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Laboratory Analysis of Manure

Charles D. Fulhage

Department of Biological and Agricultural Engineering

To make efficient use of fertilizer nutrients in manure, nutrient levels must be determined by laboratory analysis. This publication outlines methods for obtaining and interpreting laboratory analyses of manure.

What analyses should be run on the manure sample?

Generally, the nutrients nitrogen, phosphorus and potassium (N, P and K) are of most interest in using manure as fertilizer. It is useful also to know the level of ammonia nitrogen, which makes up part of the total nitrogen in manure.

$$\text{ammonia nitrogen} + \text{organic nitrogen} = \text{total Kjeldahl nitrogen}$$

Laboratory tests can determine ammonia and total Kjeldahl nitrogen; organic nitrogen is obtained by subtracting ammonia nitrogen from total Kjeldahl nitrogen according to the above equation. Ammonia nitrogen is the form that is readily available to plants and is also subject to volatilization loss to the atmosphere if not immediately incorporated into the soil. Knowing both ammonia and organic nitrogen allows you to estimate the amount of nitrogen immediately available to plants, and the amount that will become available in later years as the organic nitrogen is released. Nitrogen may also be present in the nitrate form. However the highly anaerobic conditions existing in most livestock manure management systems usually preclude nitrate nitrogen except in trace amounts. Hence nitrate nitrogen is not usually included in a typical manure nutrient analysis unless there is some reason to expect its presence (an aerobic lagoon, for example).

Total phosphorus is also made up of two components (orthophosphorus and organic phosphorus). However, since both are essentially immediately available to plants, it is not necessary to determine both forms, as it is with nitrogen. Potassium has no organic fraction and is immediately available to plants.

It is also helpful to know dry matter or total solids (moisture content) of manure samples. Lab data may be reported on a wet (as-is) basis or dry basis, or both. Total-



For solid manure piles, small amounts should be collected at several locations to get a composite, representative sample.

Solids levels affect handling qualities and bulk density characteristics of manure.

So, if a complete analysis is to be obtained, the laboratory should be instructed to run the following tests.

- Total Kjeldahl nitrogen
- Ammonia nitrogen
- Total phosphorus
- Potassium
- Moisture content (or dry matter)

Some laboratories may have a "routine" manure analysis that may include all or only some of the above tests. If you are not sure what the capabilities of a laboratory are, call and ask.

Micronutrients such as calcium, sodium and magnesium may be important in certain cases. These tests can usually be obtained at additional expense if the lab is so instructed.

How do I get a manure sample?

The first step in sampling manure is to obtain a container suitable for the sample. Sterility, or extreme

cleanliness, is not necessary for manure samples as it would be with drinking water, where very small contaminant levels must be measured. However, the container selected should be rinsed out and reasonably clean. If you are sampling a liquid (such as a lagoon), a final rinse with the effluent being sampled is good practice. The container selected should be suitable for mailing, as most manure samples are carried through the regular postal system. The amount of manure that should be collected depends somewhat on the tests being run. However, a routine manure analysis, as described above, usually can be accomplished with a one-pint volume of sample. Contact the lab that will be analyzing the sample if you have questions about the container and amount of sample to collect. Some laboratories will provide sample containers.

Solid manure

Solid, or "dry" (less than 50 percent moisture) manure samples can usually be collected and handled in small plastic "twist-tie" or "ziplock" type freezer bags. Obtaining a representative sample with dry or solid manure is sometimes difficult because there is no mixing or agitation to make a uniform material. Solid manure piles, or solid manure on floors in confinement buildings, can be quite variable in moisture content, bedding material, and manure content. The best procedure is to use your own judgment and take several samples in proportion to the variable conditions you observe. These samples can then be mixed to form a composite that is representative of the manure to be spread. If manure is stored in a pile, take a sample from each of 10–12 representative points in the pile, and mix for a final composite sample. See MU publication G9340, *Sampling Poultry Litter for Nutrient Testing*, for detailed sampling information.

