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HOMESTEAD ASSESSMENT SYSTEM

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Reducing the Risk of Groundwater Contamination from

Livestock Manure Management

R. Miner

Spreading livestock and poultry manure on crop and pastureland is a way to reclaim the value of the plant nutrients in manure. This practice is the most popular and widely recommended way to utilize these manures. Nitrogen and phosphorus are the nutrients of greatest value in manure and are the most frequent basis upon which land application rates are calculated.

The challenge in managing manure is to apply it in the quantity and method that will meet the following objectives:

- Provide the proper amount of nitrogen and phosphorus
- Prevent manure from being carried off the land surface due to runoff
- Assure that nutrients are not carried beyond the root zone to contribute to groundwater contamination

1. Amount of nutrients available

The best way to know the quantity of nutrients in manure is to have it tested. Frequently, however, manure samples for analysis are not readily available. If not, you can use Tables 1–4 to estimate the amount of nitrogen and phosphorus available for use in your fields.

- Table 1 provides an estimate of nitrogen and phosphorus contained in various fresh manures.
- Table 2 suggests the extent to which the nutrients are conserved in various manure handling systems.
- Table 3 shows the percentage of these nutrients that is conserved by various means of distributing manure onto cropland. Note that some nitrogen is lost in each application method.
- Table 4 provides the numbers necessary for estimating the nitrogen that is available after denitrification losses. Note that in areas with greater water application (either rainfall or irrigation), there is greater nitrogen loss.

By multiplying the number of animals supplying manure by the appropriate values from Tables 1–4, you can estimate the number of pounds of nitrogen and phosphorus available for use in your fields.

For glossary, see page 2 of EM 8596.

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OREGON STATE UNIVERSITY EXTENSION SERVICE

For example, from Table 1, you see that a dairy cow excretes about 0.45 lb nitrogen and 0.094 lb phosphorus each day. If you have 100 dairy cows, this yields a total of 45 lb nitrogen and 9.4 lb phosphorus per day:

N: 0.45 lb x 100 cows = 45 lb
P: 0.094 lb x 100 cows = 9.4 lb

If you store the manure dry in a roofed shed, Table 2 tells you that you retain about 70 percent of the nitrogen and 90 percent of the phosphorus. This leaves you with 31.5 lb nitrogen and 8.46 lb phosphorus:

N: 45 lb x 0.70 = 31.5 lb
P: 9.4 lb x 0.90 = 8.46 lb

Table 1.—Production and nutrient content of freshly excreted manure from various farm animals.

Animal	Animal size, lb	Manure production gal/day	% water	Nitrogen production lb/day (N)	Phosphorus lb/day (P)
Dairy	1,000	10	88	0.45	0.094
Beef	1,000	9.4	91	0.43	0.12
Swine	200	1.5	89	0.10	0.036
Sheep	100	0.46	87	0.045	0.0066
Horse	1,000	6	78	0.28	0.05
Layers	4	0.027	84	0.0034	0.0012

Table 2.—Percent of original nutrient content of manure retained by various manure management systems.

Method	Beef N	Beef P	Dairy N	Dairy P	Horse N	Horse P	Poultry N	Poultry P	Sheep N	Sheep P	Swine N	Swine P
Daily spread	-	-	80	90	75	90	65	90	75	90	-	-
Dry storage, roofed	60	75	70	90	70	90	60	90	65	90	-	-
Earthen storage	65	80	55	60	-	-	60	60	-	-	60	60
Lagoon/ flushing	30	40	30	40	-	-	25	40	-	-	30	40
Open lot	60	70	60	70	60	70	-	-	55	70	60	70
Pits under slats	75	95	75	95	-	-	70	95	75	95	75	95
Scrape to storage tank	70	85	70	90	-	-	-	-	-	-	-	-
None grazing	100	100	100	100	100	100	100	100	100	100	100	100

If you broadcast the manure, Table 3 indicates that about 80 percent of the nitrogen (25.2 lb) and all of the phosphorus (8.46) lb will be available for plant uptake:

N: 31.5 lb x 0.80 = 25.2 lb
P: 8.46 lb x 1 = 8.46 lb

Remember, the values in these tables are averages. If you have more accurate values based upon laboratory analyses or on your cropping experience, use them instead.

If your cropland is in the Willamette Valley and is irrigated, Table 4 shows that 87 percent of the nitrogen will be available after losses. This leaves you with 21.9 lb nitrogen and 8.46 lb phosphorus.

