36830 PDF

Water Quality in Georgia

# Developing a Nutrient Management Plan for the Dairy Farm

Cooperative Extension Service • The University Georgia College of Agricultural and Environmental Sciences • Athens

Manure is one of the most valuable, but often under-appreciated byproducts a dairy farm produces. It should be recognized as an asset, not a liability - a resource to be used wisely in a farm operation. Manure contains nitrogen, phosphorus, potassium and micronutrients necessary for plant growth. It increases soil organic matter, thus improving soil structure and soil tilth. Furthermore, it increases soil water holding capacity, decreases soil erosion potential, improves aeration and stimulates the growth of beneficial soil organisms.

## COMPONENTS OF WASTE MANAGEMENT

The challenge for today's dairy farmer is to develop and implement an economical, environmentally-sound management program for using manure. Such a program should cover all aspects of manure management on a farm -- from production to field application. An animal waste management program includes a combination of physical components, conservation practices and management measures for manure handling, storage, treatment and utilization on crop or pasture land.

These components, practices and measures generally fall into two distinct categories. One involves methods or structures that facilitate the collection, handling, storage and treatment of manure consistent with the purpose of the waste management plan.

The second category includes the application of manure nutrients to the soil and the retention of nutrients in the soil profile where use by plants occur. A Nutrient Management Plan (NMP) fits in this category.

## NUTRIENT MANAGEMENT

A NMP takes into account the following: nutrients present in the soil, nutrients in collectable manure, nutrient losses in manure storage or treatment, nutrient availability to plants, crop uptake as a function of realistic yield goals, and the potential for leaching and runoff following application. In other words, a NMP manages the amount, form, placement and timing of applications of plant nutrients (manure and commercial fertilizer). The goal of nutrient management is to maximize the economic advantage of the nutrients and minimize their impact on the environment.

Before starting a NMP, there are several factors to consider and tasks to complete before the NMP can be finalized. The two most critical tasks to be accomplished are: (1) an up-to-date soil analysis of the fields where the manure is to be applied and (2) an analysis of the manure for nutrient composition. These and other considerations are as follows:

**First**, perform a soil test to determine the soil fertility of the fields on which animal waste will be spread. Be sure the soil samples are accurate and representative of the soil in each field because the analysis determines the nutrient supplemental needs of the crop.

**Second**, get a nutrient analysis of the manure you will spread. It is very easy and convenient to guess at the nutrient content of manure, or use any of the animal waste nutrient values reported by research. These numbers can serve as guides to help you estimate the nutrient content of the animal waste produced on your farm, but should never be used in a site specific NMP. The only acceptable manure nutrient content numbers for a NMP are those derived from a laboratory analysis from your manure source. Notice in Table 1 the contrast between the low and high manure nutrient values and the average for each of the different types of animal waste. Using average values such as these to determine your application rate results in either limited crop production due to a lack of nutrients, or potential for pollution because of excess nutrients applied over and above the demands of the crop.

Another reason not to use average manure nutrient content values is that many factors, such as animal size and type, manure storage and handling, and type of ration fed, affect the nutrient content of manure. Even from farm to farm and area to area there are differences. Therefore, your animal waste is unique and the method(s) used to dispose of your manure will be specific to your farm.

Animal waste and soil analysis costs and collecting procedures can be obtained from your county Extension agent. Take your samples to the county Extension office for processing and shipping. Be sure to allow a minimum of three weeks for mailing and completion of the NMP before you spread.

**Third**, all manure should be spread on a growing crop. Plan far enough ahead to have a crop ready to

utilize manure nutrients. Depending on where you are in the state and the amount of manure produced on your farm, this may mean using a double or triple cropping system. For example, an effective triple cropping system for south Georgia would be Tifton 44 bermudagrass during the summer, overseeded with corn for silage in the fall and rye for grazing in the winter and spring. In north Georgia, a double cropping system of hybrid bermudagrass overseeded with a small grain is effective in utilizing more manure nutrients.

Application of manure to bare ground or dormant forages wastes nutrients and money, has the potential to cause surface water pollution and defeats the purpose of nutrient management.

**Fourth**, determine a realistic expected crop yield.

**Fifth**, determine the soil type on your farm.

And **sixth**, determine the amount of residual nitrogen from legumes, and previous manure and fertilizer applications. This information can be obtained from your county Extension agent.

