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 pumpdown. 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 21-8 shows the ranges of expected nitrogen losses for different types of manure-handling systems.

Manure-handling systems with a high water content generally lose more nutrients than solid or slurry systems.

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.

Solid manure systems usually retain 50% to 80% of the nitrogen in manure and most of the phosphorus and potassium.

Slurry manure systems

Manure in slurry systems (underfloor 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 impact 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.

Table 21-8. Nitrogen lost and retained in various types of manure handling and storage systems.

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
Underfloor 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.

PROBLEM 1

Estimate the amount of N, P_2O_5, and K_2O available annually in a broiler operation. Assume four buildings with 20,000 birds per building, and five flocks are produced each year. Average bird weight over the 7-week growth period is two pounds.

PROBLEM 2

Estimate the amount of N, P_2O_5, and K_2O available annually in a swine operation housing 1,000 finishing hogs. Average animal weight is 150 lbs, and the manure is collected in an underfloor pit.

WORKSHEET FOR CALCULATING PROBLEM 1

Facility type (solid storage, manure tank, lagoon) broiler

Selected nutrient accumulation period = 49 x 5 = 2 days

Nitrogen

Using data in Tables 21C-1 through 21C-9, calculate the nitrogen excreted.

lbN/d-1,000 #	x	no. animals	x	lbs/animal (avg. wt.)	x	period, d/1,000
1.1	x	80,000	x	2	x	245 /1,000 = 43,120 lbN

Using the availability factor from Table 21-8, calculate the nitrogen available.

LbN	x	availability factor		
43,120	x	0.6	=	25,872 lbN available

P_2O_5

Using data in Tables 21C-1 through 21C-9, calculate the P_2O_5 excreted.

lbP_2O_5/d-1,000 #	x	no. animals	x	lbs/animal (avg. wt.)	x	period, d/1,000
0.77	x	80,000	x	2	x	245 /1,000 = 30,184 lbP_2O_5

lbP_2O_5	x	availability factor		
30,184	x	1.0	=	30,184 lbP_2O_5 available

K_2O

Using data in Tables 21C-1 through 21C-9, calculate the K_2O excreted.

lbK_2O/d-1,000 #	x	no. animals	x	lbs/animal (avg. wt.)	x	period, d/1,000
0.55	x	80,000	x	2	x	245 /1,000 = 21,560 lbK_2O

lbK_2O	x	availability factor		
21,560	x	1.0	=	21,560 lbK_2O available

WORKSHEET FOR CALCULATING PROBLEM 2

Facility type (solid storage, manure tank, lagoon) swine underfloor pit

Selected nutrient accumulation period = 365 days

Nitrogen

Using data in Tables 21C-1 through 21C-9, calculate the nitrogen excreted.

lbN/d-1,000 #	x	no. animals	x	lbs/animal (avg. wt.)	x	period, d/1,000		
0.42	x	1,000	x	150	x	365	/1,000 =	22,995 lbN

Using availability factor from Table 21-8, calculate the nitrogen available.

LbN	x	availability factor		
22,995	x	0.75	=	17,246 lbN available

P_2O_5

Using data in Tables 21C-1 through 21C-9, calculate the P_2O_5 excreted.

lbP_2O_5/d-1,000 #	x	no. animals	x	lbs/animal (avg. wt.)	x	period, d/1,000		
0.36	x	1,000	x	150	x	365	/1,000 =	19,710 lbP_2O_5

lbP_2O_5	x	availability factor		
19,710	x	1.0	=	19,710 lbP_2O_5 available

K_2O

Using data in Tables 21C-1 through 21C-9, calculate the K_2O excreted.

lbK_2O/d-1,000 #	x	no. animals	x	lbs/animal (avg. wt.)	x	period, d/1,000		
0.26	x	1,000	x	150	x	365	/1,000 =	14,235 lbK_2O

lbK_2O	x	availability factor		
14,235	x	1.0	=	14,235 lbK_2O available

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 unagitated swine lagoons in normal pumpdown procedures. Agitation will increase these percentages, but unless the lagoon is completely emptied, some residual nutrient accumulation will be present.

In a lagoon, significant nitrogen is lost through volatilization, and phosphorus and potassium accumulate in the treatment volume and sludge layer.

PROBLEM 3

Estimate the amount of N, P_2O_5, and K_2O available annually in a swine operation housing 1,000 finishing hogs. Average animal weight is 150 lbs/head, and manure is collected in a lagoon system. Assume that 5% of the excreted phosphorus and 15% of the excreted potassium are available annually through lagoon pumpdown (no agitation).

WORKSHEET FOR CALCULATING PROBLEM 3

Facility type (solid storage, manure tank, lagoon) ____swine lagoon____

Selected nutrient accumulation period = ____365____ days

Nitrogen

Using data in Tables 21C-1 through 21C-9, calculate nitrogen excreted.

lbN/d-1,000#	x	no. animals	x	lbs/animal (avg. wt.)	x	period, d/1,000		
0.42	x	1,000	x	150	x	365	/1,000 =	22,995 lbN

Using availability factor from Table 21-8, calculate nitrogen available

LbN	x	availability factor		
22,995	x	0.15	=	3,449 lbN available

P_2O_5

Using data in Tables 21C-1 through 21C-9, calculate P_2O_5 excreted.

lbP_2O_5/d-1,000#	x	no. animals	x	lbs/animal (avg. wt.)	x	period, d/1,000		
0.36	x	1,000	x	150	x	365	/1,000 =	19,710 lbP_2O_5

lbP_2O_5	x	availability factor		
19,710	x	0.05	=	986 lbP_2O_5 available

K_2O

Using data in Tables 21C-1 through 21C-9, calculate K_2O excreted.

lbK_2O/d-1,000#	x	no. animals	x	lbs/animal (avg. wt.)	x	period, d/1,000		
0.26	x	1,000	x	150	x	365	/1,000 =	14,235 lbK_2O

lbK_2O	x	availability factor		
14,235	x	0.15	=	2,135 lbK_2O available