Nutrient Concentrations in Manure Storage Facilities

Process Improvement for Animal Feeding Operations

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Introduction

The objective of this fact sheet is to help producers understand the nutrient loss and retention characteristics of different types of manure storage. The concentration of nutrients in manure storage facilities is important for planning land application activities. Nutrient concentration is usually the critical factor in determining the amount of manure to be spread per acre of land. Manure systems similar in type and management may have characteristically similar concentrations of manure nutrients. However, manure nutrient concentrations can be highly variable, even among similar systems, so laboratory analysis of the manure should always be performed to establish a trend or baseline of manure nutrient concentration.

Table 1

Manure Type	Nutrient Concentration, lbs/ton			
	Total Kjeldahl N	Ammonia N	P2O5	K2O
Poultry Litter[1]	40-80	10-20	30-60	30-50
Separated dairy Solids[2] 23% DM	5.8-7.4	0.3-0.7	1.8-2.4	2.4-3.6
Swine hoop structure[3]	12-15			
Mortality compost[4]	15-25	3-6	1-3	4-8
Beef feedlot, dirt lot	21-24	7	14-36	4-23

1 Range of values from NRCS Agricultural Waste Management Field Handbook 1996; MWPS-18, Livestock Waste Facilities Handbook 1993; University (U) of Missouri (MO) studies.
2 Performance of screen separator at U of MO dairy farm.
3 Studies from Iowa State U Rhodes Research Farm using cornstalk bedding.
4 Swine mortality compost, U of MO.

Solid manure systems

Examples of solid manure systems include poultry litter, separated manure solids, manure/bedding mixtures in hoop structures for swine, and mortality compost. Table 1 gives ranges of values that might be expected for nutrient concentrations in several types of solid manure.

Slurry manure systems

Typical slurry manure systems include under floor pits and outdoor storage tanks or basins to which manure is scraped, flushed, or drained by gravity (pull-plug). Slurry manure usually contains 5% to 10% dry matter and is usually handled with manure pumps and tank wagons. However, continuous pumping systems using "drag-hose injection" are becoming more popular for managing slurry manure. Slurry storage facilities should always be agitated before emptying because considerable settling and stratification of solids typically occurs in these structures. As with other types of manure, slurry manure can be quite variable in nutrient content, and a laboratory analysis should always be conducted to determine actual nutrient levels. Table 2 shows typical nutrient levels for different slurry manure systems.

Table 2

Slurry Type	Nutrient Concentration, lbs/1,000 gallons			
	Total Kjeldahl N	Ammonia N	P2O5	K2O
Poultry	60-80	15-60	35-45	30-95
Dairy	25-35	10-15	15-20	20-30
Swine	30-45	20-30	20-30	20-30
Beef	30-40	10-25	15-30	25-35

Source: Range of values from MWPS-18, Livestock Waste Facilities Handbook 1993; NRCS Agricultural Waste Management Field Handbook 1996; Ohio Livestock Manure and Wastewater Management Guide 1992; and studies at the University of Missouri

Liquid manure systems

Liquid manure systems (less than 5% solids) may be designed to function as lagoon systems that provide a degree of manure treatment. Climatic

Table 3

Manure Type	Nutrient Concentration, lbs/acre-inch (lbs/1,000 gallons)			
	Total Kjeldahl N	Ammonia N	P2O5	K2O
Poultry lagoon	80-170 (2.9-6.3)	60-120 (2.2-4.4)	50-150 (1.8-5.5)	400-500 (15-18)
Dairy lagoon	80-150 (2.9-5.5)	45-80 (1.7-2.9)	50-100 (1.8-3.7)	100-200(3.7-7.4)
Swine lagoon	100-300 (3.7-11)	85-250 (3.1-9.2)	40-80 (1.5-2.9)	100-300 (3.7-11)
Beef lagoon	40-120 (1.5-4.4)	40-60 (1.5-2.2)	80-250 (2.9-9.2)	100-250(3.7-9.2)
Beef feedlot, runoff holding pond	45 (1.67)	41 (1.50)	n/a	244 (9)

Source: Range of values from MWPS-18, Livestock Waste Facilities Handbook 1993; NRCS Agricultural Waste Management Field Handbook 1996; Ohio Livestock Manure and Wastewater Management Guide 1992; and studies at the University of Missouri.

effects such as rainfall and runoff from open lots can significantly influence the nutrient concentration of lagoons. Additionally, some nutrients are concentrated in the sludge layer and may not be available if the lagoon is not agitated. Lagoon effluent can be highly variable in nutrient content and should be analyzed to determine actual nutrient concentrations. Table 3 shows the ranges of values for nutrient concentration in lagoon effluent.

