How to Sample Manure for Nutrient Analysis

A field-by-field nutrient management program requires multiple components to maintain adequate fertility for crop growth and development. A well-designed soil sampling plan, including proper soil test interpretations, along with manure sampling, manure nutrient analysis, equipment calibration, appropriate application rates and application methods are all necessary components of a nutrient management plan. Implementing these components allows manure to be recognized and used as a credible nutrient resource, potentially reducing input costs and the potential of environmental impacts.

Animal manure has long been used as a source of nutrients for crop growth. Standard nutrient values are guides to determine the amount of nutrients that animal manure will supply as a fertilizer source. The Iowa State University Extension and Outreach publication PMR 1003 Using Manure Nutrients for Crop Production (store.extension.iastate.edu/product/12874), discusses nutrient availability and losses at application by type of animal, manure handling system and application methods.

While "book values" like those in Midwest Plan Service publication MWPS-18-S1 Manure Characteristics (https://www-mwps.sws.iastate.edu/catalog/manure-management/manure-characteristics) are reasonable average values, an individual farm's manure analyses can vary from those averages by 50% or more. Species, age of animal, feed rations, water use, bedding type, management, and other factors make every farm's manure different. Two key factors affecting the nutrient content of manure are manure handling and type of storage structures used. Each handling system results in different types of nutrient losses, some unavoidable, and others that can be controlled to a certain degree. Because every livestock production and manure management system is unique, the best way to assess manure nutrients is by sampling and analyzing the manure.

This publication describes how to sample solid, semi-solid, and liquid manure. Manure with greater than 20% solids (by weight) is classified as dry manure and is handled as a solid, usually with box-type spreaders. Manure with 10-20% solids is classified as semi-solid manure and can usually be handled as a liquid. Semi-solid manure usually requires the use of chopper pumps to provide thorough agitation before pumping. Manure with less than 10% solids is classified as liquid manure and is handled with pumps, pipes, tank wagons, and if low enough solids content, irrigation equipment.

A representative manure sample is needed to provide an accurate reflection of the nutrient content. Unfortunately, manure nutrient content is not uniform within storage structures, so obtaining a representative sample can be challenging. Mixing and sampling strategies should therefore ensure that samples simulate as closely as possible the type of manure that will be applied.

When to sample manure

Sampling manure prior to application will ensure that the analysis is received in time to adjust nutrient application rates based on the nutrient concentration of the manure. However, sampling manure prior to application may not completely reflect the nutrient concentration of the manure due to storage and handling losses if long periods of time pass before

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application begins or when liquid storage facilities are not adequately agitated while sampling. "Pre-sampling," such as dipping samples off the top of storage structure for nitrogen (N) and potassium (K) concentrations, can be done to estimate application rates. (See page 4 for more on pre-sampling). Producers must remember to go back and determine the actual nutrient rates applied by using manure samples collected during application and calculating volumes.

For best results, manure should be sampled at the time of application or as close as possible to application. Sampling during application will help to ensure that samples are well-mixed and representative of the manure being applied. Because manure nutrient analysis typically takes several days at a lab, sampling at the time of application will not provide immediate manure nutrient recommendations. The results can, however, be used for subsequent manure applications and to adjust commercial fertilizer application. This is why it is important to develop a manure sampling history and use those analyses in a nutrient management plan. A manure sampling history will also help you recognize if unplanned changes have occurred to your system if management and other factors have remained constant. A manure sampling history will give you confidence in using manure, and show how consistent the nutrient concentration is from year-to-year.

Take manure samples annually for three years for new facilities. If results are consistent, sampling frequency can be reduced to every three-to-five years, unless animal management practices, feed rations, or manure handling and storage methods change drastically from present methods. However, it is still recommended that manure samples be collected and analyzed annually for greater confidence in the manure nutrient value. If you apply manure several times a year, take samples when you plan to apply the bulk of manure. For example, it may be appropriate to sample in the spring when manure that has accumulated all winter will be applied. If storage is emptied twice a year, it may be necessary to sample in both spring and fall since the different storage temperatures in summer versus winter will affect manure nutrient levels.

NOTE: Implementation of future federal regulations may require concentrated animal feeding operations (> 1,000 animal units) to sample annually). Check state and federal requirements to determine sampling frequency.

How to sample semi-solid or liquid manure

In liquid and semi-solid systems, settled solids can contain over 90% of the phosphorus (P), so complete agitation is needed to accurately sample the entire storage if all the manure in the storage structure is going to be applied. If, however, solids will purposely be left on the bottom of the storage structure when the manure is pumped out, as is sometimes the case with lagoons, then complete agitation during sampling may generate artificially high nutrient values. In this case agitation of the solids or sludge on the bottom of a lagoon is not needed for nutrient analysis.

