AEN-91

UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY — COLLEGE OF AGRICULTURE

Managing Liquid Dairy Manure

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One of the primary issues in the dairy production industry is the storage, management, and land application of manure. Producers should plan how and when to apply manure to agricultural land to minimize the risk of water pollution and odor nuisance and maximize nutrient use.

The concentration of nutrients in the manure is important when planning land application operations. Nutrient concentration information is needed to determine the amount of manure to be spread per acre. Nutrient concentrations in manure may be similar from year to year for a given site where genetics, diet, housing, and management operations do not change significantly. However, nutrient concentrations can also be highly variable. Manure is not usually homogeneous in nature, and nutrients may stratify during storage. Nutrient content will change with changes in feed, bedding, handling, etc., and with seasons, depending on precipitation. Therefore, laboratory analysis of the manure should be performed each year to track nutrient concentrations.

An effective testing program must be attentive to when manure samples are collected, how they are obtained, how many samples are taken, and how frequently manure is tested.

Sampling Dairy Liquid Manure

Ideally, manure should be sampled during or just prior to hauling for land application operations. This will give the most accurate nutrient analysis because the process of agitation ensures that samples represent the contents of the storage structure. Make sure you do not wash away the banks or damage the liner during mixing. Samples taken at various stages during agitation and pumping of dairy manure in Kentucky showed no significant differences between samples. Sampling the manure from the application equipment is quicker and safer than collecting samples from the storage facility (Figure 1).

Alternatively, manure samples can be collected from the tanker that delivers manure to the fields (Figure 2). Sample as the tanker is being filled since solids may settle in the tanker if sampling is done later.

The primary drawback to sampling during agitation or hauling of manure to agricultural land is that the results of the current sample will not be available to plan the current year's application. However, the results can be used to determine whether adequate amounts of nutrients were applied, and they can be used as an estimate for next year's manure nutrient content. A series of samples from a specific farm can be used to estimate manure nutrients by comparing the moisture content as well.

Figure 1. Sampling manure directly from the pumping line.

Figure 2. Sampling manure from a tanker. (Source: University of Minnesota Extension Service)

Samples submitted to a laboratory for analysis should be a mixture of manure taken from different loads representing the beginning, middle, and end of the application process. A good rule of thumb is to take one subsample per 300,000 gallons of pumped manure. Typically, only one sample made out of three or four subsamples is needed for liquid slurries that have been properly agitated. Mix these subsamples thoroughly in a 5-gallon bucket.

If the slurry is not agitated, three or more samples of the storage are required because solids settle on the bottom of the storage pond and nutrients tend to stratify. Samples should be collected around the storage pond at several locations, and subsamples should roughly correspond to the top, middle, and bottom portions of the pond. A can or other container is often attached to a long pole and dipped into the manure, but this device is not suitable for collection of samples at different depths.

Instruments that have a manually operated valve that opens and shuts at the desired depth are more appropriate.

When manure is not too thick, a core-taker or "sludge judge" can be used. These devices are made of ½- or ¾-inch PVC pipe and contain a float valve at their end. The pipe is slowly lowered to the bottom of the storage, allowing manure to flow in through a float valve. The pipe fills up to surface level and can then be raised. Raising the pipe sets the check valve, trapping the manure inside. Contents are then emptied into a bucket.

Safety precautions should always be taken while sampling near manure storages. 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, and make sure all means of egress are accessible.

Sample containers that are sent to the laboratory should be clean and dry. Leak-proof plastic containers with a wide mouth work the best. Fill the container about two-thirds or three-quarters full to allow room for gas expansion. The minimum sample size is eight ounces of manure. Wipe off the sample jar and seal it in a bag with a zipper lock to help contain any possible leakage from the bottle. Manure samples should be frozen prior to mailing in order to slow down any microbial activity and mailed early in the week to avoid weekends and holidays. Sample containers should be mailed using polystyrene or plastic coolers. The use of ice packs is recommended to help keep the temperature low inside the cooler.

