Chapter 4
Nutrient Budgeting with Nitrogen and Phosphorus

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Introduction

Animal manure has long been recognized as a source of nutrients for crops. The effluent and solid waste generated from livestock operations can be used in agricultural fields to supply nutrients to crops and improve soil chemical and physical properties. Knowing the mineral contents of the manure enables the farmer to decide on the amount of manure to apply or to move off-site. By actively managing the nutrient balance on-farm and marketing or exporting manure when necessary, farms with confined animal operations can prevent future buildup of soil nutrients that may potentially move into streams and lakes.

Inventory of Nutrient Sources

The first step in managing nutrients generated on-site is to conduct an inventory of all nutrient sources. This requires sampling and analysis of the manure sources as well as the soils to which the manure will be applied. Manure analysis is also very important in marketing manures because it provides needed information on the manure's fertilizer value.

Manures can be quite variable in nutrient content due to differences in animal species, feed composition, bedding material, storage and handling as well as other factors. Moreover, manures should be sampled and tested near the time of application because the nutrient content can change considerably over time, particularly if stockpiled and unprotected from the weather. Therefore, growers should not base application rates on laboratory test results from previous years because nutrient concentrations can change significantly, particularly when the manure has been exposed to the environment.

Manure Sampling

The following are some manure-type specific guidelines for collecting representative samples:

<ins>Solid Manure.</ins> It is **not recommended** that manure be sampled in the barn or poultry house because it is very difficult to obtain a representative sample. Instead, sample manure or poultry litter after it has been removed from the poultry house or barn and placed in a pile or spreader truck during cleanout. Solid manure samples should represent the average moisture content of the manure.

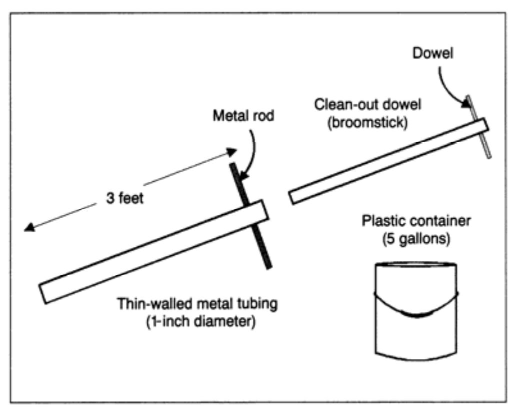


Figure 1. Solid manure sampling device.

<ins>Piled manure, litter, or from a spreader truck.</ins> This procedure is for manure or litter temporarily collected into piles during clean out. To obtain a representative sample, collect at

least 10 small shovels of manure or litter from the piles or from the spreaders, and combine the collected portions in a clean 5-gallon plastic bucket or wheelbarrow, and mix thoroughly. Place a one-quart portion from this mixture in a zippered plastic bag, seal it securely, and ship it to the laboratory as soon as possible. For wet manure, refrigerate the sample if it will not be shipped within one day of sampling. Samples stored for more than two days should be refrigerated. Fig. 1 shows a device for sampling solid manure.

<u>Stockpiled manure or litter.</u> A stockpile consists of manure or litter stored in a pile for later use. Store stockpiled manure or litter under cover on an impervious surface. The weathered exterior of uncovered waste may not accurately represent the majority of the material, since rainfall generally moves water-soluble nutrients down into the pile. Collect samples from stockpiles using the same method for piles described above except collect at a depth of 18 inches from the surface of the pile, and as close as possible to its application date.

<u>Liquid slurry</u>. Manure slurries that are applied from a pit or storage pond should be mixed prior to sampling. Manure should be collected from approximately eight areas around the pit or pond and mixed thoroughly in a clean, plastic container. An 8- to 10-foot section of 0.5- to 0.75-inch plastic pipe can also be used: extend the pipe into the pit with ball plug open, pull up the ball plug (or press your thumb over the end to form an air lock), and remove the pipe from the manure, releasing the air lock to deposit the manure into the plastic container.