A representative liquid manure sample is most easily obtained during land application, for it is potentially more difficult and dangerous to sample from liquid storage facilities than dry manure systems. When sampling manure during application is not possible, or pre-application analysis is desired for determining rates, refer to the section on sampling from a storage facility. If sampling from a liquid storage facility, use caution to prevent accidents, such as falling into the manure storage facility or being overcome with hazardous gases produced by manure. Have two people present at all times. Never enter confined manure storage spaces without appropriate safety gear such as a self-contained breathing apparatus.

Ideally, liquid manure should be agitated so a representative sample can be obtained for laboratory analysis. When agitating a storage pit below a building, be sure to provide adequate ventilation for both animals and humans. (See page 6 for resources about safe ventilation practices). When agitating outdoor unformed pits, monitor activities closely to prevent erosion of berms or destruction of pit liners.

LIQUID MANURE SAMPLE PREPARATION

- All liquid samples should be handled as follows:
- Prior to sampling, label a plastic bottle with your name, date and sample identification number using a waterproof pen.
- If the sample cannot be mailed or transported to a laboratory within a few hours, it should be frozen. Place the container in a tightly sealed plastic bag and keep it cold or frozen until it arrives at the laboratory.
- Most manure analysis laboratories do have plastic bottles available for sample collection. Do not use glass containers, as expansion of the gases in the sample can cause the container to break.

LIQUID MANURE SAMPLING DURING LAND APPLICATION

- Since settling begins as soon as agitations stops, samples should be collected as soon as possible after the manure tank wagon is filled unless the tanker has an agitator.
- Immediately after filling the tank wagon, use a clean plastic pan to collect manure from the loading or unloading port or the opening near the bottom of the tank. Be sure the port or opening does not have a solids accumulation from prior loads.
- Use a ladle to stir the sample in the bucket to get the solids spinning in suspension. While the liquid is spinning, remove a ladle full and carefully pour in the sample bottle (Figure1).
- Repeat this procedure and take another sample until the sample bottle is three-quarters full. Make sure the manure solids have not settled to the bottom of the bucket as each ladle is extracted; it is important to include the solids in the sample. Screw the lid on tightly.

LIQUID MANURE APPLIED BY IRRIGATION SYSTEMS

- Place catch pans or buckets randomly in the field to collect liquid manure that is applied by an irrigation system. Inexpensive aluminum roasting pans or plastic buckets can be used as catch pans. Use several pans at different distances from the sprinkler head.
- Immediately after the manure has been applied, collect manure from catch pans or buckets and combine the manure in one bucket to make one composite sample.
- Use a ladle to stir the sample in the bucket. While the liquid is spinning remove a ladle full and carefully pour into a sample bottle (Figure 1).
- Repeat this procedure and take another sample until the sample bottle is three-quarters full. Screw the lid on tightly.

Liquid manure sampling from storage

For best sampling results, samples should be taken with a sampling probe or tube (Figure 2). Probes can be constructed out of 1.5-inch diameter PVC pipe. Cut the PVC pipe a foot longer than the depth of the pit. Run a 1/4-inch rod or string through the length of the pipe and attach a plug such as a rubber stopper or rubber ball (Figure 2). The rod or the string must be longer than the pipe. If using a rod, bend the top over to prevent it from falling out of the pipe.

Figure 1. Collecting a liquid manure sample.

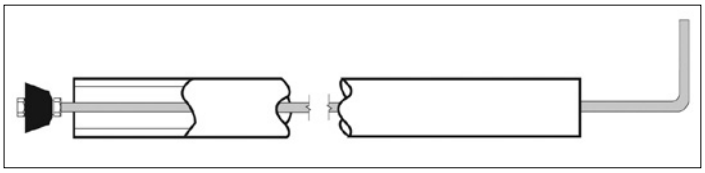

Figure 2. Example sampling probe schematic. Rubber stopper attached to a metal rod to serve as a stopper for PVC manure sampling tube.

- Insert the pipe slowly into the pit or lagoon, with the stopper open, to the full depth of the pit.
- Pull the string or rod to close the bottom of the pipe and extract the vertical profile of the pipe (be careful not to tip the pipe and dump the sample.
- Release the sample carefully into a bucket.
- Repeat the process at least three times around the pit or lagoon creating a composite sample in the bucket.
- Use a ladle to stir the sample in the bucket to get the solids spinning in suspension. While the liquid is spinning, take a ladle full and carefully pour into a sample bottle.
- Repeat again and take another sample until the sample bottle is three-quarters full. Make sure the manure solids have not settled to the bottom of the bucket as each dipper is extracted; it is important to include the solids in the sample. Screw the lid on tightly.

