



Manure Sampling & Analysis

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In the effort to manage natural resources wisely, agricultural best management practices (BMP) call for nutrient analysis of soil to determine necessary amendments for crop success. Furthermore, knowledge of the nutrient content and release characteristics of the amendments is necessary. While nutrient values of different kinds of manure have been determined for typical management conditions, the values can vary considerably due to feed type and quality, physiological state of the animal, manure storage time and conditions, etc. Therefore, manure analysis is an additional BMP that will help farmers fine-tune the crop nutrient availability in soil. BMPs for managing manure recommend maximum utilization of nutrients, which may require intensive monitoring, record-keeping, and special equipment. However, some livestock producers are less concerned about nutrient efficiency; their primary objective is to “dispose” of manure by land application. Regardless of whether nutrient utilization by crops is to be maximized, land application should be done in a way to minimize pollution risk to nearby water. This is an “extra” challenge when limited field acreage is available. Knowing nutrient availability from soil and manure will prevent over-application of manure that could build up soil nutrient levels (particularly nitrogen and phosphorus), which are potentially damaging to water quality.

When to Sample Manure

Sampling manure prior to its application to fields gives a farmer the advantage of determining proper application rate for the current crop season. However, difficulties and hazards in obtaining representative

samples from storage structures and timeliness of analysis discourage this approach. Sampling during hauling provides for a more representative sample, requires little extra effort, and is safer, though it doesn't allow for modifying the current year's application rate based on the analytical results. Still, the analysis is useful for adjusting subsequent application rates to avoid building up excessive levels of soil nitrogen (N) and phosphorus (P).

When manure is stored over a year-long period, sampling and analysis should be done annually, just prior to or during application, especially with storage structures that are most susceptible to variation in temperature and precipitation that would affect nutrient retention or loss. Seasonal differences in manure composition should also be expected, and so spring-time analysis of manure should not be used to estimate rates of fall-applied manure. Less frequent sampling may be suitable for manure stored in underground pits or covered tanks, which are less likely to be affected by environmental conditions. Long-term comparison of manure analysis will help to assess the required frequency of testing. If data is sufficiently uniform over 3 or more years, repeat analysis can be reduced to once every 3–5 years, assuming no changes are made. Any change in species, feed, bedding, manure handling, or other factors warrants additional testing.

How to Sample Manure

The best method of sampling depends primarily on the dry matter content of the manure. Manure having at least 15% dry matter is considered solid, while



manure with less than 15% dry matter (85% or more water content) behaves like a liquid. Dairy, beef, and swine manure may be either solid or liquid (with inclusion of urine or barn floor and milking parlor wash water); horse and poultry manures are solid. Solid manures often include bedding materials.

Multiple subsamples need to be taken and combined to create a representative sample, which averages out differences within the storage structure. Any stratification within a pile should dictate separate samples or suitable attention to obtaining samples with similar proportions of the layers. The more subsamples (properly taken), the more accurate the results will be.

Solid Manure

Collecting subsamples.

1. *To sample while spreading*, spread a tarp in the field and catch the manure from a pass of the manure spreader. Repeat to obtain 5 subsamples from different locations in the field representing various stages of the application. (This method can also be used to calibrate tractor speed to manure spreader application rate.)

2. *To sample daily haul*, place a five-gallon bucket under the barn cleaner while loading a spreader. Repeat procedure for a total of 5 subsamples. To test variability with time, repeat sampling and analysis several times.

3. *To sample while loading spreader from a stack or bedded pack*, take at least 5 subsamples while loading into the manure spreader. Because of stratification, it is generally not recommended to sample directly from the stack.

4. *To sample stockpiled litter or other solid manure pack*, take 10 subsamples at random locations around the pile at depths of at least 18 inches (to the depth that the manure will be removed for application).

5. *In a poultry house*, collect at least 8 samples randomly throughout the house to the depth that litter will be removed. The number of subsamples near

feeders and waterers should be proportional to the area that they represent.

Composite sample. After obtaining the recommended number of solid manure subsamples, they can be combined into a composite sample by mixing thoroughly in a clean 5-gallon plastic bucket or by piling the subsamples on a clean surface and shoveling from the outside of the pile to the center. Place 1 pound of the composite sample into a gallon-size, heavy-duty sealing plastic storage bag, pushing out excess air. Use permanent marker to label the plastic bag, recording farm name, animal species, and date. Send to the testing lab immediately or freeze.

Safety while sampling:

Caution must be taken to avoid potentially fatal accidents while sampling liquid manure from a storage facility or tank. Besides the obvious danger of falling into the liquid manure, gases released from the manure storage facility are hazardous at high concentrations, and the fumes can overcome a person. Ensure adequate ventilation for enclosed structures or use self-contained breathing apparatus, and never sample alone.