N: 25.2 lb x 0.87 = 21.9 lb
P: 8.46 lb x 1 = 8.46 lb

Remember, these are per-day amounts. By multiplying these amounts times 365, you find that your total annual nutrient availability from manure is 7,993 lb nitrogen and 3,088 lb phosphorus:

N: 21.9 lb x 365 = 7,993 lb
P: 8.46 lb x 365 = 3,088 lb

Table 3.—Percent of manure nutrients available for plant uptake compared to that available from the storage system.

Application method	Nitrogen	Phosphorus	Potassium
Soil injection	95	100	100
Broadcast	80	100	100
Broadcast with immediate incorporation	95	100	100
Sprinkling	75	100	100
Grazing	85	100	100

Table 4.—Percent of field-applied manure nitrogen available to the crop after denitrification losses, by region in Oregon.

Location	Percent N available
Coastal valleys	80
Willamette Valley and southern Oregon	
Irrigated	87
Nonirrigated	92
Eastern Oregon	95

2. Amount of cropland available

To use manure efficiently and responsibly as a source of crop nutrients, you must apply it at a rate consistent with that removed by the growing crops. Table 5 lists nutrient utilization rates for crops commonly grown on livestock farms in Oregon.

Estimate your yields for the crops you grow and enter them in Table 5 under "Your yield (tons/acre)." Then multiply your yields times the application rates listed in Table 5 to find your application rates per acre. Enter these numbers under "Your application rate per acre." Similar values for pastures are included in Table 6.

For example, if you grow red clover for silage, Table 5 tells you that the nutrient application rate is 14.5 lb nitrogen per ton and 2 lb phosphorus per ton. If your yield is 8 tons per acre, multiply each of these rates times 8 to determine your nutrient application rate per acre:

N: 14.5 lb N x 8 = 116 lb N per acre
P: 2 lb P x 8 = 16 lb P per acre

Table 5.—Rates of nutrients used.

Crop	Unit	Rate (lb) N	P	K	Your yield (tons/acre)	Your application rate per acre N	P	K
Alfalfa hay, immature and early bloom	per ton	65.0	5.3	42.0	______	___	___	___
Alfalfa hay, midbloom to mature	per ton	45.0	4.5	36.0	______	___	___	___
Canarygrass hay	per ton	40.0	7.5	63.0	______	___	___	___
Orchardgrass	per ton	38.4	6.1	37.6	______	___	___	___
Cereal grain hay	per ton	24.0	3.4	10.0	______	___	___	___
Grass hay	per ton	25.0	3.6	19.4	______	___	___	___
Barley/oats	per ton	34.0	5.0	7.2	______	___	___	___
Alfalfa/grass silage	per ton, wet	22.0	2.9	19.0	______	___	___	___
Red clover silage	per ton, wet	14.5	2.0	12.0	______	___	___	___
Corn silage	per ton, wet	7.0	2.5	6.6	______	___	___	___
Corn earlage	per ton, wet	25.5	4.6	5.6	______	___	___	___

Table 6.—Suggested nutrient application rates for pastures, by location, harvested and grazed (lb/acre).*

Location	Harvested N	Harvested P	Harvested K	Grazed N	Grazed P	Grazed K
Coast	220	28	132	165	24	110
NW valleys						
irrigated	200	25	120	150	22	100
nonirrigated	110	21	95	80	20	92
Southern Oregon						
irrigated	180	24	110	75	20	90
nonirrigated	80	20	92	50	19	87
Eastern Oregon	200	25	120	120	21	96

*These values include a fraction of the nutrients in addition to the plant uptake values to account for the portion that is unavailable to the plant and contributes to an increase in soil organic matter.

Now, by calculating the number of acres that each nutrient will cover, you can determine how to gain the greatest economic value from the manure and avoid applying excess manure.

In the earlier example on page 3, we calculated a total annual nitrogen availability of 7,993 lb. If you need 116 lb nitrogen per acre, you have enough nitrogen for 69 acres:

N: 7,993 lb ÷ 116 lb per acre = 69 acres

You have 3,088 lb of phosphorus. If you need 16 lb phosphorus per acre, you have enough phosphorus for 193 acres:

P: 3,088 lb ÷ 16 lb per acre = 193 acres

Select the nutrient that is available for the greatest acreage, in this case phosphorus. On page 7 you will calculate the rate at which to apply the manure based on the quantity of phosphorus available. You can then supplement the manure with commercial fertilizer to supply the nutrient that is inadequately provided by the manure.

3. Site characteristics

Examine your cropland carefully in order to avoid pollution. Sites with a deep soil profile above the water table can store more nutrients in the profile. As a result, there is less chance of groundwater contamination.

Soil texture also is important. Medium- to fine-textured soils rich in loam and silt have much greater nutrient- and water-holding capabilities than do coarse, sandy soils.

