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G97-1334 Estimating Manure Nutrients from Livestock and Poultry

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Estimating Manure Nutrients from Livestock and Poultry

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This NebGuide discusses A procedures for estimating the quantity of nutrients in livestock manure

When managed properly, nutrients in livestock manure can be a valuable resource. When managed improperly, however, these same nutrients become a potential environmental pollutant. Accurate crediting of manure nutrients within a total crop nutrient program is fundamental to utilizing manure as a resource. This NebGuide will help producers estimate the total manure nutrients produced by their livestock (N, P and K) and show how to adjust for losses for various storage and handling situations (parts a and b, *Figure 1*). A companion NebGuide, G97-1335, will estimate the crop available nutrients (part c, *Figure 1*) from manure. To illustrate this process, calculations will be given for an example livestock farm. A worksheet for completing these calculations for your farm also is provided.

Total Manure Nutrients Produced

Livestock and poultry use only a portion of the nutrients fed them to produce meat, milk or eggs. The remaining nutrients are excreted in urine and feces. For example, in a normal finishing diet, yearling cattle retain between 10 and 20% of the nitrogen (N) and phosphorus (P) fed. A finishing pig will retain about 40% of the nitrogen.

The feeding program followed by the producer influences the nutrient quantity in manure. For example, excess levels of dietary protein and phosphorus lead to increased excretion of N and P. Availability of feed nutrients to the animal also will influence nutrient excretion. Livestock nutrition recommendations, such as the "Nutrient Requirements for Beef Cattle"[1] and "Swine Nutrition Guide"[2] maximize animal performance and minimize nutrient excretion in manure.

Using *Table I*, an estimate of total manure nutrients produced annually by a livestock or poultry operation can be calculated. First, enter the average animal capacity in column 2 (average number of animals at any one time, not the total animals marketed). In column 3, write the average weight for each animal group. Calculate a total animal weight (column 4) and multiply by the appropriate factor to obtain annual manure N (column 6), P_2O_5 (column 8) and K_2O (column 10) production. Sum the totals of columns 6, 8 and 10 for all livestock groups to determine total N, P_2O_5 and K_2O excreted by all livestock and poultry. Because nutrient losses will vary for different storage or treatment systems, it will be best to separate and total the manure nutrients delivered to each storage system.

Manure Nutrient After Storage Losses

Nitrogen is the nutrient most easily lost from manure. Manure nitrogen is found mostly in two forms. The ammonium form (NH_4^+) originates from urea nitrogen in the urine. Ammonium nitrogen is lost primarily by volatilization into the atmosphere. The remaining nitrogen is in a more stable, organic form; the losses from it are small. Phosphorus and potassium losses are generally minimal except in treatment lagoons where phosphorus settles with other solids.

[1]1996 Nutrient Requirements of Beef Cattle by National Research Council. Available from National Academy Press, 2101 Constitutional Avenue, Washington, D.C. 20418.

[2]Nebraska-South Dakota Swine Nutrition Guide. Available from IANR Communications and Information Technology, University of Nebraska, 105 Ag Communications Building, P.O. Box 830918, Lincoln, Nebraska

Figure 1. Three key estimates needed to use manure nutrients as a resource.

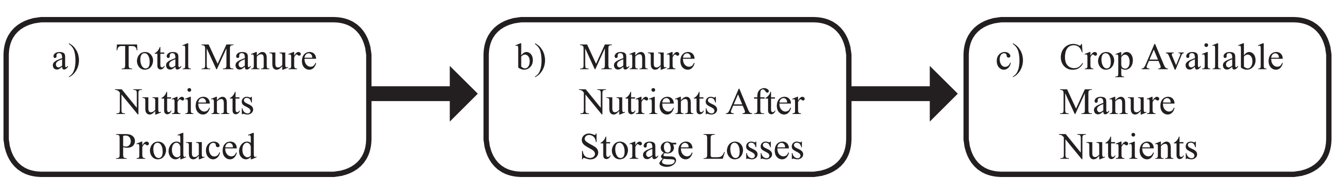

Table I. Total manure nutrients produced by livestock. Nitrogen, P_2O_5, and K_2O production can be calculated by entering livestock operation's information into columns 2 and 3 for the appropriate animal species and multiplying by the relevant factors.