Liquid Manure

Collecting subsamples.

1. *To collect subsamples from the manure spreader or from irrigation*, place buckets at different locations within the field. At least 5 subsamples should be taken.

2. *To sample from a storage tank or lagoon*, the liquid manure must first be agitated for a minimum of 4 hours to counteract stratification of nutrients that occurs with settling. Large lagoons or small-capacity pumping equipment may dictate longer periods of mixing.

With adequate agitation, only 5 subsamples need to be collected from a depth of 6" or more at different areas, avoiding the outer edge where surface scum or debris may collect. Alternatively, the sampling can be done while loading the spreader.

Composite sample. The liquid manure subsamples must be mixed thoroughly to create a composite sample. Use a 5-gallon plastic bucket to contain the subsamples, and thoroughly mix with a paddle or plunger-type device. Before settling occurs, pour or ladle out about 3 cups of liquid manure into a quart-size (1-liter) plastic bottle. Do not use glass bottles, and do not fill completely; leave space for gas expansion. Use a permanent marker to label the plastic bottle, recording farm name, animal species, and date. Send to the testing laboratory immediately or freeze.

Send Sample to Laboratory

If the sample is not to be delivered immediately to the laboratory, freeze the sample until it can be sent or delivered; this will preserve the composition of the manure for accurate analysis. Arrange delivery of the sample to ensure that it doesn't sit in a warehouse or post office over a weekend or holiday.

Laboratories will have their own paperwork, but generally the information accompanying the sample should include the same information on the sample label (farm name, animal species, and date sampled/applied).

Contact information for laboratories in the region that analyze manure:

Agricultural Analytical Services Laboratory
 Penn State University
 Tower Road
 University Park, PA 16802
 Tel: (814) 863-0841
 Fax: (814) 863-4540

Agri Analysis Inc.
 280 Newport Road
 Leola, PA 17540
 (717) 656-9326

A & L Eastern Agricultural Laboratories, Inc.
 7621 Whitepine Road
 Richmond, VA 23237
 (804) 743-9401

Dairy One
 730 Warren Road

Ithaca, NY 14850
 (607) 257-1272

Manure Analysis

Examples of nutrient values for different manures “as excreted” are shown in Table 1. This demonstrates the variability of animal manures and indicates the potential value of manures as plant nutrient sources. However, these values should not be considered as typical or standard values since initial concentrations depend on feed, and any handling, storage, or application method can modify the final nutrient values.

Table 1. Reference values of nutrient concentration in animal manure “as excreted.”

	Manure nutrient concentration, as excreted		
	N	P ₂ O ₅	K ₂ O
	lb nutrient/T manure		
Dairy cow, lactating	13.2	5.2	3.7
Beef cow, finishing	11.2	3.4	9.3
Swine, grower	16.7	6.5	8.8
Swine, gestating	12.9	8.3	10.5
Swine, lactating	15.2	10.1	11.6
Poultry, broiler	21.8	14.6	14.9
Poultry, layer	36.8	26.5	16.5
Turkey, female	30.0	19.3	15.9
Horse, intense exercise	11.9	5.9	8.9
Horse, sedentary	7.1	2.4	2.6
Sheep (lamb)*/goat	19.5	22.3	23.5

Most values calculated from data in ASAE Standards D384.2, 2005. Values for sheep manure from MWSP, 2004.

*Sheep values can also be used for goat manure.

Nutrient results of manure analysis may be presented as “pounds per ton” for solid manure or “pounds per 1000 gallons” for liquid manure. For semi-solid manure (10–20% dry matter), the units used for reporting depend on the method that the manure is to be applied to the field (e.g. tank truck vs. box spreader).

Analysis of manure should include these parameters: **Ammoniacal nitrogen (NH₃+NH₄-N)**. These forms of N are soluble in soil water and therefore,

readily available to the crop in the first year. However, this form of N is susceptible to loss from the soil by volatilization as ammonia (NH₃) if not incorporated or rinsed into the soil right away. Although ammonium-N adsorbs to soil particles, its solubility may allow loss by runoff or by leaching through the root zone when rainfall is excessive. Once in soil, NH₄-N may be converted (“nitrified”) by microorganisms to the nitrate (NO₃) form of N, which likewise is readily available for uptake by plants but also is particularly susceptible to leaching since it does not adsorb to soil. Nitrification inhibitors are sometimes applied to fields, particularly for fall-applied manure or fertilizer, to retain N in the ammonium form and thus minimize leaching loss of N. Fertilizer credits for manure N applied in the current year are determined not only by the manure analysis but also by application conditions. Table 2 illustrates the availability of ammonium-N as functions of season and time-until-incorporation.

Table 2. Availability of manure Ammonium-N to next crop; generalized for all manure*.