With this information, you are ready to complete your NMP. A NMP should be completed for each field on which animal waste will be spread and when completed, it will indicate how many tons per acre, inches per acre, or thousand gallons of manure to apply to meet the nutrient demands of the crop. The USDA Natural Resources Conservation Service (NRCS) recommends applying no more than 2 inches of lagoon effluent per acre during any 24-hour period of time.

Crops grown, field descriptions, rate of application of manure (and commercial fertilizer), and other pertinent information can be recorded in the **Soils, Crop, Fertilizer and Chemical Record** (Special Bulletin No. 4) available free at the county Extension office. With good records, adjustments in your manure management program can be easily made.

The NMP is balanced for nitrogen, meaning that there is no left-over nitrogen available for crop use; however, there may or may not be excess phosphorus or potassium. The reason for balancing nitrogen is that it has the potential to move with water through the soil profile and contaminate ground water. Phosphorus and potassium, on the other hand, are held by soil particles and will move only if the soil moves or erodes.

The efficiency and effectiveness of your Nutrient Management Plan depends on keeping it up-to-date. **Your plan is not valid and needs to be updated before any animal waste is spread if:**

- The most recent manure analysis varies significantly from the analysis used to formulate this plan. (Manure should be tested each time the storage is emptied. If four tests produce similar results, sampling can be reduced to once a year.)

- There is an increase or decrease in animal numbers, or additional nutrients from another source are to be applied.

Table 1. PLANT AVAILABLE N, $P_2O_5$ AND $K_2O$ VALUES OF ANIMAL WASTE SAMPLES TAKEN THROUGH SEPTEMBER 30, 1994

| | | Nitrogen | | $P_2O_5$ | | $K_2O$ | |
|---|---|---|---|---|---|---|---|
| Manure Type | No. Samples | Mean | Range | Mean | Range | Mean | Range |
| Dairy Lagoon[1] | 103 | 45.7 | 2.4-188.0 | 25.7 | 0.13-172.0 | 54.9 | 2.8-314.0 |
| Dairy Solids[2] | 14 | 4.0 | 2.0-5.5 | 3.4 | 1.1-6.6 | 2.4 | 0.84-7.0 |
| Hog Lagoon[1] | 1 | 245.0 | | 48.0 | | 266.0 | |
| Layer Lagoon[1] | 6 | 100.6 | 44.0-144.0 | 48.8 | 21.0-125.0 | 210.0 | 127.0-360.0 |
| Layer Solids[2,3] | 6 | 23.7 | 8.9-78.8 | 41.1 | 21.1-95.0 | 20.0 | 15.0-31.0 |
| Layer Solids[2,4] | 1 | 3.3 | | 20.8 | | 1.5 | |
| Broiler Litter[2] | 3 | 16.3 | 8.1-27.5 | 45.3 | 29.5-68.0 | 18.3 | 3.7-30.0 |
| Poultry Mortality Compost[2] | 6 | 25.1 | 24.0-29.0 | 41.5 | 26.0-72.0 | 23.1 | 14.0-29.0 |

[1]Pounds per acre-inch (an acre-inch = 27,154 gallons
[2]Pounds per ton
[3]Dry layer solids
[4]Wet layer solids from pit

- You change your mind about a crop you intend to plant in a field, or make other changes in the crop rotation.

- If there is any change in the manner manure is stored or applied.

- If one growing season has passed since the last soil test, or you are rotating to another crop.

- If you change field sizes or make other changes in acreage.

- Your NMP is more than 12 months old.

- Your NMP is intended to save you money and minimize the loss of nutrients on your farm to the surface and ground waters of the state. One north central Georgia dairy farmer conservatively estimates his manure is worth $10,000 in saved fertilizer costs. Another placed the value of his manure at over $25,000.

National legislation may make NMPs mandatory before any animal waste is spread. Some states already require this. Pennsylvania passed the Nutrient Management Act which links livestock density to mandatory nutrient management. Nutrient Management Plans are mandatory in Maryland. Specific plans must detail the nutrient types used (animal wastes, commercial fertilizers or sewage sludge), the amount applied and generated, and measures employed to prevent over-fertilization and/or runoff. North Carolina adopted a water quality rule that states all animal management operations - regardless of size - must not discharge into the surface waters of the state.