Soils with an impermeable layer near the surface may experience runoff. In these soils, the available profile can become saturated, and runoff occurs independently of the rainfall or irrigation intensity. This runoff, if it occurs on manure-covered land, can be a major water quality hazard.

An ideal manure application site is level or has only a mild slope. Its surface should be covered with dense vegetation, which traps manure particles and retains rainfall or irrigation water. This reduces the likelihood of runoff carrying manure particles from the soil surface to nearby streams and enhances the likelihood of infiltration.

An appropriate site for manure application also is located at least 100 feet from a well and at a lower elevation than the well. The site should be separated from a surface watercourse by a vegetated buffer strip, which reduces any water-carried manure particles or soluble manure characteristics. Soil type also is important in evaluating the adequacy of separation from either a well or a surface watercourse.

Capacity of the farmsite to receive additional nutrients

In order to be a suitable site for manure utilization, there must be no other crop growth limitations that will interfere with the utilization of the applied nutrients. If soil characteristics or other factors within the watershed restrict crop productivity, these factors must be considered in evaluating the suitability for manure application. It may be necessary to respond to these conditions in order to make manure application safe.

Manure storage site

Manure may be stored dry, as a slurry, or as a liquid. Dry manure generally contains bedding. This bedding may be straw, wood shavings, sawdust, or previously dried manure solids.

The ideal storage site for solid manure is a roofed shed with an impermeable floor. The runoff from the roof should be collected and handled so it does not come into contact with the stored manure.

In areas of low annual precipitation, unroofed storages frequently are used to save money. Where unroofed storages are used, it is important to manage the runoff as a high strength wastewater. Collect it in an organized fashion and handle it along with any other wastewater from the facility.

Slurry and liquid manure storages have the advantage of requiring less labor than solid manure handling. Manure storages may be either above or below ground. Concrete and coated steel tanks are the most popular; however, several other materials also are used. The most important features are impermeability and ease of maintenance. Earthen basins also are acceptable but require additional maintenance and operator attention.

The manure storage required is related to local climate conditions. Where there are extended periods during which manure application is impossible or inconvenient, or significantly threatens the quality of local waterways, longer storage periods are required. In the Willamette Valley, for example, storage periods as long as 180 days are common. This avoids spreading manure on saturated lands and facilitates managing manure to gain the greatest possible benefit from it. Larger storage volumes provide greater flexibility in planning manure spreading.

Manure storages, like other waste containments, should be located away and downslope from water supply wells. Although storages are designed to be impermeable, the consequences of manure escaping to a well is so threatening that the additional precaution of separation is appropriate. Likewise, it is inappropriate to have a manure storage located adjacent to a surface water source where there are only limited possibilities of responding to an overflow or an accidental spill.

Water application

The amount of water (rainfall plus irrigation water) applied to a manure application site is an important factor in determining the risk of either surface or groundwater pollution. Under ideal conditions, the amount of rainfall plus irrigation equals the total evapotranspirational needs of the growing crop. Under these conditions, there is no downward movement of soluble nutrients beyond the root zone.

As the amount of water applied increases, the amount of downward movement increases. This is a particular problem when water is applied infrequently but in large quantities. Under these conditions, water that exceeds the infiltration and water-holding capacity of the soil will either run off or infiltrate beyond the root zone. In either case, this water will escape with a load of nutrients that would be better used by the growing crop.

In addition to the rate at which water is applied, the water-holding capacity of the soil is important in determining the risk of water quality degradation. Fine-textured soils at less than field capacity can store water in the profile. This water does not escape from the root zone and remains available.

Coarse soils, sand, and gravel, have a much lower ability to store water. Saturation also leads to low storage capacity. Like a sponge full of water, saturated soils are unable to store additional water. Avoid applying wastewater to these sites.

4. Nutrient application rates, credits, and residues

Two factors are important in deciding how much manure to apply to a particular field:

- The amount of nitrogen and phosphorus needed to produce the planned crop
- The nutrient concentration in the manure

Both of these are best estimated based upon analytical results from a water or soil testing laboratory.

In the earlier example on pages 2-4, you found that you need 116 lb nitrogen and 16 lb phosphorus as P_2O_5 per acre. If the manure analysis indicates the ammonia nitrogen concentration to be 7 lb per 1,000 gallons, divide the nitrogen needed (116 lb) by 7, and then multiply by 1,000 to find the application rate:

116 lb N ÷ 7 lb per 1,000 gal = 16.6 x 1,000 = 16,600 gal per acre

Similarly, if the testing indicated the phosphorus content to be 8 lb per 1,000 gallons as P_2O_5, then 2,000 gallons per acre would be the appropriate application rate based on phosphorus:

16 lb ÷ 8 = 2 x 1,000 gal = 2,000 gal per acre

To utilize the manure most efficiently, apply it at the lower of the two rates. In this case, you'll apply it at the 2,000-gallon-per-acre rate to 193 acres (the amount for which phosphorus is available, from page 5). Then calculate the amount of nitrogen you still need:

16,600 gal (N rate) - 2,000 gal (P rate) = 14,600 gal
14,600 gal x 7 lb N per gal = 102,200 ÷ 1,000 = 102 lb N

Use commercial nitrogen fertilizer for the remaining 102 lb nitrogen per acre.