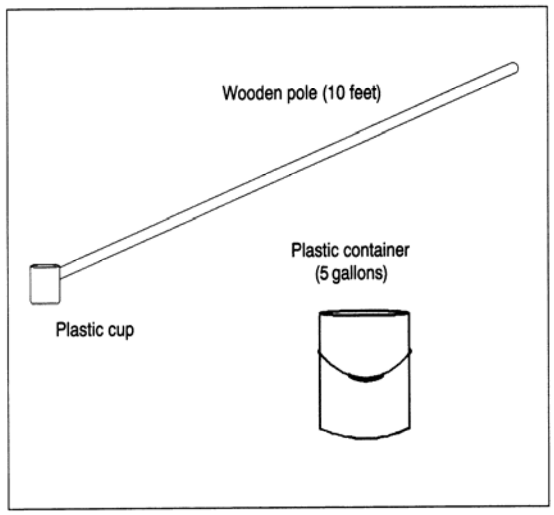


Figure 2. Liquid manure sampling device.

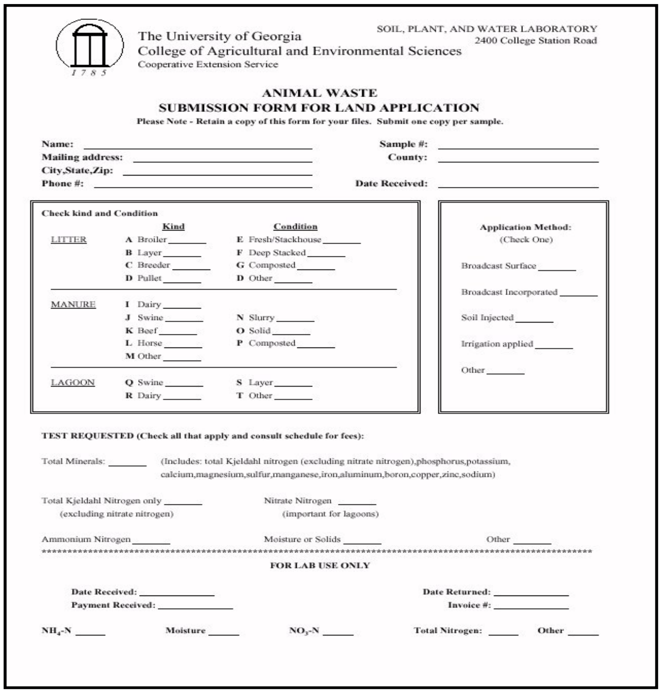
<u>Lagoon Effluent</u>**.** Collect one-pint effluent from 1-ft. depth at least 6 feet from the edge of the lagoon. This needs to be done from at least eight sites around the lagoon. Mix the materials in a clean, large plastic container and obtain a one-pint sub-sample for analysis. Galvanized containers should never be used for collection, mixing, or storage due to the risk of contamination from metals like zinc in the container.

Manure Analysis

The basic manure test package at the UGA Agricultural and Environmental Services Laboratories includes nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), sulfur (S), aluminum (Al), iron (Fe), boron (B), copper (Cu), manganese (Mn), and zinc (Zn). Other private labs may provide additional analysis.

The UGA manure sample submission form is shown in Fig. 3. This form applies to manures that are intended for land application. Poultry producers should use the form illustrated in Fig. 4, Poultry Litter/Manure Submission Form for Nutrient Management Plans.

The County Extension Office has sample submission forms and information on tests that are most often needed and can assist with shipping samples to the University of Georgia Agricultural and Environmental Services Laboratories. The amount of the total nutrients in manure that will be available to plants varies depending on the type of manure and whether it will be applied to the surface of the soil, incorporated or injected. County Extension Agents and other qualified professionals can assist with the calculation of manure nutrient availability based on when and how you will make application.



The University of Georgia
College of Agricultural and Environmental Sciences
Cooperative Extension Service
1785

SOIL, PLANT, AND WATER LABORATORY
2400 College Station Road

ANIMAL WASTE
SUBMISSION FORM FOR LAND APPLICATION
Please Note - Retain a copy of this form for your files. Submit one copy per sample.