1. Livestock or Poultry Species	*2. Number of animals (average capacity)*	*3. Average Animal Weight (lb.)*	*4. Total Animal Weight (No. X Avg. Weight)*	*5. Lb. of N per lb. of animal weight per year*	*6. Lb. N/yr. (Total weight X N)*	*7. Lb. of P_2O_5 per lb. of animal weight per year*	*8. Lb. P_2O_5 (Total weight X P_2O_5*	*9. Lb. of K_2O per lb. of animal weight per year*	*10. Lb. K_2O/yr (Total weight X K_2O.)*
Example: Swine...Finish	***2000***	***150***	***300,000***	0.15	***45,000***	0.13	***39,000***	0.10	***30,000***
Swine Nursery				0.22		0.21		0.15	
Grow				0.15		0.13		0.10	
Finish				0.15		0.13		0.10	
Sows & Litter				0.17		0.12		0.13	
Sows (Gestation)				0.07		0.05		0.05	
Gilts				0.088		0.066		0.058	
Boars				0.055		0.042		0.044	
Beef (450-750 lb.)				0.11		0.083		0.088	
Feeder (high energy diet)				0.11		0.078		0.092	
Feeder (high forage diet)				0.11		0.091		0.11	
Cow				0.12		0.10		0.11	
Dairy Cow...50 lb./d				0.18		0.087		0.100	
Cow...70 lb./d				0.22		0.096		0.110	
Cow...100 lb./d				0.27		0.110		0.130	
Dry Cow				0.11		0.074		0.079	
Heifer/Calves				0.11		0.033		0.11	
Layer				0.30		0.26		0.15	
Pullet				0.23		0.20		0.11	
Broiler				0.40		0.28		0.20	
Turkey				0.27		0.23		0.12	
TOTAL: If more than one manure storage or treatment system is used for different groups of animals, it is best to separate the groupings of animals and their nutrient excretion totals for each manure system.				System 1:					
				System 2:					

Source: NRCS Agricultural Waste Management Handbook, 4/92 with exception of dairy lactating and dry cows. Dairy estimates are from H.H. Van Horn. 1991. Achieving environmental balance of nutrient flow through animal production systems. The Professional Animal Scientist. 7:3:22-33.

Table II. Nutrients available (annually) after losses from open lot, storage or lagoon.[1] Enter the total manure nutrients produced (from *Table I*) in columns 2, 5, and 8 and multiply by the relevant factor describing your manure management system.

1. Manure Storage/Treatment System	*Nitrogen*			*P_2O_5*			*K_2O*		
	*2. N Produced **(Table I)***	*3. Multiplication Factor*	*4. Available N After Losses*	*5. P_2O_5 Produced **(Table I)***	*6. Multiplication Factor*	*7. Available P_2O_5 After Losses*	*8. K_2O Produced **(Table I)***	*9. Multiplication Factor*	*10. Available K_2O After Losses*
Example: Storage (liquid manure, top loaded storage)	***45,000***	***X 0.70 =***	***31,500***	***39,000***	***X 1.0 =***	***39,000***	***30,000***	***X 1.0 =***	***30,000***
Open lot or feedlot		X 0.5 =			X 0.95 =			X 0.7 =	
Manure pack under roof		X 0.70 =			X 1.0 =			X 1.0 =	
Storage (slurry manure, bottom loaded storage)[1]		X 0.85 =			X 1.0 =			X 1.0 =	
Storage (liquid manure, top loaded storage)		X 0.70 =			X 1.0 =			X 1.0 =	
Storage (pit beneath slatted floor)		X 0.75 =			X 1.0 =			X 1.0 =	
Poultry manure stored in pit beneath slatted floor		X 0.85 =			X 1.0 =			X 1.0 =	
Poultry manure on shavings or sawdust held in housing		X 0.50 =			X 1.0 =			X 1.0 =	
Compost		X 0.70 =			X 1.0 =			X 1.0 =	
1-Cell anaerobic treatment lagoon		X 0.20 =			X 0.35 =			X 0.65 =	
Multi-cell anaerobic treatment lagoon[1]		X 0.10 =			X 0.35 =			X 0.65 =	

Multiplication factor is portion of nutrients retained in the manure or effluent. Actual losses from individual situations may vary substantially from listed values.

Table III. Phosphorus retained as settled solids by an anaerobic treatment lagoon[1]. Enter quantity of total manure phosphorus estimated from *Table I*, interval (years) between when settled solids are removed, and complete calculation.

