WINTER WASTEWATER LAGOON AND SLURRIES MANAGEMENT

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ABSTRACT

Proper management of liquid and slurry livestock manure must consider all aspects of production, storage, treatment and land application as one system to maximize agronomic benefits and minimize the potential for odor production and environmental degradation. Identification and preparation of alternative storage facilities for emergency liquid or slurry manure storage is an important component in the overall facility management plan. Although these facilities may seldom if ever be used, a minimal amount of site preparation will allow emergency storage of slurry with minimal risk of surface or ground water impact. Alternative plans for handling liquid manure usually involve land application. From an environmental perspective, liquid waste may be applied on pasture ground or cropland all year as long as no deep percolation or runoff occurs. Because of low temperatures, winter application assures that N and P initially in organic, difficult-to-transport forms remain in those forms until temperatures rise in the spring and plant uptake increases. Alternative methods of winter slurry storage and site requirements will be discussed. Necessary site characteristics and land application techniques for liquid manure application will also be discussed.

INTRODUCTION

Regardless of the care involved in planning and facility management, sometimes circumstances beyond the dairyman's control require winter land application of lagoon effluent to avoid overtopping the lagoon embankment, or alternative methods of slurry handling or storage. Overtopping carries a significant risk of embankment failure and the resulting uncontrolled release of large quantities of effluent. Therefore, a scientifically sound method of determining when and how much effluent can be applied is needed. Such a method must assure that no runoff occurs and that the soil profile of the receiving field will not be hydraulically overloaded. Elimination of runoff assures that nutrients will be contained on the application site, and not hydraulically overloading the root zone to minimize possible movement of crop nutrients below the root zone. Alternative slurry handling methods require site preparation to assure that water from the slurry or from winter precipitation does not impact surface or groundwater.

Alternative Winter Slurry Management:

In Idaho, climate is such that land application is a viable approach during the growing season. Very low growing season precipitation allows slurry to be applied to non-crop areas and then soil incorporated without risk of water quality degradation. This same approach can be extended somewhat into earlier spring or later fall conditions, as long as soil moisture is suitable for tillage. During times when tillage cannot occur, slurry is usually stored for subsequent land application. Possible alternatives to winter storage include:

- Periodic application to compost or solid manure windrows
- Periodic shallow application for drying and subsequent windrowing as solid manure
- Storage between parallel compost windrows, for future composting

Land Application of Liquid Wastes:
Three factors determine when and how much lagoon effluent can be applied to a receiving field. These are evapotranspiration (ET), precipitation and available soil moisture storage in the crop root zone. A deep- rooted crop on a deep, high water holding capacity soil will allow more flexibility in land application than will a shallow or light-textured soil. The pattern of winter precipitation compared to the pattern of ET determines which months may be appropriate for land application. This information, in addition to the active root zone depth for the crop planted, and water holding capacity – soil moisture relationships, can be used to determine the depth of water that could be applied without deep percolation for any measured soil moisture content.

MATERIALS AND METHODS

Alternative Winter Slurry Management:

Regardless of approach, any area receiving slurry must have a suitable means of retaining runoff water from both the slurry and precipitation. This usually involves construction of berms around the lower-elevation portions of the site perimeter. Berm height should be sufficient to contain anticipated site runoff from a 25-year-24-hour storm plus the depth of winter precipitation that would be expected to occur, on the average, about once in 5 years. For typical dairy conditions in most of Southern Idaho, the sum of runoff from the 25-year, 24-hour storm and one in 5 year winter precipitation, both expressed as a depth of water, would be about 2.5 to 3.5 inches.

Site surface preparation should assure that infiltration and potential deep percolation of precipitation is minimal (e.g. surface preparation reduces soil permeability). In most cases existing soil, compacted at appropriate soil moisture, will meet this requirement. As shown in Figure 1, soil compacts best at a certain moisture content. This varies with soil texture, but in general most agricultural soils compact best at moisture contents near field capacity (moisture content 1-3 days after irrigation). Figure 2 shows the decrease in soil permeability as soil is compacted from a freshly tilled condition (specific gravity near 1.0) to maximum compaction. In many cases, soil will be adequately compacted by traffic from loaded slurry wagons.

