the nitrogen fertilizer recommendation to account for the residual nitrogen.

Net N needs, lb/acre = Recommended N needs - Residual N

Note: The amount of available residual nitrogen is often a small fraction of the total nitrogen fertilizer recommendation. In most cases, it may not be practical to consider residual nitrogen when making nitrogen fertilizer application decisions except when manure has been applied to the same land area for several years.

Solution:

Net N needs = 200 lb/acre - 2.84 lb/acre
= 197.16 lb/acre (use 197 lb/acre)

Step V. Calculate the annual manure application (ton/acre or gallon/acre) based on the amount of N required by the crop.

Manure applied = Net crop N needs / Available N in manure

Solution:

Manure applied, gal/acre = 197 lb/acre / 16.3 lb/1,000 gal
= 12,086 gal/acre

Step VI. Calculate the annual manure application (tons per acre or gallons per acre) based on the amount of P_2O_5 required by the crop.

Manure applied = Crop P_2O_5 needs / P_2O_5 in manure

Solution:

Manure applied, gal/acre = 60 lb/acre / 27 lb/1,000 gal = 2,222 gal/acre

Step VII. Calculate the annual manure application (tons per acre or gallons per acre) based on the amount of K20 required by the crop.

Manure applied = Crop K20 needs / K20 in manure

Solution:

Manure applied, gal/acre = 40 lb/acre / 22 lb/1,000 gal = 1,818 gal/acre

Step VIII. Select the annual rate of manure to be applied based on nutrient requirements, existing soil fertility, and site conditions (Table 10). If manure is to provide all the nutrient needs of the crop, select the highest application rate. This rate will result in nutrient buildup in the soil. If your objective is to maximize the utilization of manure nutrients, select the lowest application rate and supplement with commercial fertilizer.

Solution:

Recommended manure-application rates:

N = 12,086 gal/acre
P2O5 = 2,222 gal/acre
K20 = 1,818 gal/acre

The manure-application guidelines from Table 10 allow for enough manure to meet the nitrogen needs of the no-till corn. Therefore, 12,086 gallons per acre can be applied recognizing that the other nutrients will build up in the soil. If that is not desired, a lower application rate can be used to meet the phosphorus or potassium requirement, and commercial fertilizer can be used to supply the needed nutrients.

Step IX. Calculate the nutrients supplied by the selected application rate, and determine the amount of excess manure nutrients applied or additional nutrients required.

Solution:

N, lb/acre = 12,086 gal/acre x 16.3 lb/1,000 gal = 197 lb/acre (O lb/acre needed)

P2O5, lb/acre = 12,086 gal/acre x 27 lb/l,000 gal = 326 lb/acre (266 lb/acre excess)

K20, lb/acre = 12,086 gal/acre x 22 lb/1,000 gal = 266 lb/acre (226 lb/acre excess)

D. Land Required for Annual Manure Production Application

Step I. Determine annual manure nutrient production, expressed as pounds of nutrient per year. The number of animal-unit equivalents and annual manure production were calculated in Part A, Steps I and II. Estimate annual nutrient production (nitrogen, P2O5, and K20) using the annual raw manure-produc- tion values in tons per year or gallons per year (Table 4) and nutrient values from Tables 1 or 4 for raw manure or estimated annual storage volume and Tables 6 or 7 for stored manure.
The amount of stored runoff and dilution water will affect the total volume of waste to be handled annually. Table values are approximate and should be used only as estimates.

Raw-Manure Nutrients

ANP = AMP x MNC

ANP = Annual nutrient production, pounds per year
AMP =Annual manure production, ton/yr or gal/yr (Part A, Step II)
MNC = Available raw manure nutrients (Tables 1 or 4), pounds per ton or pounds per 1,000 gal

Solution:

ANP, N = 300,514 gal/yr x 54.6 lb/1,000 gal = 16,408 lb N/yr
ANP, P2O5 = 300,514 gal/yr x 42.7 lb/1,000 gal = 12,832 lb P2O5/yr
ANP, K20 = 300,514 gal/yr x 42.7lb/1,000gal = 12,832 lb K20/yr

Stored-Manure Nutrients

ANP = ASV x MNC

ANP = Annual nutrient production, lb/yr
ASV = Annual manure storage volume, ton/yr or gal/yr (Part A, Step III)
ASV = MSV x 365 / SL
MSV = Manure storage volume, cubic feet or gallons
SL = Storage length, days
MNC = Available storage manure nutrients (Tables 6 or 7 and Part C, Step II), lb/ton or 1,000 gal

Solution:

ANP, N = 185,248 gal x 365 day / 180 day x 16.3lb/1,000 gal
= 6,123 lb N/yr

ANP, P2O5 = 185,248 gal x 365 day / 180 day x 27 lb/1,000 gal
= 10,142 lb P2O5/yr

ANP, K20 = 185,248 gal x 365 day / 180 day x 22 lb/1,000 gal
= 8,264 lb K20/yr

Step II. Determine the total acres of cropland needed for manure application based on meeting the recommended crop nutrient needs to achieve a desired yield goal using the nutrient values for stored manure.