Pre-sampling nitrogen and potassium from liquid manure

If the procedures described above for sampling liquid manure are impractical due to lack of sampling equipment, or the inability to agitate the manure, manure samples can be dipped off the top of stored liquid manure to analyze for N and K concentrations. Research has shown that top-dipped liquid samples represent approximately 90% of the N concentration measured in mixed, field-collected samples. Multiply the results of the N concentration from top-dipped samples by 1.1 for a better estimate of the N concentration of the liquid storage facility. Dipping a sample from the surface of a liquid storage pit does NOT provide a good estimate of P concentration in the pit and is not recommended.

How to sample dry or solid manure

In solid manure handling systems, many of which include bedding, the proportions of fecal matter, urine, and bedding will vary from one location to another within sites, and often from season to season as well. It is necessary to take samples from various places in the manure pile, stack, or litter to obtain a representative sample for analysis. It may even be beneficial to sample several times per year based on the bedding content.

Manure sampling is best done in the field as manure is applied. This ensures losses that occur during handling, storage, and application are taken into account and that manure is better mixed, reducing stratification found during sampling storage facilities. As with field sampling of liquid manure, results will not be available in time to adjust current application rates. However, sampling during application will still allow producers to adjust any planned future commercial fertilizer rates and manure application in subsequent years. The following method describes a procedure for collecting dry or solid manure samples from the field.

Dry manure sampling during land application

Collect manure samples according to the following field sampling procedure.

- Spread a sheet of plastic or tarp on the field. A 10-by-10 foot sheet works well for sampling manure.
- Fill the spreader with a load of manure.
- Drive the tractor and manure spreader over the top of the plastic to spread manure over the sheet.
- Collect subsamples as described below (Steps 1-3, Composite Sample Collection).
- Samples should be collected to represent the first, middle and last part of the storage facility or loads applied and should be correlated as to which loads are applied on certain fields to track changes in nutrient concentrations throughout the storage facility.

Sampling from dry or solid storage facilities and open lots

Manure should be sampled at the time of application, but if time and management practices prevent this, manure samples can be collected from the storage facility. Sampling from storages is not generally recommended due to difficulty in collecting a representative sample. Although solid manure storages are generally not fully enclosed and gases are somewhat diluted, always exercise caution when sampling from storage facilities. If you have to enter a confined storage facility, follow the safety recommendations described previously in the section on sampling liquid manure storages.

Open paved lots

Manure that accumulates on paved feedlots and is scraped and hauled to the field is classified as scrape-and-haul feedlot manure. Manure is usually removed from the feedlot daily or several times a week.

- Collect manure by scraping a shovel across approximately 25 feet of the paved feedlot. This process should be repeated ten or more times, taking care to sample in a direction that slices through the large-scale variations of moisture, bedding, depth, age, etc. Avoid manure that is excessively wet (near waterers) or contains unusual amounts of feed and hay.
- Use the shovel to thoroughly mix manure by continuously scooping the outside of the pile to the center of the pile.
- Collect subsamples from this pile using the hand-in-bag method that is described below (Steps 1-3 Composite Sample Collection).
- This may need to be done several times to collect several composite samples for analysis.

Barn gutter

Manure that accumulates in a barn or housing facility, is temporarily stored in a gutter, and then removed by a barn cleaner, is classified as barn gutter manure. Manure is usually removed from the barn once or twice daily.

- Shovel a vertical "slice" of manure from the gutter, making sure the shovel reaches to the bottom of the gutter.
- Remove manure from the gutter and pile it on the barn floor. Mix the manure with a shovel or pitchfork to ensure that bedding is mixed thoroughly with manure. When collecting samples from a gutter, be sure to include the liquid that accumulates in the gutter's bottom. Discard foreign material and also take care not to add large amounts of barn lime.
- Repeat steps one and two from various locations along the gutter.

Mix each pile thoroughly and collect subsamples from each pile using the hand-and-bag method that is described in sidebar at the right (Steps 1-3, Composite Sample Collection).

Dry stack and manure with litter

Manure that is stored outside in a solid waste storage facility, such as a stacking shed or horizontal concrete silo located above ground, is classified as a dry stack. These facilities are usually covered to prevent the addition of extra water. Dry manure with litter should also be sampled in the following manner.

- Remove manure from 10-20 locations throughout the dry stack and place it in a pile using a pitchfork or shovel. Manure should be collected from the center of the stack as well as from near the outside walls, to get samples that represent all ages and moisture levels of manure in the stack. A bucket loader can cut a path into the center of the pile to provide access for sampling. Subsamples should be collected to the depth the litter will be removed for application.
- Thoroughly mix manure with the shovel by continuously scooping the outside of the pile to the center of the pile.
- Collect a composite manure sample as described in sidebar (Steps 1-3, Composite Sample Collection).