If the farm is irrigated, analyze the irrigation water periodically to determine its nutrient content and salinity. Similarly, if you use other nutrient sources such as municipal sewage sludge or food processing wastewater, include their nutrient contribution in the overall nutrient budget.

Contacts and references

Who to call about...

Design assistance and technical standards for manure storage, treatment, and land application systems

Your county Soil and Water Conservation District, Natural Resources Conservation Service (formerly the Soil Conservation Service), or county Extension office.

Financial and technical assistance in remedying a water pollution risk

Your county Soil and Water Conservation District, Natural Resources Conservation Service, or county Extension office.

Requirements for waste storage facilities and permits

Oregon Department of Agriculture, Natural Resources Division, Salem (503) 378-3810.

What to read about...

Publications are available from sources listed at the end of the reference section. (Refer to numbers in parentheses after each publication.)

Health effects of livestock wastes in groundwater

Manure Ponds: Methane, Hydrogen Sulfide, Carbon Dioxide. J.A. Moore and V.A. Sullivan, *Agricultural Safety*, Vol. 5, 1990, Bioresource Engineering Department, Oregon State University, Corvallis, OR. (2)

Handling, management, and storage of livestock waste

Manure Management Practices to Reduce Water Pollution. J.A. Moore and T.L. Willrich. Reprinted 1993. Oregon State University Extension Service. FS 281. (1)

Outside Liquid Manure Storages. 1979. 8 pages. Midwest Plan Service. AED-23. (2) Discusses earth storage basins and non-earth above ground storages.

Planning and design of livestock waste storage facilities

Agricultural Waste Management Field Handbook. 1992. Natural Resources Conservation Service. (4)

Beef Housing and Equipment Handbook. Midwest Plan Service. MWPS-6. (2)

Circular Concrete Manure Tanks. 1983. 4 pages. Midwest Plan Service. TR-9. (2)

Dairy Housing and Equipment Handbook. Midwest Plan Service. MWPS-7. (2)

Liquid Manure Tanks: Rectangular, Below Grade. Midwest Plan Service. MWPS-74303. (2)

Livestock Waste Facilities Handbook. Midwest Plan Service. MWPS-18. (2)

Livestock Waste Facilities Handbook. 1995. 112 pages. Midwest Plan Service. (2) Focuses on planning and design of livestock waste facilities and equipment, and information about land application techniques and animal waste utilization. Includes worksheet to help you determine manure application rates.

Oregon Animal Waste Installation Guidebook. Revised 1989. Natural Resources Conservation Service and the Oregon Department of Agriculture. (3)

Sheep Housing and Equipment Handbook. Midwest Plan Service. MWPS-3. (2)

Swine Housing and Equipment Handbook. Midwest Plan Service. MWPS-8. (2)

Land application of livestock wastes

Agricultural Waste Management Field Handbook. 1992. Natural Resources Conservation Service. (4)

Livestock Waste Facilities Handbook. 1985. 112 pages. Midwest Plan Service. (2) Includes information about land application techniques and animal waste utilization, as well as a worksheet to help determine manure application rates.

Calculating the Fertilizer Value of Manure from Livestock. Reprinted 1993. J.A. Moore and T.L. Willrich. EC 1094. Oregon State University Extension Service, Corvallis. (1)

Publications available from...

1. Publications Orders, Agricultural Communications, Oregon State University, Administrative Services A422, Corvallis, OR 97331-2119, (503) 737-2513. There may be charges for publications.

2. Your county Extension office or the Midwest Plan Service Secretary, Bioresource Engineering Department, Oregon State University, Corvallis, OR 97331-2307, (503) 737-4021.

3. Oregon Department of Agriculture, Natural Resources Division, 635 Capitol Street, N.E., Salem, OR 97310, (503) 378-3810. There may be a charge for some publications.

4. USDA, Natural Resources Conservation Service (formerly the Soil Conservation Service), 101 S.W. Main St., Suite 1300, Portland, OR 97204-3221, (503) 414-3247.

Information derived from Home•A•Syst worksheets is intended only to provide general information and recommendations to homeowners regarding their own home practices. It is not the intent of this educational program to keep records of individual results.

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