In summary, manure nutrient management is complex. First the nutrient balance status of the farm must be assessed. From this, a detailed NMP is developed for the farm. Finally, good records must be kept to serve as the basis for subsequent evaluations of the nutrient management process. By implementing such a process, the goals of maximizing the economic returns to the farm and minimizing environmental impact can be accomplished.

Don't forget to use the educational, technical and financial resources available to you through The University of Georgia Cooperative Extension Service, the USDA Consolidated Farm Service Agency, the USDA Natural Resources Conservation Service and the Georgia Soil and Water Conservation Commission.

The concept of nutrient management is nothing new. It is based on fundamentals such as soil and manure analysis, realistic crop yield goals, sound management and stewardship practices and good farm records. Now is the time to become familiar with NMP and begin to use them as a part of your farm's comprehensive animal waste management program.

## EXAMPLE OF COMPLETING A NUTRIENT MANAGEMENT PLAN

The completed NMP used in this example is found on page 5. Table 1 lists the first year nutrient availability coefficients for various livestock manures. Table 2 lists estimated residual values of legumes. These two tables are found on the back of Nutrient Budget Worksheets available from your county Extension Agent. Table 3 is a sample lagoon nutrient analysis. Table 4 contains useful conversion formulas to convert ppm, percent and pounds from the lab analysis of the manure into application rates (step 21 of the Nutrient Budget Worksheet).

### PROBLEM 1

A Morgan County dairy producer wants to apply anaerobic dairy lagoon liquid over a 60 acre common bermudagrass pasture. How many acre-inches of lagoon liquid should be applied to meet the nutrient requirements of the pasture?

### GIVEN INFORMATION

From the soil analysis results of the pasture, it is found that the phosphorus (P) level is low, potassium (K) is medium and the pH is 5.8. The soil analysis recommends 80 pounds of N, 80 pounds of P2O5 and 60 pounds of K2O be applied per acre. The lagoon nutrient analysis indicates 270 ppm N, 299 ppm P, and 315 ppm K in the sample.

In this example it is assumed no prior manure or commercial fertilizer applications were made over the past three years. **It is very important that all nutrients, including legumes, manures or commercial fertilizer, are accounted for. If not, the potential for ground and surface water contamination from P and K increases.** It is also assumed the pasture will not be intensively grazed.

The following information was obtained from the NRCS Farm #2, tract 15, field 4, soil series is Cecil, and leaching potential is nominal. Remember, the NRCS recommends applying no more than 2 acre-inches (or 54,312 gallons) in any 24 hour period to prevent possible soil erosion or runoff.

The following is an explanation of how the numbers are obtained for Step 21 on Page 5. The analysis found 270 ppm N, 299 ppm of P and 315 ppp K. The factors to convert pars per million (ppm) to pounds per acre inch are found in Table 4 as follows:

Nitrogen: 270 x 0.2266 = 61.2
P2O: 299 x 0.2266 x 2.29 = 155.2
Potassium (K2O): 315 x 0.2266 x 1.2 = 85.7

**SOLUTION**

The dairy producer would apply 2.6 inches of lagoon water per acre to meet the nutrient demands of the bermudagrass (see step 24(c)). At this rate there is not excess nitrogen but there is excess P2O5 and K2O (see step 26).

**PROBLEM 2**

A Putnam County dairy producer wants to reduce the volume of the animal waste lagoon by one-third. How many acres are needed to apply animal waste on?

**GIVEN INFORMATION**

The lagoon dimensions are 100 x 200 x 12. A NMP has been completed which recommends applying 0.78 inches of lagoon water per acre. The crop is wheat for silage. The dairy producer is flushing with recycled water.

**SOLUTION**

1. Determine the cubic feet of the lagoon:

100 x 200 x 12 = 240,000 cubic feet

2. Convert cubic feet into acre-inches:

240,000 cu. ft. x 7.48 gal/cu. ft.[1] = 66.1 acre-in. of lagoon water
27,154 gal/acre-inch[2]

3. Convert acre-inches to acres:

66.1 acre-inches x 1/3 reduction = 28 acres would be needed to drop the volume of the lagoon by one-third
0.78 acre-inches application from NMP

[1]Conversion factor. There are 7.48 gallons per cubic foot of water.
[2]Conversion factor. There are 27,154 gallons per acre-inch of water.

