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CLEAN WATER

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Self Assessment Worksheets for Manure Management Plans

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Sound manure management practices can reduce the potential for adverse environmental, agronomic, and economic consequences. Livestock producers do not always recognize the potential pollution risk they may be creating, thus management to lessen this risk is sometimes delayed. One way to understand the overall manure management system is to evaluate the overall farm nutrient balance--with manure as one source of nutrients and crops as the user of nutrients. By knowing the relationship between manure's nutrient content and crop needs, manure application decisions can be made for questions such as where to spread manure, how much to spread, and what nutrient to base application rates on.

Collectively, the answers to these questions form the manure management plan. The goal of a manure management plan is to maximize the agronomic benefit of manure's nutrients while minimizing any potential environmental concerns.

The worksheets in this publication can be used to provide a framework for developing a manure management plan. The questions you can answer by completing this series of worksheets are: 1) What amounts of nutrients are in manure produced by your operation? 2) What rate should the manure be spread onto each field? And 3) In comparison to the crop's nutrient needs, will supplemental commercial fertilizer be required?

Section 1. Nutrient inventory from manure production.

Knowing the amount of nutrients manure can provide is a key part of a manure management plan. There are different ways to obtain this information; the preferred method will be described. This requires that the stored manure be sampled and chemically tested to determine its nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) concentrations. A less desirable option is to use standardized manure analyses for given livestock species and handling practices (Table 1). The total volume of stored manure is then multiplied by its nutrient analyses to calculate the total amount of nutrients available. This process is outlined in Worksheet 1. The result of this worksheet will be to know how much N, P_2O_5, and K_2O are in the stored manure.

Table 1. Average nutrient analysis of liquid and solid manure.
Livestock waste facilities handbook, Midwest Plan Service, March, 1985.

Form	Specie	Bedding/Storage	Dry Matter	Total N	P_2O_5	K_2O
			-- % --	---lb/1000 gal.---		
Liquid:	Swine	Anaerobic pit	4	36	27	22
	Dairy	Anaerobic pit	8	24	18	29
	Beef	Anaerobic pit	11	40	27	34
				--- lb/ton ---		
Solid:	Swine	No bedding	18	10	9	8
		With bedding	18	8	7	7
	Dairy	No bedding	18	9	4	10
		With bedding	21	9	4	10
	Beef	No bedding-dirt	15	11	7	10
		No bedding-concrete	52	21	14	23
		With bedding	50	21	18	26
	Turkey	No bedding	22	27	20	17
		With bedding	29	20	16	13

An example used in Worksheet 1 calculates the amount of nutrients in each storage facility using a laboratory analysis of the manure. Here, in a anaerobic, slatted floor, dairy pit; liquid manure was sampled and analyzed, the results being a 24-18-29 (N-P_2O_5-K_2O) nutrient analysis per 1000 gal. The annual amount of manure being stored was 673,000 gal; therefore the total nutrients are calculated by multiplying the storage volume and the analysis. For N, 673,000 gal x 24 lb/1000 gal equals 16,152 lb N. If more than one storage facility is used, the total nutrients for each facility would be summed for a whole operation analysis.

Section 2. Crop nutrient needs.

Knowing the nutrient requirements of your farm enterprise is the next step in a manure management plan. The nutrients contained in manure only have value if crops need those nutrients. Any nutrients applied that exceed crop needs are susceptible to build-up in the soil, leaching through the soil, and/or moving with the soil through erosion from the field.

Crop nutrient needs should be determined on a field-by-field basis. A fertilizer recommendation for a given field requires knowledge of the crop to be grown, the anticipated yield goal, the previous crop, and soil test levels. Because no two fields have the same production potential or soil test level, determining nutrient needs on a field basis is more appropriate than determining nutrient needs based solely on the crop and its nutrient removal rates.

Each field's nutrient needs for N, P_2O_5, and K_2O are needed to complete Worksheet 2. These fertilizer recommendations can either be obtained from the laboratory/consultant doing the field's soil sampling; or can be determined for each operator using Minnesota Extension Service fertilizer recommendation guide that can be obtained at any county Extension office. The goal from this activity is to accurately know the total amount of N, P_2O_5, and K_2O needed on the farm.

Initially, it is suggested that only the fields where one plans to spread manure be listed in Worksheet 2. Then, if the crops' nutrient needs are less than the manure's nutrient supply, other fields that originally had not been listed may need to be added. While most producers do not consider manure applications to alfalfa and/or soybean fields, these crops do require P and K and it may be necessary to use these fields for manure application. Also, for many producers, it may not be feasible to consider fields one or two miles from the manure storage facility due to transport costs, yet manure could be applied to them if necessary.

The example in Worksheet 2 uses a field designated as the North 40, a 40-acre where corn will be the crop grown. From the University of Minnesota Soil Testing Laboratory, fertilizer recommendations of 120-30-50 were prescribed based on realistic yield goals and specific site conditions. Each of the nutrients must then be multiplied by the number of acres in the field to calculate the total nutrients required for the field. After the desired fields are listed, each field's total nutrients should be summed to arrive at a nutrient demand for the entire operation for the year being planned.