		1-Cell & Multiple Cell Treatment Lagoon		
	Total Pounds Produced Annually from Table I	*Years Between Solids Removal*	*Portion Retained in Lagoon*	*Total P_2O_5 in settled solids*
Phosphate			X 0.65 =	

[1]This applies to an anaerobic treatment lagoon with a permanent liquid pool and no agitation at time of effluent removal.

Table IV. Average manure nutrient application rate for crop land. Enter total pounds of nutrient from *Tables II* or *III* and crop acres over which manure is distributed in any one year and complete calculations.

	Total Pounds from Tables II and III	*Nutrient Application Rate on Currently Used Crop Land*	
		Land Area (acres)	*Nutrient Application Rate*
Example	***31,500 lb. of N***	***140 ac.***	***31,500 ÷ 140 = 225 lb. manure N /acre***
Nitrogen *(Table II)*			
P_2O_5 *(Table II)*			
K_2O *(Table II)*			
Settled Solids P_2O_5 *(Table III)*			

Typically, nitrogen recovered from a feedlot is 40 to 60% of the total manure nitrogen. Volatilization of ammonia is the primary loss mechanism. A small amount of phosphorus and potassium are lost with runoff from rainfall. *Table II* assumes 50% of the nitrogen and 95% of the phosphorus and potassium excreted by livestock can be recovered from an open feedlot.

Modest nutrient losses also will result from any manure storage. Nitrogen losses result from volatilization of ammonia from the storage surface and barn floor. If a storage is agitated and emptied to the same depth every year, phosphorus and potassium losses should be minimal.

Anaerobic treatment lagoons can incur significant nutrient losses. Eighty percent of the total nitrogen entering a lagoon is volatilized. While sizable amounts of phosphorus also settle out of the liquid effluent, it is not lost, but stored in the lagoon's sludge. This phosphorus will need to be managed when the sludge is removed.

Table II may be used to estimate nutrients remaining after losses from various manure management systems (see part 2 of Example). Enter the total manure nutrients produced (from *Table I*) into columns 2, 5 and 8 of *Table II*. Multiply these values by the portion of nutrients retained (multiplication factor) for the appropriate manure management system. An estimate of the phosphorus in the lagoon sludge after multiple years of accumulation can be made with *Table III*.

Manure Nutrient Application Rate

Over-application of manure nutrients is a potential water quality problem. A quick check of application rate can be done using *Table IV* and comparing your nutrient application rate to crop removal values in *Table V* (see part 3 of Example). This quick check provides a preliminary indication as to whether sufficient land is available for distributing manure nutrients. In order to determine a specific nutrient program, including the quantity of crop-available manure nutrients, producers should refer to the NebGuides listed at the end of this publication.

High rates of nitrogen application suggest water quality problems. Applying any form of nitrogen, including manure nitrogen, in excess of crop needs will impact drinking water quality, especially that of wells closest to the application site. However, this estimated nitrogen application rate requires additional review. Surface-applied manure will lose additional N to the air as ammonia. In addition, the organic fraction of the manure is not entirely available to the crop during the application year. If the nitrogen application rate from *Table IV* appears excessive, review NebGuide G97-1335 to estimate crop available manure nitrogen.

High rates of phosphorus application also are a water pollution concern. Most manure applications exceed the crop needs for phosphorus. Fields receiving livestock manure require regular soil testing and close monitoring of soil phosphorus levels. Phosphorus levels over 150 to 200 ppm represent a risk to surface water quality due to potential phosphorus loss in surface runoff. Annual manure applications to the same field will result in increased soil phosphorus levels. High potassium levels also are common problems with regular manure applications. While high potassium levels are not a water quality concern, they may result in excessive potassium levels in animal feeds and, under extreme conditions, create soil structure problems similar to those resulting from sodium.

As discussed above, manure typically provides more phosphorus than the crop needs. Crops uptake of nitrogen and phosphorus is in a ratio ranging from 4.5 to 9 pounds of nitrogen per pound of phosphorus (P). Manure is generally

Table V. Average nutrient removal by crops.