# NUTRIENT BUDGET WORKSHEET

## (SAMPLE WORKSHEET)

1. Producer _____ 2. County MORGAN 3. Date _____
4. Farm # _____ 5. Tract # _____ 6. Field # _____ 7. Acres _____
8. Soil Series _____ 9. Leaching Potential _____
10. Tillage Practices _____
11. Planned Crop COMMON BERMUDA PASTURE 12. Yield Expectations _____
13. Soil Test Rating ( a ) P 11(L) ; ( b ) K 119(M) ; ( c ) pH 5.8
14. Nutrients recommended (lbs/ac): ( a ) N 80 ; ( b ) $P_2O_5$ 80 ; ( c ) $K_2O$ 60
15. Lbs/ac starter fertilizer used: ( a ) N -0- ; ( b ) $P_2O_5$ -0- ; ( c ) $K_2O$ -0-
16. Residual nitrogen credit from legumes (See back) -0- lbs/ac
17. Net N needs of crop (14a minus 15a and 16) 80 lbs/ac
18. Net $P_2O_5$ needs of crop (14b minus 15b) 80 lbs/ac
19. Net $K_2O$ needs of crop (14c minus 15c) 60 lbs/ac
20. Type of manure ANAEROBIC DAIRY LAGOON LIQUID
21. Manure nutrient content:
    (a) N 61.2 (lbs/ton) (lbs/ac-in)
    (b) $P_2O_5$ 155.2 (lbs/ton) (lbs/ac-in)
    (c ) $K_2O$ 85.7 (lbs/ton) (lbs/ac-in)
22. Manure application method (See back) IRRIGATION
23. Nutrients in manure available to crop: (21 a, b & c multiplied times the availability coefficient) (See back)
    a. Available N: 61.2 X .5 = 31 (lbs/ton) (lbs/ac-in)
    b. Available $P_2O_5$: 155.2 X .7 = 109 (lbs/ton) (lbs/ac-in)
    c. Available $K_2O$: 85.7 X .7 = 60 (lbs/ton) (lbs/ac-in)
24. Manure application rate to supply the priority nutrient:
    a. Priority nutrient N
    b. Amount of priority nutrient needed (17, 18, or 19) 80 lbs/ac
    c. Rate of manure needed (24b divided by 23a, 23b, or 23c) 2.6 (tons/ac) (in/ac)
25. Pounds per acre of available nutrients supplies at the manure application rate needed to supply the priority nutrient:
    a. N: 31 (23a) X 2.6 (24c) (tons/ac or in/ac) = 80 lb/ac
    b. $P_2O_5$: 109 (23b) X 2.6 (24c) (tons/ac or in/ac) = 283 lb/ac
    c. $K_2O$: 60 (23c) X 2.6 (24c) (tons/ac or in/ac) = 156 lb/ac
26. Nutrient balance: (Net nutrient need (-) or excess (+) after the application of manure at the calculated rate)
    a. N balance: 80 (25a) X 80 (17) = -0- lb/ac
    b. $P_2O_5$: 283 (25b) X 80 (18) = +203 lb/ac
    c. $K_2O$: 156 (25c) X 60 (19) = +96 lb/ac
27. Completed by: _____ Title _____