After completing Worksheet 2, the first objective of a manure management plan can be evaluated: that is, does one have enough fields planned for application based on the amount of manure produced? The overall comparison between nutrients produced and nutrients required is important because this has a large bearing on how the manure is managed. The values to compare are the totals summed for all facilities from Worksheet 1 with the totals summed for all fields in Worksheet 2.

On farms where the amount of manure (nutrients) is greater than the cropland needs, there are environmental implications such as potential groundwater contamination from overapplication of N in manure and fertilizer. Management decisions can be made that will diminish the threat to the environment. First, other fields that are an option for spreading manure should be included in Worksheet 2; including distant fields and those with legumes. Also, the option using unincorporated broadcast applications will increase N volatilization losses and, therefore, remove some of the threat of N leaching below the rooting zone. Another option is to distribute the manure to off-farm locations.

When the amount of nutrients from manure is less than the crops' needs, management strategies should be planned that most efficiently use the manure. From economic, agronomic, and environmental perspectives, it is best to apply the manure at rates based on the P content. This generally requires supplemental N fertilization, which can easily fit into most producers systems. Also, one can manage manure to minimize nutrient losses by incorporating any broadcast manure and eliminate winter/summer manure applications.

Section 3. Field rate determination

The next phase of the manure management plan is to allocate manure to fields--a process whose goals are to minimize excess nutrients applied to a field and/or minimize supplemental fertilizer. There will always be either shortages or excesses of nutrients because the analysis of manure is rarely proportional to the crop's needs.

Although a common practice has been to apply manure at relatively high rates that facilitated manure disposal or eliminated the need for supplemental fertilizer, this concept should be reevaluated in light of environmental concerns. Excess N can pose a threat to groundwater quality while excess P can be a serious threat to surface waters.

In calculating the manure application rate for each field, one decision a producer makes that affects rate calculations is the application method. Application method has the most effect on the N supplied by the manure because of differences in N availability and losses that can occur. Unincorporated liquid manure will have a considerably lower N availability status compared to an injected application (Table 2).

Rate of manure application is a function of which nutrient (normally N or P) is selected as a basis for the rate. Manure is relatively high in P and low in N compared to crops' needs for P and N. Thus, when manure supply is great compared to cropland acres, N is the nutrient that should be selected for basing application rates, unless surface water contamination potential is high. Or, if there are plenty of fields for manure and supplemental fertilizer will be purchased, basing the application rate on P is most efficient. After selecting which nutrient to base the rate on, it is important to note the excesses or shortages of the other nutrients.

Table 2. Nitrogen availability estimates for the growing season following manure application as a function of application method.

	Broadcast-Incorp.[1/]			Injection	
Specie	None	≤12 hrs	≤4 day	Sweep	Knife
	% of Total N				
Swine	30	65	45	65	50
Dairy	20	60	40	55	45
Beef	25	60	45	55	45
Poultry	30	75	55	-	-

[1/] The categories refer to the length of time between manure application and incorporation.

Worksheet 3 uses information that was also used in Worksheets 1 and 2. For example, the fertilizer recommendations for the North 40 field are listed. Next, nutrient availability is considered; for N, Table 2 gives the availability based on method of application. In this example, liquid dairy manure is broadcast onto the field and is incorporated the following day, for an availability of 0.40 (decimal form of 40%). The P and K availability is considered to be 0.80 and 0.85, respectively, regardless of application method.

Each of these application availability indices is then multiplied by the nutrient analysis from Worksheet 1 to result in the available nutrients in the applied manure. In this example, the N in manure is 24 lb/1000 gal, with 40% availability for 9.6 lb N/1000 gal available. With P, there was 18 lb/1000 gal from manure analysis, and this would be multiplied by 0.80 for 14.4 lb/1000 gal available after application.

Because the crop needs 120 lb N, it would take 12,500 gallons (120 lb N needed divided by 9.6 lb N available per 1000 gal) of manure per acre based on N. For P, considering the 80% availability, it would take 2,100 gallons (30 lb P_2O_5 needed by crop divided by 14.4 lb P_2O_5/1000 gal available in applied manure) of manure per acre.

In Worksheet 4, the selected rate in this example was chosen to be the rate determined using P_2O_5 as a basis (2,100 gallons per acre). This selected rate can then be multiplied by the available nutrients in the applied manure to determine the available applied nutrients. In this example, there was 24.7 lb K_2O per 1000 gal and this is multiplied by 2,100 gal per acre for a total of 52 lb per acre of available K_2O applied.

Supplemental fertilizer will be needed if the crop's nutrient recommendations are greater than the available nutrients applied. For this example, the N required was 120 lb per acre and the applied, available N was 20 lb/acre, therefore 100 lb per acre (120-20=100) of supplemental N is needed. Residual nutrients are listed when the amount of available applied nutrients are greater than the nutrient recommendations. In this example, there was 2 lb per acre of residual K_2O (52 lb applied minus 50 lb needed).