Liquid or slurry manure

Liquid or slurry manure is usually in the range of 80 percent to 95 percent moisture and is best collected in a plastic bottle or container that can be tightly closed. Some plastic bottles used for livestock medicines and pharmaceuticals have a wide-mouth opening and can be closed tightly, making ideal sample bottles. Liquid, or slurry manure, can also be a nonuniform mixture due to sedimentation and stratification of solid and liquid layers. This material should be thoroughly agitated or mixed before a sample is taken.

Lagoons

Lagoons usually have a solids content of 2 percent or less in the liquid layer. Manure nutrients dissolved or suspended in the liquid layer are usually quite uniform in the horizontal and vertical profile as long as the sample is taken in the liquid layer (region of uniform solids content). Nutrient concentrations increase significantly at lower levels where solids begin to accumulate



Slurry manure should be well agitated before a sample is taken.

as sludge. If a lagoon is pumped my means a floating intake (effluent drawn from the top two feet), a single sample taken from this region of the liquid layer will be representative of the effluent being pumped as long as it excludes any surface debris or bottom sludge. If a recycle flush system is in place, the sample may be taken at the discharge into the flush tanks if the recycle pump is located at the approximate level of the irrigation pump intake. As with slurry manure, a lagoon sample should be collected in a plastic bottle that can be tightly closed.

If a lagoon is agitated, or the pump intake is resting on the lagoon bottom (sludge layer), it is much more difficult to obtain a sample that will accurately represent the effluent pumped. It is often difficult to agitate a lagoon uniformly because of its size and depth. Under these conditions, widely varying concentrations of manure nutrients enter the pump intake as solids "break loose," or are suspended in the region of the pump intake by agitation. In these cases, more meaningful samples may be taken during the pumping operation (samples taken through a valve at the pump, or in "catch cans" in the application area).

When should I collect the sample, and how should it be handled?

Experience and research with manure samples have shown that preservation measures such as acid stabilization or cooling/freezing do not significantly increase the accuracy of the analysis compared to sample storage at ambient temperatures for periods up to 7 days. Hence, for routine manure fertilizer nutrient analyses, the difficulty associated with procuring and handling acid and refrigerating or freezing samples is not justifiable on the basis of increased accuracy. Regulatory or permit requirements may dictate that some manure samples be preserved. Effort should be made to minimize the elapsed time between sample collection and its arrival at the laboratory. Also, samples should not be allowed to "lay around" in conditions of extreme heat, such as the trunk of a car or the cab of a truck in the summer. Gases generated by bacteria in the sample can burst the sample container under these conditions. Sample bottles should have lids tightly closed and secured with tape.

They should be mailed in a cardboard box large enough to allow packing material to be placed around the bottle. This will minimize the effects of rough handling in the postal system.

Samples should be collected so that they can be mailed to the laboratory without being in the postal system over a weekend. Call the laboratory you are using to determine the best day of the week for samples to arrive at the lab.

What do my lab results mean?

Laboratory analyses are worthless if they are not properly interpreted. Laboratories may report nutrient levels on either a wet (as-is) basis, dry basis, or both. Nutrient reports on a wet or "as-is" basis refer to the weight of nutrient per unit weight of wet or "as-is" manure (e.g., pounds of nitrogen per ton of manure for broiler litter). Nutrient reports on a dry basis refer to the weight of nutrient per unit weight of dry matter in the manure. Nutrient reports on a dry basis are usually converted to wet basis because manure is handled and spread in the wet or "as-is" form. Reporting units typically used by laboratories include percent, parts per million (ppm), milligrams per liter (mg/L), or milligrams per kilogram (mg/kg). None of these units are useful without converting to units descriptive of the way fertilizer and manure are handled. Some laboratories may perform these conversions in their report. Generally, the following conversions may need to be made.