	Percentage of applied manure NH ₄ -N available for crop					
Time of year applied:	Days till incorporation into plow layer					
	1 d	2 d	3 d	4 d	5 d	6+ d
March/April	50%			25%		
May/June	75%		25%			
July/August	75%		25%			
Sept/Oct.	25%		15%			
Nov. - Feb.	50%				25%	

* For poultry manure, include 50% of organic-N in the ammonium-N factoring since it is rapidly converted.
Note: Manure should not be applied to frozen soil.
Ohio State.

Total Kjeldahl nitrogen (TKN). This includes ammoniacal N as well as N in organic form, which will slowly become available as the manure decomposes. Therefore, fertilizer credits can be given for manure organic N applied in previous years, as well as for the current year. The amount of organic-N is calculated as N_{org} = (Total nitrogen) – (Ammonium-N). Table 3 provides an estimate of availability of

manure organic-N in the year applied and in subsequent years as the manure continues to break down and release nitrogen.

Table 3. Availability of organic-N from applied manure to subsequent crops.

Availability in first year of application	
	Percent of organic-N
Poultry	60%
Swine	50%
Other manure, <18% DM	35%
Other manure, >18% DM	25%
Past applications, all manure	
Second year	12%
Third year	5%
Fourth year	2%
Fifth year	1%
Sixth year	1%

Adapted from “Using the Penn State Manure Analysis Report,” MA-1. Agricultural Analytical Services Laboratory.

Total phosphorus (P). Nearly all (80–100%) of the manure P will be available to the crop within the first season. If content is given in P lb/ton or lb/1000gal, convert to fertilizer (P₂O₅) credits by multiplying by 2.29.

Potassium (K). Nearly all (90–100%) of the manure K will be immediately available for crop uptake. One hundred percent of K content in “as is” manure in lb/ton or lb/1000gal can be figured as credit for fertilizer (K₂O). If content is given in K lb/ton or lb/1000gal, multiply by 1.21 to get K₂O equivalent.

Dry matter percentage (DM). A manure sample is dried prior to determination of the nutrients; therefore it is necessary to know the original water content vs. dry matter in order to calculate the nutrient values in the original (moist). The nutrient values on the report may be expressed in terms of the dry matter basis but should also provide values for the manure as received, or “as-is”, that is, at the moisture content

that the sample was received and would be applied. With the “as-is” nutrient values, the manure application rate can be converted to a nutrient application rate.

This information is necessary to determine future manure application rates and nutrient credits for the crop. Remember that the specifics of manure application are important for assessing potential nutrient losses and calculating nutrient credits, particularly with regard to nitrogen.

Other manure tests that may be included or selected as an option are:

pH. Manure pH is typically neutral (7.0) to alkaline. Once applied to the soil, decomposition processes may temporarily acidify the soil, but regularly manured fields commonly have near-neutral pH. Manure with excessively high pH may indicate excess soluble salt levels.

Electrical Conductivity, or Soluble Salt Level. Fresh manure may have high levels of salts that would harm seed or growing plants. Because they are soluble, these salts are readily leached with time when exposed to precipitation and allowed to drain. Aged or composted manure is less likely to be problematic.

Manure contains significant content of other nutrients (for example, **calcium, magnesium, copper, zinc, sulfur, boron**). Manure is not typically analyzed for these additional nutrients, primarily because fertilization plans would rarely be affected by the results. Manured fields typically would not show a deficiency for those nutrients, and soil testing is most appropriate for monitoring levels of these elements.

Nutrient Management Plans

The information from a manure analysis report is a necessary part of a comprehensive nutrient management plan (CNMP). Besides the nutrient content and dry matter analysis of the manure, the agricultural agent or crop consultant will need to know the rate and method of manure application in the field. To develop CNMPs, the agent or consultant will need soil test reports, cropping history and plans, and

records of prior applications of any amendment in addition to the manure analysis report.

Application rate of manure may be based on either the N requirement or P Index. The P Index was developed by the Natural Resources Conservation Service “to provide field staffs, watershed planners, and land users with a tool to assess the various landforms and management practices for potential risk of phosphorus movement to water bodies” (www.nrcs.usda.gov/technical/ECS/nutrient/pindex.html). **Thus, this P Index is meant as a planning tool and not as a regulatory measure.** When the potential for P pollution of water by soil erosion (as determined by the Phosphorus Index) is suitably low, application rates are determined by N content vs. crop need. If N-based application rates would result in excess P, the P Site Index dictates the allowed application rate of manure. In either case, some fertilizer may still be necessary.

As suggested by availability figures for N, immediate incorporation of manure is recommended. Not only does this conserve manure ammonium-N for the crop by minimizing volatilization, but it also decreases odors and possible loss of all nutrients by runoff and erosion, and protects water quality.

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