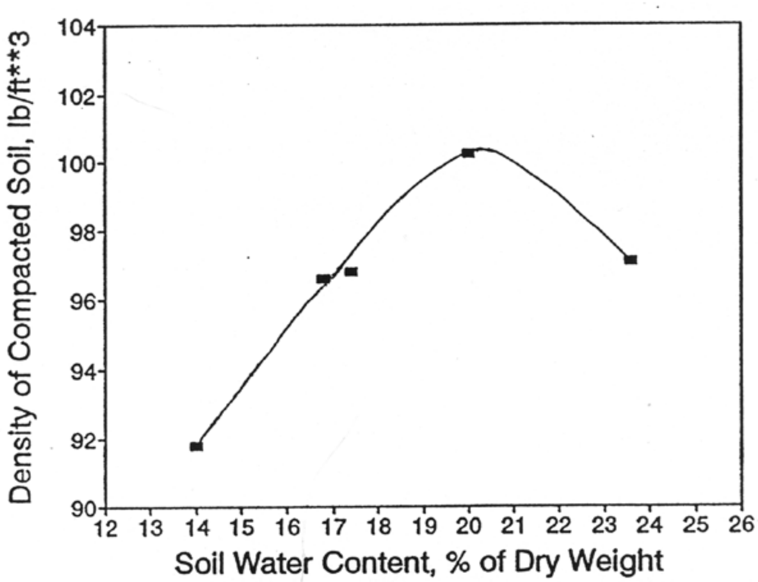

Figure 1. Soil moisture-density relationship for a typical silt loam soil (From Neibling et al., 1993)

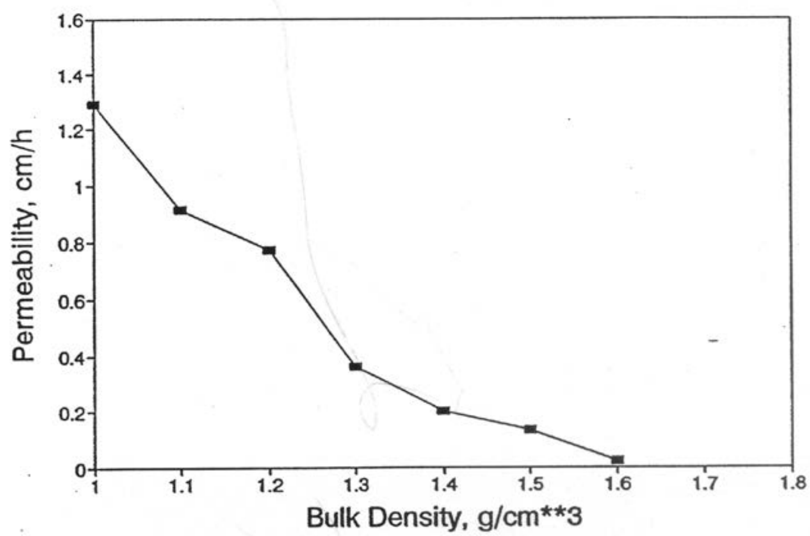

Figure 2. Constant-head laboratory permeability for silt loam soil cores compacted to varying bulk densities (From Neibling et al., 1993)

In some cases, addition of soil additives such as bentonite will be required. This would be particularly true in more coarse-textured soils. The reduction in soil permeability due to addition of a small percentage of bentonite is shown in Figure 3. All data shown are for soil cores with no compaction (specific gravity = 1.0). The fact that fine organic particles from the slurry also tend to seal the soil surface provides an additional level of protection

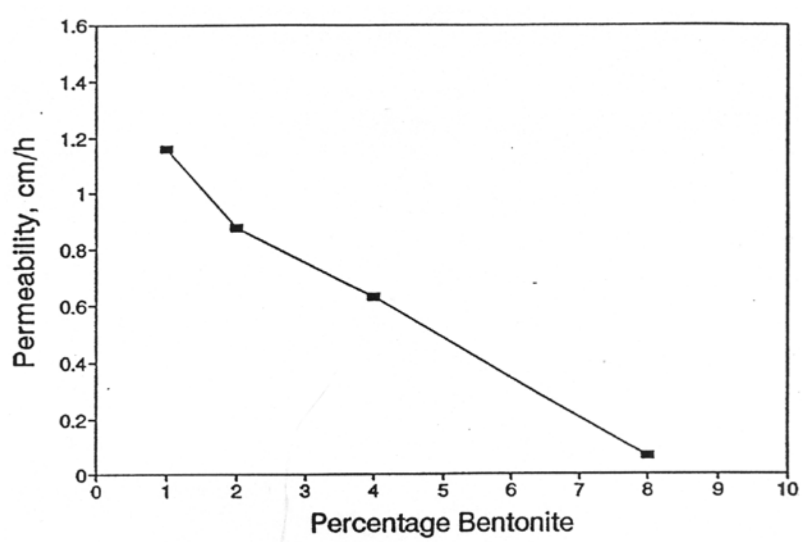

Figure 3. Constant-head laboratory permeability for silt loam soil cores with varying percentage of bentonite added to dry soil. Bulk density of the core is 1.0. (From Neibling et al., 1993)