Agency: _____

## TABLE 2. LIVESTOCK MANURE NUTRIENT FIRST-YEAR AVAILABILITY COEFFICIENTS

| Type Manure | Application Method | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Injection[1] | | Soil Incorporation[2] | | Broadcast[3] | | Irrigation[4] | |
| | Plant Nutrient | | | | | | | |
| | N | Other | N | Other | N | Other | N | Other |
| Paved surface scraped manure | | | | | | | | |
| Dairy | - | - | .6 | .8 | .4 | .7 | - | - |
| Beef | - | - | .6 | .8 | .4 | .7 | - | - |
| Swine | - | - | .6 | .8 | .4 | .7 | - | - |
| Sheep | - | - | .6 | .8 | .4 | .7 | - | - |
| Goat | - | - | .6 | .8 | .4 | .7 | - | - |
| Rabbit | - | - | .5 | .8 | .5 | .7 | - | - |
| Layer | - | - | .6 | .8 | .4 | .7 | - | - |
| Unpaved surface manure application | | | | | | | | |
| Beef, feedlot | - | - | .6 | .8 | .6 | .7 | - | - |
| Horse, stable | - | - | .5 | .8 | .5 | .7 | - | - |
| Layer, deep pit | - | - | .6 | .8 | .4 | .7 | - | - |
| Poultry house litter | | | | | | | | |
| Broiler | - | - | .6 | .8 | .5 | .7 | - | - |
| Broiler breeder | - | - | .6 | .8 | .4 | .7 | - | - |
| Turkey | - | - | .6 | .8 | .4 | .7 | - | - |
| Duck | - | - | .6 | .8 | .4 | .7 | - | - |
| Poultry stockpiled litter | | | | | | | | |
| Broiler | - | - | .6 | .8 | .4 | .7 | - | - |
| Turkey | - | - | .8 | .8 | .5 | .7 | - | - |
| Duck | - | - | .8 | .8 | .5 | .7 | - | - |
| Liquid manure slurry | | | | | | | | |
| Dairy | .7 | .8 | .8 | .8 | .4 | .7 | .4 | .7 |
| Beef | .7 | .8 | .7 | .8 | .4 | .7 | .4 | .7 |
| Veal | .9 | .8 | .7 | .8 | .4 | .7 | .3 | 7 |
| Swine | .8 | .8 | .7 | .8 | .4 | .7 | .3 | ./ |
| Layer | .8 | .8 | .7 | .8 | .4 | .7 | .3 | .7 |
| Anaerobic lagoon liquid | | | | | | | | |
| Dairy | .8 | .8 | .7 | .8 | .6 | .7 | .5 | .7 |
| Beef | .7 | .8 | .7 | .8 | .5 | .7 | .6 | .7 |
| Veal | .8 | .8 | .7 | .8 | .6 | .7 | .6 | .7 |
| Swine | .9 | .8 | .8 | .8 | .5 | .7 | .5 | .7 |
| Layer | .9 | .8 | .8 | .8 | .5 | .7 | .5 | .7 |
| Anaerobic lagoon sludge | | | | | | | | |
| Dairy | .7 | .8 | .9 | .8 | .4 | .7 | .4 | |
| Beef | .7 | .8 | .6 | .8 | .4 | .7 | .4 | |
| Swine | .6 | .8 | .6 | .8 | .5 | .7 | .4 | .7 |
| Layer | .6 | .8 | .6 | .8 | .5 | .7 | .4 | .7 |

[1]Manure injected directly into soil and covered immediately.

[2]Surface spread manure plowed or disked into soil within 2 days.

[3]Surface spread manure uncovered for 1 month or longer.

[4]Sprinkler irrigated liquid uncovered for 1 month or longer.

*Adapted from NC State University, Soil Facts.

TABLE 3. ESTIMATED RESIDUAL NITROGEN PROVIDED BY A GOOD STAND OF LEGUMES GROWN IN ROTATION

| Legume | Residual Nitrogen Available (lb/ac) |
|---|---|
| Alfalfa 1/ | 80-100 |
| Hairy Vetch 1/ | 80-100 |
| Crimson Clover 1/ | 60-75 |
| Austrian Winter Pea 1/ | 50-60 |
| Soybeans 2/ | 15-30 |
| Peanuts 2/ | 20-40 |

1/ Killed before planting current spring crop
2/ Legume is planted in previous year/season. More nitrogen will be available if the fall-planted crop immediately follows the legume. On sandy soils and in years with normally high precipitation, less nitrogen will be available to spring-planted crops.

Source: The University of Georgia Cooperative Extension Service.

TABLE 4. NUTRIENT ANALYSIS OF AN ANAEROBIC DAIRY LAGOON*

| Nutrient | Concentration (ppm) | Nutrient | Concentration (ppm) |
|---|---|---|---|
| Ammonia (NH4-N) | 210 | A1 | 15 |
| Nitrate (NO3) | 214 | B | <1 |
| Nitrogen (TKN) | 270 | Cu | <1 |
| P | 47 | Zn | <1 |
| K | 315 | Na | 94 |
| Ca | 136 | Pb | <1 |
| Mg | 93 | Cd | <1 |
| Mn | <1 | Ni | <1 |
| Fe | 27 | Mo | <1 |

*From an actual analysis of a dairy lagoon in Putnam County.