Quick Tests

Dairy farmers should be able to have an estimate of the nutrient contents of the manure as it is being applied to cropland. On-farm quick tests provide a way to monitor approximate nutrient content of liquid manure during land application.

There are several different types of kits for on-farm quick tests. Some of the most common kits include hydrometers, electrical conductivity meters, and simple nitrogen meters (Figure 3).

Analysis usually takes less than 10 minutes, and the equipment is relatively simple to use. Hydrometers can be used to obtain an estimate of the total solids and phosphorus contents. Electrical conductivity and the Agros® N meter can be used to obtain an estimate of the ammonium nitrogen.

Quick tests are less accurate than standard laboratory analyses but are useful as a manure utilization tool. Table 1 gives the coefficient of determination (R^2) for different quick tests used with dairy manure obtained from farms located in the Mammoth Cave area in central Kentucky. The higher the R^2 value, the higher the confidence in the test for estimating manure dry matter content and nutrients.

Researchers from other regions of the country obtained good results using conductivity pens when they diluted the manure sample first at a 5:1 ratio (Peter Wright, personal communication).

Table 1. Coefficient of determination (R^2) for different quick tests—Mammoth Cave area.

Quick Test	Nutrient	R^2
Hydrometer	Total Solids	0.76 – 0.81
	Total P	0.93
	Total N	0.89
Agros® N meter	NH_4^+-N	0.66
Conductivity meter	NH_4^+-N	0.70
Conductivity pen	NH_4^+-N	0.67 – 0.77

Development of a dairy waste utilization management tool has been completed for the Mammoth Cave area. This tool includes calibration of regression equations that can use rapidly determined parameters such as manure specific gravity and conductivity to estimate the nutrient content of dairy manure stored in earthen basins. It also explains how to estimate plant-available nitrogen from quick test results. Details about this tool are given in a separate University of Kentucky Cooperative Extension publication (AEN-92, *Dairy Waste Utilization Management Tool*).

On-farm quick tests can be valuable for estimating nutrient concentrations for land application management, but they should not replace traditional laboratory analyses of manure samples. Quick tests should be used in conjunction but *not* in place of laboratory tests. When selecting a quick test, it is useful to understand what the method measures and how it works. It is also important to become aware of its accuracy and limitations.

Figure 3. Hydrometer, conductivity meter, conductivity pen, and Agros® N meter (instruments shown are in different scales).

Land Application

Nutrient management planning is considered a best management practice that aims at optimizing crop yield and quality, minimizing inorganic fertilizer inputs, and protecting the environment (air, soil, and water). All dairy farms should have and follow a nutrient management plan. Details on the development of such plans are available from the University of Kentucky Cooperative Extension publications such as IP-71, *Nutrient Management in Kentucky*, and AGR-146, *Using Animal Manures as Nutrient Sources*.

Applying manure to land that is already overloaded with nutrients, especially phosphorus, may be a problem. For most farms trying to meet a nutrient standard, the most immediate problem is finding enough land to spread manure on. According to a recent study by USDA (Ribaudo et al., 2003), only 2% of large dairies (more than 700 cows) have enough land to meet a phosphorus standard resulting in a production cost increase of about 3.25%. The higher cost associated with a phosphorus standard reflects higher concentrations of phosphorus in manure than of nitrogen relative to crop nutrient needs. Basically more land is required to spread manure under a phosphorus standard than under a nitrogen standard because less manure is needed to satisfy crops' phosphorus needs.

Land application operations should exercise every precaution to avoid contaminating surface and groundwater. Manure should not be applied within 50 to 300 feet of a watercourse, pond, or well, depending on the type of equipment used. Note that the risk of causing groundwater pollution is high in Kentucky since a large portion of land directly overlies geological karst formations that may have fairly direct surface-to-groundwater connections. Avoid land application when the soil is wet, frozen, or covered with snow. Land application operations should be postponed when heavy rainfall is forecast.