Name: ______ **Sample #:** ______
Mailing address: ______ **County:** ______
City,State,Zip: ______
Phone #: ______ **Date Received:** ______

Check kind and Condition

	Kind	Condition
LITTER	A Broiler ____	E Fresh/Stackhouse ____
	B Layer ____	F Deep Stacked ____
	C Breeder ____	G Composted ____
	D Pullet ____	D Other ____
MANURE	I Dairy ____	
	J Swine ____	N Slurry ____
	K Beef ____	O Solid ____
	L Horse ____	P Composted ____
	M Other ____	
LAGOON	Q Swine ____	S Layer ____
	R Dairy ____	T Other ____

Application Method:
(Check One)
Broadcast Surface ____
Broadcast Incorporated ____
Soil Injected ____
Irrigation applied ____
Other ____

TEST REQUESTED (Check all that apply and consult schedule for fees):

Total Minerals: ____ (Includes: total Kjeldahl nitrogen (excluding nitrate nitrogen),phosphorus,potassium, calcium,magnesium,sulfur,manganese,iron,aluminum,boron,copper,zinc,sodium)

Total Kjeldahl Nitrogen only ____ (excluding nitrate nitrogen) Nitrate Nitrogen ____ (important for lagoons)

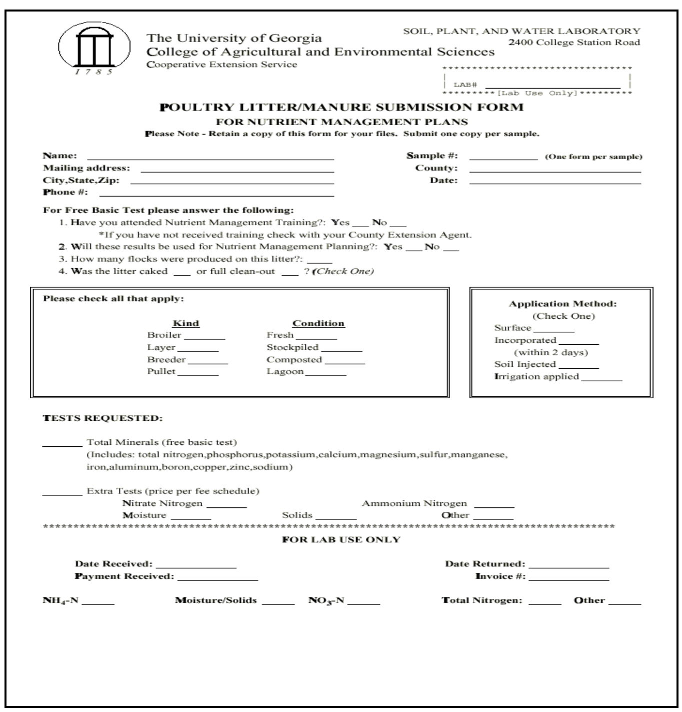
Ammonium Nitrogen ____ Moisture or Solids ____ Other ____

FOR LAB USE ONLY

Date Received: ______ **Date Returned:** ______
Payment Received: ______ **Invoice #:** ______

NH_4-N ____ **Moisture** ____ **NO_3-N** ____ **Total Nitrogen:** ____ **Other** ____

Figure 3. Sample submission form for manure intended for land application.



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SOIL, PLANT, AND WATER LABORATORY
2400 College Station Road

LAB# ______ [Lab Use Only]

POULTRY LITTER/MANURE SUBMISSION FORM
FOR NUTRIENT MANAGEMENT PLANS
Please Note - Retain a copy of this form for your files. Submit one copy per sample.

Name: ______ **Sample #:** ______ **(One form per sample)**
Mailing address: ______ **County:** ______
City,State,Zip: ______ **Date:** ______
Phone #: ______

For Free Basic Test please answer the following:

1. Have you attended Nutrient Management Training?: Yes ___ No ___
   *If you have not received training check with your County Extension Agent.
2. Will these results be used for Nutrient Management Planning?: Yes ___ No ___
3. How many flocks were produced on this litter?: ____
4. Was the litter caked ___ or full clean-out ___ ? *(Check One)*

Please check all that apply:

Kind	Condition
Broiler ____	Fresh ____
Layer ____	Stockpiled ____
Breeder ____	Composted ____
Pullet ____	Lagoon ____

Application Method:
(Check One)
Surface ____
Incorporated ____ (within 2 days)
Soil Injected ____
Irrigation applied ____

TESTS REQUESTED:

____ Total Minerals (free basic test)
(Includes: total nitrogen,phosphorus,potassium,calcium,magnesium,sulfur,manganese, iron,aluminum,boron,copper,zinc,sodium)

____ Extra Tests (price per fee schedule)
Nitrate Nitrogen ____ Ammonium Nitrogen ____
Moisture ____ Solids ____ Other ____

FOR LAB USE ONLY

Date Received: ______ **Date Returned:** ______
Payment Received: ______ **Invoice #:** ______

NH_4-N ____ **Moisture/Solids** ____ **NO_3-N** ____ **Total Nitrogen:** ____ **Other** ____

Figure 4. UGA sample submission form for poultry litter/manure for NMPs.

