Unit I Sampling Livestock Waste for Analysis

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1. Introduction

There are essential pieces of information required to determine the proper application rate and nutrient credits for livestock waste to meet crop needs. These include the acreage of the field, capacity of the spreader and nutrient concentration of the manure. Nutrient concentration can be assigned by using estimated "book" or average available N, P_2O_5 and K_2O concentrations. However, testing manure may better indicate how factors such as animal and manure management affect manure nutrient content. Using good sampling technique is critical for maintaining confidence in manure nutrient analysis results. Appropriate sample handling and laboratory methods are also important to ensure accurate results.

2. Sampling livestock waste

Data in the livestock waste facilities handbook (MWPS-18, 2000) provides "typical" or average nutrient contents for manure from several types of animals. These values probably give an acceptable estimate for "typical" producers, especially if current sampling methods used do not represent the pit, pack or gutter adequately. However, an analysis of a well-sampled system may give a better estimate of manure nutrient concentrations for individual farms than book values, especially if herd and manure management are not "typical." The MWPS total nutrient estimates are compared in table 1 to actual manure analysis of 51 farms in Minnesota (Wagar et al., 1994) and from 1959 manure samples submitted to the University of Wisconsin Soil and Forage Analysis Laboratory between 1998–2001 (Combs, 1991). On average, the actual farm values compare

Table 1.
Comparison of analyzed manure total nutrient concentrations to "typical" nutrient concentrations

Animal Type	System	Nutrient	Minnesota* Avg.	Minnesota* Range	Wisconsin** Avg.	Wisconsin** s.d.	Wisconsin** Range	MWPS*** Avg.
					lbs/1000 gal			
Dairy	Liquid	N	29	10-47	22	9	1-73	31
		P_2O_5	15	6-28	9	7	1-118	15
		K_2O	24	11-38	20	11	1-114	22
					lbs/t			
Dairy	Solid	N	13	7-25	12	10	2-97	9
		P_2O_5	6	3-13	6	7	1-78	4
		K_2O	8	2-18	8	7	1-60	7
					lbs/1000 gal			
Swine	Liquid	N	48	7-107	34	20	1-91	28
		P_2O_5	28	3-64	16	12	1-60	24
		K_2O	21	7-51	20	12	2-70	23

*Nutrient levels in manure samples taken from 51 farms.

**Nutrient levels in 799 solid/semi-solid dairy, 746 dairy liquid and 414 liquid swine manure samples submitted to the University of Wisconsin Soil and Forage Analysis Lab, 1998-2001.

****Livestock Waste Facilities Handbook* (MWPS-18, 2000) well to the MWPS estimates. Note, however, that the actual analysis values range widely from the MWPS estimates, indicating poor sampling, management or other on-farm differences. Lindley et al. (1988) also found actual manure analysis values to be highly variable and ranged from 50 to 100% of published values.

2.1 Technique

In virtually any type of agricultural analytical work the results are greatly influenced by sampling. For solid manure, it is generally recommended to sample from loaded spreaders rather than from the actual manure pack. A Wisconsin study (Peters and Combs, 1998) showed that even when well-trained professionals sampled dairy manure, variability was much higher when samples were collected directly from the barnyard and pack compared to those collected from the loaded spreader. The data also indicated that taking several samples would help minimize potential variability.

In this same study, several samples of liquid manure were taken from a thoroughly agitated lagoon while being pumped into a spreader tank. The results of multiple samples taken by different individuals from a well-agitated liquid dairy manure lagoon indicate that variability is much lower than in the solid manure/barnyard system.

Variability can exist among different samplings even when they are taken by the same individual under ideal conditions. This occurred when samples of liquid and semi-solid dairy manure were collected. Five-gallon samples were mixed as thoroughly as possible before being split into twenty-four subsamples. The results indicate that the variability between liquid samples was quite low, but higher with semi-solid dairy samples. This was particularly apparent with total N and dry matter measurements (Peters and Combs, 1998).

2.2 Time

An evaluation of long-term sampling of solid/semi-solid manure showed little variability occurred in nutrient concentration over a three-year period at the University of Wisconsin Arlington Agricultural Research Station (Combs, 1991). Sampling a stanchion barn periodically for three years showed that all samples had similar total nutrient values. The least variation occurred for N while most variation was associated with K. These results seem to indicate that with good representative sampling and no significant change in herd management, consistent results, even for solid manure, are possible.

On the other hand, results from sampling solid manure in a poultry-laying barn at the University of Wisconsin Arlington Agricultural Research Station indicated inconsistent results over time (Peters and Combs, 1998). These poultry manure samples taken from the same barn approximately five months apart show a significant difference in all parameters measured. This could be partially a result of seasonal changes in the feed ration, feed contamination or differences in individual sampling technique. Commonly, five to six batches of birds are grown out before the litter is removed. Poultry houses are normally sampled when the last batch of birds is removed from the house, since the nutrient content in poultry litter will change over time. Therefore, sampling earlier is not recommended.

Due to these variations over time, manure nutrient concentration values used to determine field nutrient credits should ideally be based on long-term farm averages, assuming herd and manure management practices have not changed significantly. If an established baseline level does not exist for a farm, manure testing needs to be done frequently and consistently to develop a historic record that spans at least two–three years. Preferably, manure sampling and analysis should be done just prior to land application, with the time of year noted to monitor potential seasonal variability.

2.3 Storage management

The segregation of manure that occurs in liquid storage requires that special care be taken to ensure that a homogeneous mix is sampled. In a Minnesota study, manure agitated for 2–4 hours before application had highly consistent results for total N, P, K concentrations and percent solids when individual tanks (first to last) were analyzed (Wagar et al., 1994). Samples taken at various stages during the storage system emptying process at Wisconsin also showed very little variability providing the material was thoroughly agitated (Peters and Combs, 1998).