Liquid manure should be placed as close to the ground as possible. Effective placement of manure depends on manure characteristics, the crop being fertilized, soil properties, moisture conditions, and the equipment used.

A major concern of land application operations is the release of odors and loss of nitrogen to the air, in the form of ammonia. If possible, inject manure (Figure 4), or incorporate it by plowing soon after application. The amount of odor emitted can be reduced by 85 to 90% when manure is injected as compared with liquid broadcasting. Ammonia losses can be reduced by 90 to 95%.

Injecting manure may reduce the risk of runoff as long as the rate at which the manure is applied is appropriate to the site. Avoid injection into porous backfill over drainage systems, particularly on very heavy soils, or into very light gravelly soils. Make sure there is no visible ponding on the soil surface or runoff from the land application area. Another alternative is to till the soil to facilitate movement of the liquid manure into the ground (Figure 5).

Traveling guns (Figure 6) are somewhat popular among dairy farmers to apply liquid manure to fields. Manure with solid content as high as 8% can be applied through a traveler if the manure is well mixed and solids have been reduced to small particles with a chopper pump (Jarrett and Graves, 2002).

The main disadvantages to using traveling guns to apply manure include uneven distribution of liquid on the fields, crop damage or soil compaction (basically due to droplets hitting the soil surface with high energy), significant losses of ammonia, and emission of offensive odors. The dark appearance of the manure stream shooting through the air, combined with the odor, draws negative public perception.

Try to spread manure when the wind is blowing away from public areas. In any case, avoid spreading on weekends or holidays. A little planning can go a long way to maintaining good neighbor relations. The best spreading conditions are where air mixes to a great height above the ground. Typically, sunny, windy days, followed by cloudy, windy nights, are best. These conditions help odors to dilute and disperse more rapidly.

Figure 4. Application and incorporation of manure into soil.

Figure 5. Tilling and manure application.

Figure 6. Application of manure with traveling gun.

Regular checking of a manure irrigation system is essential. Malfunctioning travelers may continually apply manure in one location, resulting in overapplication. Clogged nozzles, broken or separated pipes, and hoses can cause severe environmental problems that must be handled quickly and efficiently. It is a good idea to have a management plan as well as an emergency response plan in place. A well-thought-out emergency response plan should provide the necessary information to allow immediate containment and timely clean-up in the event of manure spills. It is important to know whom to contact and to document all procedures and steps taken since the spill occurred.

Dairy Manure Management Top 10 List

1. Develop a nutrient management plan.
2. If possible, sample manure during agitation and pumping, and follow the necessary safety precautions.
3. Test manure and soil nutrients before land application.
4. Use quick tests to estimate manure nutrients during application.
5. Use laboratory tests to make corrections for the following year's application.
6. Use common sense when applying manure–it is obvious that applying manure next to a watercourse or near an open tile inlet is fraught with danger.
7. Try to spread manure when the wind is blowing away from public areas; in any case, avoid spreading on weekends or holidays.
8. If possible, inject manure or incorporate it by tilling soon after application.
9. If you pump and irrigate manure, make sure the system is frequently checked for malfunctioning, nozzle clogging, broken or separated pipes.
10. Develop an emergency response plan.

References and Additional Resources

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Acknowledgments

Funding for this project was provided in part by a grant from the U.S. Environmental Protection Agency (USEPA) through the Kentucky Division of Water, Nonpoint Source Section, to the University of Kentucky as authorized by the Clean Water Act Amendments of 1987, §319(h) Nonpoint Source Implementation Grant No. C9994861-97. The contents of this document do not necessarily reflect the views and policies of the USEPA, KDOW, or University of Kentucky, nor does the mention of trade names or commercial products constitute endorsement. This document was printed on recycled paper.

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Issued 10-2006