Soil Testing
Soil testing tells you the fertility status of the soil and how much, if any, additional nutrients are needed for the particular crop. It is through soil testing that one can detect nutrient deficiencies or over applications of nutrients, especially phosphorus (P). Soil testing can track the build-up of P and assist with management decisions to utilize high phosphorus animal waste on soils with lower soil test P. Soil testing can also monitor any build-up of zinc, which could possibly increase to toxic levels (for sensitive crops like peanuts) from long-term and heavy applications of poultry litter.

Soil Sampling and Analysis
When: Soils should be tested annually. Fall is a good time to take samples, but samples can be taken at any time of the year. To make good comparisons from year to year it is important to sample at approximately the same time each year.

Where: Areas within a field that have obviously different soil type, drainage, crop growth, or slope characteristics should be sampled separately. Collect in zigzag pattern within a sub-area (Fig. 5). Avoid areas where fertilizer or lime was stockpiled as well as areas around old house or barn locations.

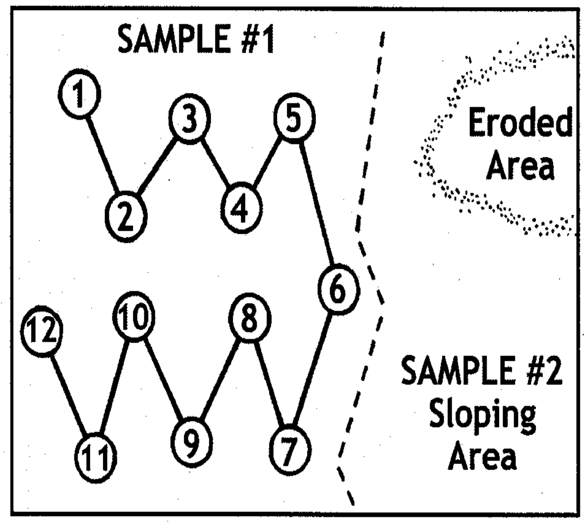

Figure 5. Zigzag pattern of soil sampling .

How: From plowed fields take the sample to 6 inches or to plow depth. No-till fields or pastures should be sampled to 4-inches depth (Fig. 6). From each area to be sampled take 10 to 20 cores at random, place in clean, plastic container and thoroughly mix. Remove about a pint of the composite soil for submission to the laboratory. Be sure to clearly mark each sample so that you know which field and area of field it represents.

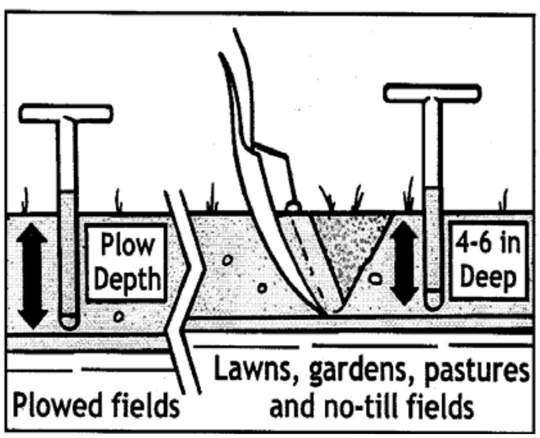

Figure 6. Soil sampling depths for plowed fields (6 inches or plow depth) and no-till or pastures (4 inches).

Nutrient Budgeting
Understanding the sources of nutrients is critical in identifying management strategy for reducing nutrient losses and achieving an environmentally sustainable operation. It is

necessary to account for nutrients coming from all sources such as livestock manure or credits from legumes, or from off the farm, such as purchased fertilizer or irrigation water.