TABLE 5. CONVERSION FORMULAS FOR USE IN COMPLETING STEP 21 OF THE NUTRIENT BUDGET WORKSHEET

| (A) **Pounds/Acre-Inch** | (B) **Pounds/1000 Gallons** | (C) **Pounds/Ton** |
|---|---|---|
| 1. "Total N"[1] ppm x 0.2266[2] = ____ lbs/acre-in. N[5] | 4. "Total N"[1] ppm x 0.008352[2] = ____ lbs/1000 gal N | 7. "Total N"[1] ppm x 0.002 = ____ lbs/ton |
| 2. "Total P"[1] ppm x 0.2266 x 2.29[3] = ____ lbs/acre-in. $P_2O_5$ | 5. "Total P"[1] ppm x 0.008352 x 2.29[3] = ____ lbs/1000 gal $P_2O_5$ | 8. "Total P"[1] ppm x 0.002 x 2.29 = ____ lbs/ton |
| 3. "Total K"[1] ppm x 0.2266 x 1.2[4] = ____ lbs/acre-in. $K_2O$ | 5. "Total K"[1] ppm x 0.008352 x 1.2[4] = ____ lbs/1000 gal $K_2O$ | 9. "Total K"[1] ppm x 0.002 x 1.2 = ____ lbs/ton |

[1] "Total N" is the N or TKN number given in the manure analysis from the lab. Same with the P and K.
[2] Conversion Factors
[3] The molecular weight of $P_2O_5$
[4] The molecular weight of $K_2O$
[5] Lbs/acre-inch can be converted to lbs/1000 gal by dividing by 27.
[6] Lab analysis can also come back in percent. Instead of multiplying by 0.002, multiply by 20.

References


Bandel, V.A. 1991. Soil Phosphorus: Managing it Efficiently. *Fact Sheet 513*. Cooperative Extension Service. University of Maryland System.

Blake, John, J. Donald and W. Magette. 1992. National Livestock, Poultry and Aquaculture Waste Management-*Proceedings of the National Workshop. ASAE.* p. 11.

Ellington, D.L., P.E. and Scott D. Walllace. An Overview of Best Management Practices for Florida's Dairies. P. 224-230. *University of Georgia Cooperative Extension Service Waste Material Notebook, Vol. 3.*

Fulhage, Charles D. 1990. *Reduce Environmental Problems with Proper Land Application of Animal Waste. Bulletin WQ201.* University of Missouri-Columbia Extension.

Gould, M.C. 1992. *Water Quality Courier Newsletter.* Vol. I No. 2 p. 1.

Johnson, J.C., G.L. Newton, and J.L. Butler. 1991. Recycling liquid dairy waste to sustain annual triple crop production of forages. *Proceedings of Florida Dairy Production Conference,* Dairy Science Dept., University of Florida Cooperative Extension.

Maryland Department of Agriculture. 1993 news release.

Segars, William I. 1992. Nutrient Management Plans. Preface to UGA CES *Waste Management Handbook.* Vol. 3.

Wise, Hal, et al. 1993a. North Carolina adopts nondischarge rule for animal waste management systems. *Nonpoint Source News-Notes.* 30:21-22.

Wise, Hal, et al. 1993b. Clean Water Act may target agriculture, reports upper midwest conference. *Nonpoint Source News-Notes.* 30:23.

United States Department of Agriculture. 1990. *Soil Conservation Service Field Office Technical Guide.* Nutrient Management (Acre). All Resource Areas, Code 680.





**By M. Charles Gould, Area Dairy Agent - Michigan State University; Larry Guthrie Extension Coordinator - Dairy Science; Bill Segars, Extension Water Quality Coordinator**





Circular 819-16 April 1996

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, The University of Georgia College of Agricultural and Environmental Sciences and the U.S. Department of Agriculture cooperating.
Gale A. Buchanan, Dean and Director

UPD 960774
96-44