Nutrients Available After Losses in Manure Storage Facilities

Manure nutrients, especially nitrogen, are subject to many potential loss pathways after the animal excretes them. Volatilization to the atmosphere is a major loss pathway for nitrogen. Phosphorus and potassium can be lost in uncontrolled runoff or captured in settled solids or sludge that may not be agitated and removed during pump down. Many of the actual and apparent nutrient losses occur during manure collection, during manure transport to the manure storage facility, and in the facility itself. These accumulated losses are usually estimated and assigned according to the type of manure handling and storage system in place. The loss estimates can then be applied to excreted nutrient values, determining the nutrients available for land application. Table 4 shows the ranges of expected nitrogen losses for different types of manure-handling systems.

Table 4

System	Nitrogen Lost, %	Nitrogen Retained, %
Daily scrape and haul	20-35	65-80
Manure pack	20-40	60-80
Open lot	40-55	45-60
Deep pit (poultry)	25-50	50-75
Litter	25-50	50-75
Under floor pit	15-30	70-85
Aboveground tank	10-30	70-90
Holding pond	20-40	60-80
Anaerobic lagoon	70-85	15-30
Adapted from MWPS-18, Livestock Waste Facilities Handbook 1993.		

Solid manure systems

In solid manure systems, manure is usually mixed with a considerable amount of bedding. If the manure collection and transport system effectively captures all of the manure, then very little phosphorus and potassium will be lost. Since phosphorus and potassium are not subject to volatilization, most of these nutrients that the animal excretes should be available from the manure storage facility.

Slurry manure systems

Manure in slurry systems (under floor tanks, outdoor tanks or basins) usually has a moisture content of 90% to 95%. The relatively high content of water in slurry manure provides the potential for some biological activity that may affect nutrient availability. Nitrogen may be somewhat more subject to volatilization in slurry manure than solid manure because of the higher moisture content. Phosphorus and potassium, however, should not be lost if the manure collection and storage system effectively captures the nutrients.

Liquid manure systems

Liquid or lagoon systems typically exhibit solids concentrations less than 5%. Nitrogen volatilization is usually quite significant in lagoons due to the large surface area, relatively long-term storage, and biological activity, which convert organic nitrogen to the ammonia form. Additionally, since lagoons are not typically agitated and completely emptied (as are slurry pits or tanks), nitrogen, phosphorus, and potassium will accumulate in the lagoon's sludge layer. While this accumulation does not represent a loss to the outside environment, these nutrients are not available when the lagoon is pumped, unless agitation is included in the pumping operation, and are often considered "lost" when estimating available nutrients. Phosphorus in lagoons tends to concentrate in the sludge layer, which greatly reduces the fraction of available phosphorus if the lagoon is not agitated. Potassium is mostly soluble (dissolved in the liquid portion of the lagoon); however, lagoons typically may have only 20% to 30% of their volume pumped (depending on the ratio of treatment volume to total volume). Both phosphorus and potassium tend to accumulate in the sludge and treatment volume of lagoons. Research at the University of Missouri suggests that as little as 5% to 10% of excreted phosphorus and 15% to 30% of excreted potassium may be pumped from un-agitated swine lagoons in normal pump down procedures. Agitation will increase these percentages, but unless the lagoon is completely emptied, some residual nutrient accumulation will be present.

Reference: Livestock and Poultry Environmental Stewardship curriculum, lesson authored by Charles Fulhage and John Hoehne, University of Missouri, courtesy of MidWest Plan Service, Iowa State University, Ames, Iowa 50011-3080.