Crop/Forage	*N Content*	*P_2O_5 Content*	*K_2O Content*
GRAIN	lb. N/bu. of grain	lb. P_2O_5/ bu. of grain	lb. K_2O / bu. of grain
Corn Grain	0.90	0.39	0.22
Grain Sorghum	0.90	0.38	0.21
Oats	0.38	0.24	0.15
Soybean	3.76	0.82	1.20
Wheat	1.36	0.50	0.27
FORAGE	lb. N/ton of forage	lb. P_2O_5/ton of forage	lb. K_2O /ton of forage
Alfalfa Hay	57.2	11.8	55.1
Alfalfa Haylage	25.0	5.5	21.4
Corn Silage	8.6	3.2	7.7
Forage Sorghum	7.0	2.7	9.6

excreted at N to P ratios of 2 or 3 to 1. Adding to the problem: nitrogen is easily lost while phosphorus is not. By the time manure is delivered to the field, the relative application of N and P provided is far from the crops needs. What may result from regular application of manure to a field is increased soil phosphorus levels which, in turn, increase the risk of surface water contamination. To avoid high soil phosphorus levels, consider:

1. Applying manure at a rate based upon crop's phosphorus needs. Supplementing with commercial fertilizers to meet nitrogen needs.
2. Applying manure at a nitrogen-based rate only once every three to five years. Excess phosphorus and potassium is then harvested by crops during the intervening non-application years.
3. Regularly test soil for soil phosphorus level. Avoid manure applications to any site where soil phosphorus levels exceed 150 ppm.

Summary

Use of manure nutrients as a resource means estimating the quantity of each nutrient produced and available from your manure management system. Using typical manure nutrient production values and approximate nutrient losses from manure storage systems, a reasonable estimate of the nutrients produced by a livestock operation can be made. This information can assist in a quick check of the land requirements for spreading manure. However, NebGuide G97-1335 should be used for determining a desired application rate based upon crop available nutrients.

Other NebGuide Resources

G97-1335	Determining Crop Available Nutrients from Manure
G74-174	Fertilizer Suggestions for Corn
G82-595	Understanding Nitrogen in Soils
G87-859	Fertilizer Suggestions for Soybeans
G91-1000	Guidelines for Soil Sampling
G94-1178	Fertilizer Nitrogen Best Management Practices
G95-1267	Manure Applicator Calibration
G95-1266	Environmental Considerations for Manure Application Systems Selection

Example

A swine finishing facility maintains an average population of 2,000 finishing pigs (150 pounds average weight). The pigs are housed on slatted floors with storage below the slats. Manure from the facility is spread on 140 acres of pivot-irrigated corn each spring and fall. This field is in continuous corn with a five year yield history of 175 bushels per acre.

Question	*Answer/Recommendation*
1. **Total Manure Nutrients Produced:** What quantity of manure nutrients are produced by this livestock operation?	From *Table I*, it is estimated that this swine operation annually produces manure containing 45,000 pounds of nitrogen, 39,000 pounds of P_2O_5, and 30,000 pounds of K_2O prior to any losses. N: 2000 animals X 150 lbs. X 0.15 = 45,000 lbs./year P_2O_5: 2000 animals X 150 lbs. X 0.13 = 39,000 lbs./year K_2O: 2000 animals X 150 lbs. X 0.10 = 30,000 lbs./year
2. **Manure Nutrients After Storage Losses:** After considering storage losses, how much nitrogen, phosphorus, and potassium will be available for land application? From *Table II*, it is estimated that 70% of the nitrogen and all of the phosphorus and potassium will be removed annually from storage and available for land application:	N: 45,000 lbs./year X 0.70 = 31,500 lbs./year P_2O_5: 39,000 lbs./year X 1.0 = 39,000 lbs./year K_2O: 30,000 lbs./year X 1.0 = 30,000 lbs./year
3. **Manure Nutrient Application Rate:** Is there sufficient land area for use of manure nutrients?	From *Table IV*, it is estimated that manure nutrients are being applied at the following rates: N: 31,500 lbs./year ÷ 140 acres = 225 lbs./acre P_2O_5: 39,000 lbs./year ÷ 140 acres = 279 lbs./acre K_2O: 30,000 lbs./year ÷ 140 acres = 214 lbs./acre From *Table V*, crop nutrients are removed from this field at a rate of: N: 175 bu./ac. X 0.90 lb. N/bu. of grain = 158 lbs./acre P_2O_5: 175 bu./ac. X 0.39 lb. P_2O_5/bu. of grain = 68 lbs./acre K_2O: 175 bu./ac. X 0.22 lb. K_2O /bu. of grain = 39 lbs./acre Both P and K application rates are excessive. Manure nitrogen application after application losses and slow release of organic nitrogen may be less of a problem. Based upon this information the producer should consider: • calculation of the crop available nitrogen from manure (see NebGuide G97-1335), • implementation of a soil test program, and • a review of alternative sites for manure application for the next two years.

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