- **Total phosphorus to P₂O₅.** This conversion allows manure nutrients to be matched to typical phosphorus levels recommended by soil tests.

$$P_2O_5 = \text{total phosphorus} \times 2.27$$

- **Potassium to K₂O.** This conversion allows manure nutrients to be matched to typical potash levels recommended by soil tests.

$$K_2O = \text{potassium} \times 1.2$$

- **Nutrient levels (wet basis) in percent, PPM or mg/L to pounds per ton.** Because solid manure is usually spread on a "tons per acre" basis, it is necessary to know the nutrient levels in pounds per ton of manure to adjust application rates.

$$\text{pounds per ton} = \text{percent} \times 20$$

$$\text{pounds per ton} = \text{PPM or mg/L} \times 0.002$$

- **Nutrient levels (wet basis) in percent, PPM or mg/L to pounds per 1,000 gallons.** Slurry manure is usually handled in tank wagons of a known volume, and is spread on the basis of "thousands of gallons per acre." So, knowing nutrient levels in pounds per thousand gallons allows proper adjustment of spreading rates.

$$\text{pounds per 1,000 gallons} = \text{percent} \times 83.4$$

$$\text{pounds per 1,000 gallons} = \text{PPM or mg/L} \times 0.00834$$

- **Nutrient levels in percent or PPM to pounds per acre-inch.** Because lagoon liquid is usually handled by irrigation equipment applying volume described in acre-inches, knowing nutrient levels in pounds per acre-inch allows proper management of irrigation equipment to obtain the desired nutrient levels.

$$\text{pounds per acre-inch} = \text{percent} \times 2265$$

$$\text{pounds per acre-inch} = \text{PPM or mg/L} \times 0.2265$$

- **Dry basis to wet basis.** Laboratories may report results on either a dry or wet basis, or both. If only dry basis is given, you must make the conversion to wet basis because manure is handled and spread wet, or "as-is."

$$\begin{aligned} \text{nutrient level, wet basis} &= \text{nutrient level, dry basis} \\ &\times (100 - \text{percent moisture}) \div 100, \text{ or} \end{aligned}$$

$$\begin{aligned} \text{nutrient level, wet basis} &= \text{nutrient level, dry basis} \\ &\times \text{percent dry matter or total solids} \div 100 \end{aligned}$$

Your laboratory may make some or all of these conversions for you in the report, or it may make the conversions for you if you request this in your sample mailing. In any event, you must be sure of the units as reported by the lab in order for them to be useful.

What other information do I need?

Obtaining a laboratory analysis is the first step in efficiently using fertilizer nutrients in manure. Soil tests based on crop and yield goals can be used with the laboratory analysis to determine proper application rates. Manure spreaders, tank wagons and irrigation equipment should be calibrated to ensure that manure is being applied at the intended rate.

Significant field losses of manure nutrients (especially ammonia nitrogen losses due to volatilization) can occur if the manure is not incorporated into the soil immediately after spreading. Nitrogen applied in the organic form may not be fully available in the year it is applied. Application rates should take into account any expected field losses and delayed release of organic nitrogen.

Manure is usually applied at a rate intended to meet the nitrogen needs of the crop being grown. This practice may result in the application of more phosphorus than the crop can take up or use. If the soil is deficient in phosphorus, this practice may be acceptable. If soil phosphorus levels are elevated (often occurs where manure has been repeatedly applied for many years), manure may need to be applied according to crop uptake or removal of phosphorus. Repeated overapplication of phosphorus can result in a buildup that may eventually depress yields or cause problems with surface water or groundwater. Regulatory agencies in some states may require that manure be applied with a phosphorus limit rather than a nitrogen limit. See MU publications G9182, *Managing Manure Phosphorus to Protect Water Quality*, and G9181, *Agricultural Phosphorus and Water Quality*, for a more detailed discussion on phosphorus considerations.

Example

A laboratory analysis of fertilizer nutrients in a poultry litter sample yields the following values ("as-is" or wet basis):

Dry matter (percent)	73.2
Total Kjeldahl nitrogen (percent)	4.3
Ammonia nitrogen (percent)	0.11
Phosphorus (percent)	1.7
Potassium (percent)	1.5

Results of the soil test report call for a nitrogen application rate of 120 pounds per acre, and P₂O₅ and K₂O application rates of 75 and 140 pounds/acre, respectively. The poultry litter will be surface-applied with no incorporation. The field to be spread has received similar poultry litter applications in prior years. How many tons per acre should be applied?