ACRE = ANP / CNR

ACRE = Total cropland required to apply manure, acre/yr
ANP = Annual manure nutrient production, lb nutrient/yr
CNR = Nutrients required to grow crop, lb nutrient/acre

Solution:

ACRE, N = 6,123 lb N/yr / 197 lb N/acre = 31.1 acre/yr
ACRE, P2O5 = 10,142 lb P2O5/yr / 60 lb P2O5/acre = 169 acre/yr
ACRE, K,O = 8,264 lb K20/yr / 40 lb K20/acre = 206.6 acre/yr

Example 2:

Use the same farming situation as given in Example 1. Formulate a new manure management plan for land application using the new soil-test conditions listed below. Assume the potential for runoff is high and the farmer is unable to incorporate the manure 8 inches or greater.

Soil test:
pH = 6.3
LTI = 68

P1 = 130 lb/a
K = 480 lb/a
Ca = 3,000 lb/a
Mg = 640 lb/a
CEC = 11 meq/100 g

Solution:

A. Manure Production

Manure-production values and needed storage capacity are the same as in Example 1. Annual manure production is 300,514 gallons per year and the 180- day storage volume is 185,248 gallons.

B. Nutrient Requirements and Availability

Step I. The fertilizer recommendation from the Ohio Agronomy Guide or the REAL Lab for this yield goal of no-till corn would be:

Lime = none
N = 200 lb/a
P2O5 = 0 lb/a
K20 = 0 lb/a

Step II. A chemical analysis of the manure is not available. Use the values from Table 7 for liquid manure stored in a
below-ground storage pit.

Total N = 36 lb/1,000 gal
NH4 = 26 lb/1,000 gal
P2O5 = 27 lb/1,000 gal
K20 = 22 lb/1,000 gal

C. Annual Manure-Application Rate

Step I. The soil-test P1 value is high enough that no phosphorus is recommended for this yield level in the Ohio Agronomy Guide. The land available for manure application is considered a high-runoff-potential site. From Table 10, enough manure can be applied to meet the equivalent P2O5 removed in the harvested crop.

Crop Removal Rate
Refer to Table 12 for crop nutrient removal rates. Corn removes 0.37 pounds of P2O5 per bushel. Calculate the crop removal rate for P2O5.

P2O5 crop removal = Yield, bu/acre x P2O5 in crop, lb/bu
= 150 bu x 0.37 lb/bu
= 55.5 lb P2O5/acre

Step II-V. The manure-application rate is not affected by nitrogen in this case, so these steps can be skipped.

Step VI. Calculate the annual manure application (tons per acre or gallons per acre) based on the amount of P2O5 removed by
the crop.

Manure applied = Crop removal, P2O5 / P2O5 in manure

Manure applied = 55.5 lb/acre / 27 lb/1,000 gal
= 2,056 gal/acre

Step VII. The manure-application rate is based on the equivalent P2O5 removed by the harvested crop, so the application rate
based on K20 does not need to be determined.

Step VIII. The maximum manure-application rate for these conditions is 2,056 gallons per acre.

Step IX. Determine the nutrients supplied by the selected application rate and the amount of excess manure nutrients applied or
additional nutrients required. The available manure nutrients were determined in Example 1.

N, lb/acre = 2,056 gal/acre x 16.3 lb/1,000 gal
= 33.5 lb/acre (need 163.5 lb/acre additional)

P2O5 lb/acre = 2,056 gal/acre x 27 lb/1,000 gal
= 55.5 lb/acre (O lb/acre needed)

K20, lb/acre = 2,056 gal/acre x 22 lb/1,000 gal
= 45.2 lb/acre (5.2 lb/acre excess)

D. Land Required for Annual Manure Production Application

Step I. From Example 1, the annual nutrient production is:

ANP, N = 6,123 lb N/yr
ANP, P2O5 = 10,142 lb P2O5/yr
ANP, K20 = 8,264 lb K20/yr

Step II. Determine the total acres of cropland needed for manure application based on meeting the P2O5 crop removal rate.

ACRE, P2O5 = 10,142 lb P2O5/yr / 55.5 lb P2O5/acre
= 183 acre/yr

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