Developing nutrient budgets as a management tool for farmers has the potential to effectively reduce excess levels of nutrients on the farm and decrease nutrient inputs. This allows the farmer to compare all the sources of nutrients and nutrient needs of the crops. Nutrient budgeting can serve a number of different purposes. The most common purpose will be to determine the proper nutrient application rates for a given field using real numbers for crop needs and nutrients in manure. Nutrient budgeting can also be used as a planning tool at the farm level to determine if adequate land is available for using all of the farm's manure in the cropping system planned. Finally, nutrient budgeting can be used as an educational tool to calculate application rates based on various "simulated" scenarios, for example, how much manure one can apply given a particular soil test phosphorous level.

There are three steps required in developing a nutrient budget:

1) Determine crop nutrient requirements. This is accomplished by knowing the nutrient requirement of the crop and accounting for the residual nutrients in the field that will receive the manure. The field's fertility is determined through soil testing. The fertilizer recommendation given in the soil test report is based on a calibration of the soil test results and the nutrient requirement of the crop to be grown. These calibrations have been developed previously from field research in Georgia's soils and climate.

2) Determine nutrients supplied by manure. The animal manure is analyzed to determine the nutrient content of the manure. As with soil sampling, taking a representative sample is important to get an accurate estimate of the nutrient content of the manure (please refer to the guidelines above in collecting samples). Using "book values" to estimate nutrient content of manure should be avoided whenever possible because of high variability between manures as discussed earlier in this chapter. Manure samples may be submitted to a reputable laboratory for analysis.

3) Balancing crop nutrient needs with nutrients supplied by manure. The third and final step in calculating a nutrient budget for animal manures is to simply match the nutrient needs of the crop to be grown in step 1 (based on a soil test) with the nutrient content of the manure determined in step 2. For example, if 60 pounds of nitrogen per acre is recommended for a crop, and the manure analysis indicates it contains 30 lb available nitrogen per ton, then two tons of manure per acre would be recommended.

Nitrogen-based vs. Phosphorus -based manure application

Nitrogen (N) and phosphorus (P) are the major plant nutrients found in manures that can contaminate the environment if too much is applied. Therefore, application rates for manure, litter, or lagoon effluent must not exceed the field's capacity to minimize nitrogen and phosphorus transport from the field to surface waters. It should also be noted that manures have a poor N:P ratio relative to plant needs; this is further explained below.

When applying manures to cropland, there are two strategies that can be followed:

1) N-based approach where manure is applied at rates that meet the crop's need for nitrogen
2) P-based approach where manure is applied to satisfy the crop's need for phosphorus

The N-based approach is the most common strategy for utilizing manure to meet the N requirement of crops. Manure application rates are calculated to provide N to crops because most crops require more N than P. In many cases, N-based nutrient management plans are employed to supply just the right amount of N for optimum crop production, while avoiding excessive N applications that may cause nitrate leaching into groundwater. This strategy, however, usually results in the addition of P in excess of the nutrient needs of the crops. This leads to increases in available P in the soil

The P-strategy, on the other hand, results in less P application, just enough to meet the needs of the crops. Additional N is needed to meet the needs of the crop, which is usually provided using commercial fertilizers. Legumes are an exception because they can manufacture their own nitrogen through N-fixation from the atmosphere. Thus, recent environmental concerns have focused more on excessive phosphorus applications from manures and its adverse effect on surface water quality. Because of concern for P in runoff to sensitive water resources, many nutrient management plans now are based on P. The P-based plan, however, is not currently required but it will be considered in the future. Overall, P-based application for manures should be used where there is high risk for water contamination by excess P through runoff.

A tool to identify fields, which have the potential for P pollution is the P index. The P index will help farmers identify areas and adjust manure application rates and other management practices to minimize P losses from agricultural areas and alleviate P pollution of water bodies.

Off-site use of manures

Aside from using the manures for crop production on-farm, farmers can sell their manures to other farmers to generate additional income. This would be a necessary option in situations where the supply of manures exceeds the needs of the crops on that farm. Sale of manure to other farmers is more likely when manure application is based on a P-strategy where a larger area is required to spread a given volume of manure compared to when the application is N-based. Moving the manure to a site where it is needed will minimize the risk of water pollution. Nutrient testing of manure for export and sale is required by state law. This analysis should be provided to the person taking the litter just like you would expect to get a fertilizer tag or analysis if purchasing chemical fertilizer. By actively managing the nutrient balance on-farm and marketing or exporting manure when necessary, confined animal operations can achieve a relative level of nutrient sustainability that should prevent future buildup of soil nutrients like phosphorus.