Land Application of Liquid Wastes:

This paper uses existing data collected by Dr. James Wright, USDA-ARS, and standard hydrologic analyses to develop strategies for land application of lagoon effluent. Measured cumulative ET from bare soil and grass, 30-year average daily precipitation and monthly average precipitation for the 5 years of study at Kimberly, Idaho are shown in Figure 4. These data show an excess of about 0.75 inches in grass ET relative to average precipitation over an October – March period. ET is greater than precipitation for October and March while precipitation exceeds ET for the winter months. For a low snow year, ET is greater than precipitation for the entire winter. In this case, even with a full soil profile on October 1, some lagoon water could be applied without deep percolation. In a high snow winter, however, cumulative precipitation exceeded ET from both alfalfa stubble and grass for the winter period. In this case, land application except to an initially dry, deep high water holding capacity soil should not occur before mid-winter. Comparison of the precipitation data points for the years studies and for the 30-year average (solid line) indicate that precipitation for the study period was representative of that from the entire record.

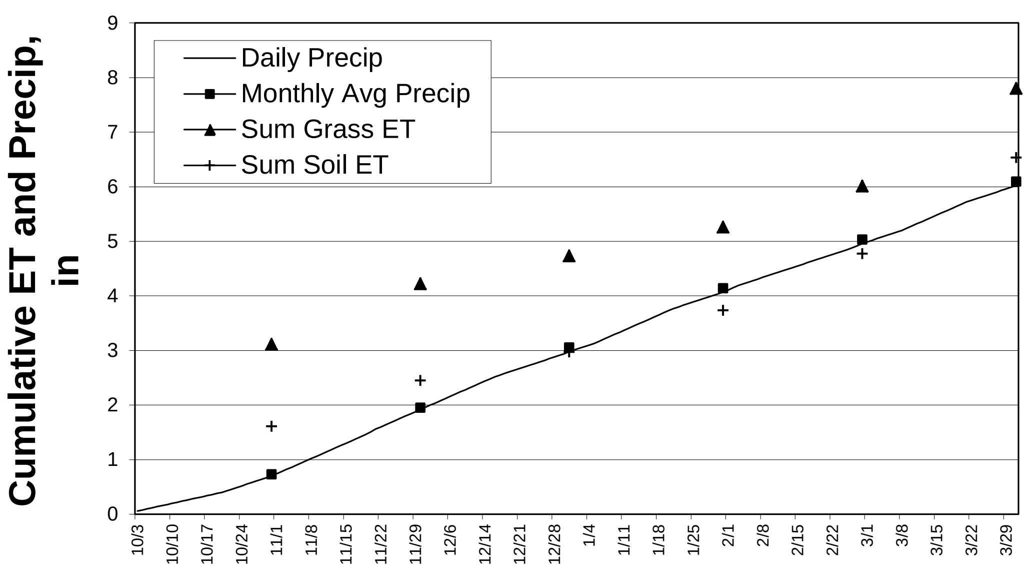

Figure 4. Cumulative October – March ET and precipitation. ET data from lysimeter studies at Kimberly, ID (Wright, 1993).

Table 1 can be used with appropriate soil moisture information to decide how much effluent can be added after January 1 for either bare soil or grass conditions. Precipitation exceeds ET for January and February. However, if about 0.75 inches of available root zone storage was available on January 1, no water would move below the root zone during the remainder of the winter. That is, the maximum difference between cumulative precipitation and grass ET is about 0.75 inches at any point from January 1 to the end of March. Any root zone storage in excess of 0.75 inches could be used to store lagoon water without risk of deep percolation under average conditions for the remainder of the winter. For bare soil conditions, precipitation exceeds ET by only about 0.4 inches, and this occurs in January. Thus, for bare soil conditions land application could occur if more than 0.4 inches of available soil moisture storage was available.