3. Sampling recommendations

The number of manure samples tested by public and private labs has increased from approximately 6,220 in 1988 to almost 16,000 in 1996 (Soil, Plant and Animal Waste Analysis Status Report, 1992-96). However, the majority of animal producers still do not sample manure. Reasons for not doing so include sample heterogeneity and the inherent difficulty of taking a representative sample.

Several states have developed guidelines for sampling manure to minimize the sample heterogeneity problem. This information was used to help develop the sampling guidelines presented here. It is generally not recommended to attempt to sample bedded packs or unagitated liquid manure storage facilities. In fact, using nutrient analysis results from poorly sampled systems will not improve the accuracy in estimating N or P loading to a field and may in fact be detrimental.

Taking an adequate number of subsamples is critical for getting a good estimate of nutrient value. In order to characterize N content of a beef manure stockpile within 10%, it took a Colorado State researcher 17 subsamples (Successful Farming, August 1998). However, getting that level of accuracy for P required 20 subsamples and for K it required 30.

4. Recommended procedures for sampling livestock waste for analysis

Recommended procedures for sampling liquid and solid waste are given below. Producers may choose from these methods as appropriate.

4.1 Solid manure—dairy, beef, swine, poultry

Obtain a composite sample by following one of the procedures listed below. Also, one method of mixing a composite sample is to pile the manure and then shovel from the outside to the inside of the pile until well mixed. Fill a one-gallon plastic heavy-duty zip lock bag approximately one-half full with the composite sample, squeeze out excess air, close and seal. Store sample in freezer if not delivered to the lab immediately.

1. **Sampling while loading—***Recommended method for sampling from a stack or bedded pack*. Take at least five samples while loading several spreader loads and combine to form one composite sample. Thoroughly mix the composite sample and take an approximately 1-lb. subsample using a one-gallon plastic bag. *Sampling directly from a stack or bedded pack is not recommended.*
2. **Sampling during spreading**—*Spread tarp in field and catch the manure from one pass.* Sample from several locations and create a composite sample. Thoroughly mix composite sample together and take a one-pound subsample using a one-gallon plastic bag.
3. **Sampling daily haul**—*Place a five-gallon pail under the barn cleaner 4–5 times while loading a spreader.* Thoroughly mix the composite sample together and take a one-pound subsample using a one-gallon plastic bag. Repeat sampling 2–3 times over a period of time and test separately to determine variability.
4. **Sampling poultry in-house**—*Collect 8–10 samples from throughout the house to the depth the litter will be removed.* Samples near feeders and waterers may not represent the entire house and subsamples taken near here should be proportionate to their space occupied in the whole house. Mix the samples well in a five-gallon pail and take a 1-lb. subsample; place it in a one-gallon zip lock bag.
5. **Sampling stockpiled litter**—Take 10 subsamples from different locations around the pile at least 18 inches below the surface. Mix in a 5-gallon pail and place a 1-lb. composite sample in a gallon zip lock bag.

4.2 Liquid manure—dairy, beef, swine

Obtain a composite following one of the procedures listed below and mix thoroughly. Using a plunger, an up-and-down action works well for mixing liquid manure in a 5-gallon pail. Fill a one-quart plastic bottle not more than three-quarters full with the composite sample. Store sample in freezer if not delivered to the lab immediately.

1. **Sampling from storage**—Agitate storage facility thoroughly before sampling. Collect at least five samples from the storage facility or during loading using a five-gallon pail. Place a subsample of the composite sample in a one-quart plastic container. *Sampling a liquid manure storage facility without proper agitation (2-4 hrs. minimum) is not recommended due to nutrient stratification, which occurs in liquid systems. If manure is sampled from a lagoon that was not properly agitated, typically the nitrogen and potassium will be more concentrated in the top liquid, while the phosphorus will be more concentrated in the bottom solids.*
2. **Sampling during application**—Place buckets around field to catch manure from spreader or irrigation equipment. Combine and mix samples into one composite subsample in a one-quart plastic container.

4.3 Sample identification and delivery

Identify the sample container with information regarding the farm, animal species and date. This information should also be included on the sample information sheet along with application method, which is important in determining first year availability of nitrogen.

Keep all manure samples frozen until shipped or delivered to a laboratory. Ship early in the week (Mon.–Wed.) and avoid holidays and weekends.

5. References

1. Combs, S. M. 1991. Effects of herd management and manure handling on nutrient content: A lab summary. New Horizons in Soil Sci. No. 5-91. Dept. Soil Sci., University of Wisconsin-Madison, WI.
2. Lindley, J. A., D. W. Johnson and C. J. Clanton. 1988. Effects of handling and storage Systems. on manure value. ASAE. Applied Engr. Agric. 4(3), 246-252.
3. MWPS Livestock waste facilities handbook. Handbook #18, 2000. Midwest Plan Service. Ames, Iowa.
4. Peters, J. B. and S. M. Combs. 1998. Variability in Manure Analysis as Influenced by Sampling and Management. New Horizons in Soil Sci. No. 6-98. Dept. Soil Sci., University of Wisconsin-Madison, WI.
5. Peters, J. B. and S. M. Offer. 2002. Laboratory data summary, unpublished. UW Soil and Forage Analysis Laboratory, May, 2002.
6. Wagar, T., M. Schmitt, C. Clanton and F. Bergsrua. 1994. Manure sampling and testing. FE-6423-B. University of Minnesota, Extension Service.