In the previous situation, the selected application rate was relatively low, being based on the P calculations. When N is used as the determining factor, the application rate is generally higher, the amount of supplemental fertilizer is lower, and the amounts of residual nutrients will be higher. Also, note that there will always be residual N from manure applications. Some N is not available the first year; yet will become available in the second year. The amount of this second-year credit is approximately 20% of the total N applied. Thus for the previous example, with an initial N content of 24 lb N/1000 gal and an application rate of 2,100 gal per acre, the amount of N credit the second year would be 10 lb N/acre (2100 gal/acre x 24 lb N/1000 gal x 0.20).

In using these Worksheets, the calculation of manure rates for each field on a field-by-field basis assumes that there is an unlimited supply of manure and no manure will be remain after all field rates are calculated. This is obviously not reality. Therefore, decisions will need to be made in prioritizing fields and being aware of the overall nutrient supply and crop demands for the entire operation when selecting the appropriate rates to use.

Summary

A whole-farm manure management plan should be developed to assess both the nutrient amounts in manure and the farm's nutrient needs on a per field basis. With this information, management decisions regarding manure application (i.e. method of application, rate of application) can be made to reduce excessive nutrient applications while minimizing the amount of commercial fertilizer that needs to be applied to each field.

Worksheet 1.

Determination of nutrient production based on storage quantity and manure analysis.

Storage Facility	Handling Basis[1/]	Capacity	Manure Analysis[2/] N	P₂O₅	K₂O	Analysis Source[3/]	Total Nutrients[4/] N	P₂O₅	K₂O
	L or S	1000 gal ---ton---	---------lb/1000 gal-------- ------------lb/ton------------			L or T	---------------lb--------------		
Beneath barn pit	L	673	24	18	29	L	16,152	12,114	19,517
						Total			

1/ Handling basis refers to whether the manure will be treated as a liquid (L) or a solid (S). If a liquid, all appropriate units will be per 1000 gal; if solid, all appropriate units will be per ton.

2/ Manure analysis will be lb of nutrients (Total N, P_2O_5, and K_2O) per 1000 gal or per ton.

3/ List source of manure analysis, either L for laboratory analysis or T for tabled values, such as those in Table 1.

4/ Total nutrients are from capacity times analysis for each facility and then summed for all facilities.

Worksheet 2.

Fertilizer nutrient requirements for individual fields and the entire farm.

			Nutrient Recommendations[1/]			Total Nutrients Required[2/]		
Field Name	Size	Crop	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	-acre-		---------- lb/A ----------			---------- lb ----------		
North 40	40	Corn	120	30	50	4800	1200	2000
					Total			

[1/] Fertilizer recommendations are to be listed as lb of nutrients (Total N, P_2O_5, and K_2O) per acre.

[2/] Total nutrients required are from field acreage times fertilizer recommendation for each field and then summed for all fields.

Worksheet 3.

Manure rate determinations based on N, P, and K for individual fields.

Field Name	Nutrient Recommendations[1/]			N Application Availability[2/]	Available Nutrients in Manure[3/]			Application Rate Based On[4/]		
	N	P_2O_5	K_2O		N	P_2O_5	K_2O	N	P_2O_5	K_2O
	------lb/A-------			-------%------	-----lb/1000 gal---- --------ton/A-------			---1000 gal/A--- -----ton/A-----		
North 40	120	30	50	40	9.6	14.4	24.7	12.5	2.1	2.0

1/ Nutrient recommendations for each field can be transferred from Worksheet 2.

2/ These values are in Table 2 for N. Note that for calculations, one must use decimal form of availability percentages.

3/ Multiply N availability by manure N content from Worksheet 1. For P_2O_5 and K_2O, use availability indices of 0.80 and 0.85, respectively, to multiply by Worksheet 1 nutrient contents.

4/ For each nutrient, divide the nutrient recommendation by the available nutrients in the applied nutrients.

Worksheet 4.

Nutrients applied onto individual fields and supplemental fertilizer/residual nutrient amounts.

Field Name	Selected Rate[1/]	Applied, Available Nutrients[2/]			Supplemental Fertilizer[3/]			Residual Nutrients[4/]		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	1000 gal/A --ton/A--	---------- lb/A ----------			---------- lb/A ----------			------------ lb/A ------------		
North 40	2.1	20	30	52	100	0	0	0	0	2

1/ The selected rate of manure to be applied (see Worksheet 3).

2/ Multiply the selected rate by the available nutrients in manure (Worksheet 3) for each nutrient.

3/ With each nutrient, subtract the applied nutrients from the nutrient recommendations (Worksheet 2 or 3). List negative numbers as 0 (zero).

4/ For each nutrient, subtract the nutrient recommendations from the applied, available nutrients. List as 0 (zero) if a negative value.

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