Table 1. Cumulative January through March precipitation, soil and grass ET in inches. ET data from lysimeter measurements at Kimberly, ID Wright, 1993)

		Cumulative ET and Precipitation from Start Date to:		
Start Date		**1/30**	**2/28**	**3/31**
January 1	Soil ET	0.75	1.80	3.55
	Grass ET	0.50	1.25	3.05
	Precipitation	1.10	1.95	3.00
January 15	Soil ET	0.4	1.45	3.2
	Grass ET	0.25	1.00	2.80
	Precipitation	0.55	1.45	2.50
February 1	Soil ET	-	1.05	2.80
	Grass ET	-	0.75	2.55
	Precipitation	-	0.85	1.95
February 15	Soil ET	-	0.55	2.6
	Grass ET	-	0.8	2.2
	Precipitation	-	0.45	1.5

As time passes, less winter precipitation is typically predicted so uncertainty decreases. For example, if more than 0.45 inches of root zone storage is available on January 15, the excess storage could be used for lagoon water. Corresponding values are 0.2 inches for February 1 and 0.1 inch for February 15. Therefore, the information required for determination of the maximum depth of lagoon water to apply on any date is the type of cover, current crop (if applicable), future crop and rooting depth, and the water content of the root zone (or future root zone) based on soil moisture measurements at 6-inch depth increments. Soil moisture content may be determined by sampling and oven drying, use of USDA-NRCS publication “Estimating Soil Moisture by Feel and Appearance” (USDA-NRCS, 1998), or by any number of matric potential or soil moisture by volume sensors. University of Idaho personnel can provide information to convert any of these measurements into remaining available soil moisture in the root zone.

Soil Moisture Sensors:
Granular matrix (Watermark) soil moisture sensors are the preferred sensing device since they have been used successfully in irrigation scheduling research for a number of years, are relatively inexpensive and will give valid readings beneath a frozen soil surface. These devices measure soil matric potential, and indirectly, soil water content. As long as soil matric potential levels indicate drier soil conditions than field capacity, almost no saturated flow below the root zone can occur. These or other equivalent devices should be installed at three randomly selected locations, representative of topographic conditions, in each field where winter land application is desired. Three should be placed at the 12" depth and three at the 24" depth. Because of evaporation, the moisture gradient will be upward except during a few large precipitation events (saturated flow). Therefore, any unsaturated flow will be upward.

Monitoring:

Soil moisture levels should be monitored periodically to assure that sensors are working properly. Soil moisture levels should be monitored monthly and before and after lagoon water application. The purpose of monitoring is to determine at those times when land application is desired, both the soil moisture storage available in the soil profile, and the degree of soil saturation. At other times, sensors can indicate conditions where deep leaching may occur but cannot indicate if leaching did occur and the amount of leaching.

The procedure for determination of maximum depth of lagoon water to apply on any date would then be:

1. Sample or read instruments and determine remaining available soil moisture in the root zone depth.
2. From Table 1 for the date and soil cover type, determine the minimum soil moisture storage required to contain the remainder of expected winter precipitation in excess of ET.
3. Determine any excess storage available for land application.
4. Determine pivot speed required for land application of the desired depth and apply subject to the following constraints:
   - Do not apply on frozen ground or snow if application depth is greater than 0.15 inches.
   - Do not apply more than 0.5 inches total during the winter to minimize potential infiltration problems due to accumulation of small organic particles on the soil surface.
   - The total depth of lagoon effluent applied during the year should be limited by agronomic uptake rates as specified by an approved nutrient management plan.
   - If odor problems during land application have been a historic problem at this site, use drop hoses to release water about one foot above the soil surface. Drag hoses may reduce odor a bit more but will apply water less uniformly and with an increased risk of runoff on the outer spans of the pivot.

REFERENCES

USDA-NRCS. 1998. Estimating Soil Moisture by Feel and Appearance. Program Aid # 1619. U.S. Dept. of Agric. Natural Resources Conservation Service. p. 12.

Neibling, W.H., A.L. Thompson, D.L. Pfost, and Gandi Said. 1993. Underground outlet terrace systems in the deep loess hills – Mechanisms of failure and potential solutions. Final report to the Missouri Soil and Water conservation Districts Commission, project No. 482. p. 31.

Wright, J.L. 1993. Nongrowing Season ET from Irrigated Fields. In: "Management of Irrigation and Drainage Systems". Symposium Proceedings. Park City, UT July 21-23. p. 1005-1014.