Composite sample collection for dry or solid samples

1. Whether collecting from a plastic tarp in the field, a feedlot, a storage facility, or a barn, sample in a grid pattern so that all areas are represented. Combine 10-20 subsamples in a bucket or pile and mix thoroughly. More subsamples will produce more accurate results and are often required to produce a composite that best represents nutrient levels.
2. The final composite sample that will be submitted for nutrient analysis should be collected using the hand-in-bag method. To collect a composite sample from the mixed subsamples, place a one-gallon re-sealable freezer bag turned inside out over one hand. With the covered hand, grab a representative handful of manure and turn the freezer bag right side out over the sample with the free hand. Be careful not to get manure in the sealable tracks.
3. Squeeze excess air out of the bag, seal, and place it in another plastic bag to prevent leaks. Label the bag with your name, date, and sample identification number with a waterproof pen and freeze it immediately to prevent nutrient losses and minimize odors. For manure with ahigh degree of variability, multiple samples may need to be analyzed. Manure samples should be mailed or delivered to the laboratory as soon as possible after sampling.

Manure samples should be sent to a lab for chemical analysis as quickly as possible to avoid nutrient losses. For a list of commercial laboratories, call your Iowa State University Extension and Outreach office or visit the Iowa Manure Management Action Group Soil Manure Testing Labs webpage, extension.iastate.edu/immag/soil-manure-testing-labs.

SUMMARY

Basic manure analyses determined by laboratories include total nitrogen, total phosphorus, and total potassium. Results from commercial laboratories are presented either as a percent of the sample weight, as pounds per ton, as pounds per 1,000 gallons of manure, or in parts per million (ppm). Table 1 shows factors used to convert between measurements. Usually, nutrients are expressed as N, P_2O_5, or K_2O on a wet or "as received" basis, but some labs may instead report data on an elemental (P instead of P_2O_5, K instead of K_2O) or dry (without water) basis; so, be sure to confirm the units. In any case, manure values from commercial laboratories express nutrients as the total amount of nutrient in the manure sample.

Table 1. Conversion factors.

To switch from	Multiply by	To get
mg/l	1.0	ppm
ppm	0.0001	%
ppm	0.00834	lb/1,000 gal
ppm	0.002	lb/ton
ppm	0.2265	lb/acre-inch
lb/1,000 gal	0.012	%
lb/ton	0.05	%
%	83.4	lb/1,000 gal
%	20.0	lb/ton
%	2265	lb/acre-inch
P (elemental)	2.29	P_2O_5
K (elemental)	1.2	K_2O

Some primary nutrients, such as N and P, may not be completely available for plant growth the first year manure is applied. A portion of some nutrients present in manure are in an organic form and unavailable for immediate plant uptake. Organic forms require transformation to an inorganic form to be available for plant uptake. This transformation is dependent on temperature, moisture, chemical environment, and time. Availability of nutrients can be limited by field losses, which are affected by the type of manure and by manure application methods. These losses are not accounted for in laboratory results. Refer to the ISU Extension and Outreach publication PMR 1003, Using Manure Nutrients for Crop Production (store.extension.iastate.edu/product/12874) for nutrient availability estimates and losses due to types of manure application methods.

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ADDITIONAL RESOURCES

AE 3517 Manure Storage Poses Invisible Risk (store.extension.iastate.edu/Product/4996)

AE 3600 Distribution of Liquid Manure Application (store.extension.iastate.edu/Product/14891)

AE 3601A Calibrating Liquid Tank Manure Applicators (store.extension.iastate.edu/Product/6499)

PM 1941 Calibration and Uniformity of Solid Manure Spreaders (store.extension.iastate.edu/Product/5536)

PMR 1003 Using Manure Nutrients for Crop Production (store.extension.iastate.edu/Product/12874)

MWPS-18-S1 Manure Characteristics (http://www-mwps.sws.iastate.edu/catalog/manure-management/manure-characteristics)

AE 3603 Hydrogen Sulfide Safety – Monitoring (store.extension.iastate.edu/Product/15106)

AE 3604 Hydrogen Sulfide Safety – Manure Agitation (store.extension.iastate.edu/Product/15107)

AE 3605 Hydrogen Sulfide Safety – Barn Ventilation at Cattle Facilities (store.extension.iastate.edu/Product/15108)

AE 3606 Hydrogen Sulfide Safety – Swine Barn Ventilation (store.extension.iastate.edu/Product/15109)

Iowa Manure Management Action Group (IMMAG) website (extension.iastate.edu/immag)