The first step is to convert the nutrient levels from percent to pounds per ton, and phosphorus and potassium to P₂O₅ and K₂O:

Total Kjeldahl nitrogen, lb/ton	= 4.3 × 20	= 86 lb/ton
Ammonia nitrogen, lb/ton	= 0.11 × 20	= 2.2 lb/ton
Phosphorus, lb/ton	= 1.7 × 20	= 34 lb/ton
P ₂ O ₅ , lb/ton	= 34 × 2.27	= 77.2 lb/ton
Potassium, lb/ton	= 1.5 × 20	= 30 lb/ton
K ₂ O, lb/ton	= 30 × 1.2	= 36 lb/ton

Because the field has had poultry litter spread on it in prior years, the organic nitrogen available this year will be about 75 percent of the organic nitrogen applied this year. If the field had not been spread with poultry litter in prior years, only about 50 to 60 percent of the organic nitrogen spread this year would be available this growing season. Ammonia nitrogen is much more subject to field losses than is organic nitrogen. From 20 to 80 percent of applied ammonia nitrogen may not be available to plants, depending on timing of the application and on soil and climatic conditions. Phosphorus and potassium are much less subject to field losses than ammonia is, and they are generally assumed to be 100 percent available to plants.

Nitrogen available this year:

Available organic nitrogen	= (86 - 2.2) × 0.75	= 63 lb/ton
Available ammonia nitrogen	= 2.2 × 0.6	= 1 lb/ton
Total available nitrogen	= 63 + 1	= 64 lb/ton

Field application rate based on nitrogen:

$$\text{tons litter/acre} = 120 / 64 = 1.9 \text{ tons/acre}$$

If litter is applied at this rate for nitrogen, phosphorus and potassium rates will be as follows:

$$\begin{aligned}\text{pounds P}_2\text{O}_5/\text{acre} &= 77.2 \times 1.9 = 147 \text{ lb/acre} \\ \text{pounds K}_2\text{O}/\text{acre} &= 36 \times 1.9 = 68 \text{ lb/acre}\end{aligned}$$

So, applying litter at the rate for nitrogen results in

an overapplication of phosphorus by 147 - 75 = 72 lb/acre, and a potassium deficiency of 140 - 68 = 72 lb/acre.

Field application rate based on P₂O₅

$$\text{tons litter/acre} = 75 / 77.2 = 1.0 \text{ tons/acre}$$

If litter is applied at this rate for phosphorus, then nitrogen and K₂O rates will be as follows:

$$\begin{aligned}\text{pounds available nitrogen/acre} &= 64 \times 1.0 = 64 \text{ lb/acre} \\ \text{pounds K}_2\text{O}/\text{acre} &= 36 \times 1.0 = 36 \text{ lb/acre}\end{aligned}$$

Therefore, applying litter at the rate for P₂O₅ results in a deficiency of nitrogen by 120 - 64 = 56 lb/acre, and a potassium deficiency of 140 - 36 = 104 lb/acre.

What is an acceptable time period between lab analyses and manure spreading?

Generally, samples and analyses should be obtained as close to the spreading activity as reasonably possible. However, nutrient levels in manure storage structures do not change rapidly, and an elapsed time of 2 to 3 weeks is not likely to be critical. Seasonal changes do occur, however, and a manure analysis obtained in the spring should not be used for a fall application.

A typical difficulty with slurry manure, or any manure that must be agitated or mixed, is that the sample is (and should be) taken at the time of agitation. Since the spreading activity takes place at the same time, or very closely following agitation, laboratory results may not be available when the manure is spread. In these cases, the laboratory results comprise a record of what was spread and offer guidelines on spreading rates for the next spreading event based on the current analysis and application rate. This type of continuous record of analyses can be very useful in determining application rates even though current analyses are not available for the spreading event.

For further information

Dougherty, M., D. Vaughan, E. Collins, and G. Evanylo. 1995. Nitrogen values of liquid dairy manure and dry broiler litter as affected by sample preservation. ASAE Paper No. 952408. American Society of Agricultural Engineers, St. Joseph, Mich.

MU Extension Publications – 1-800-292-0969

G9340 *Sampling Poultry Litter for Nutrient Testing*

G9182 *Managing Manure Phosphorus to Protect Water Quality*

G9181 *Agricultural Phosphorus and Water Quality*



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