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Overview of Guidelines for Liquid Manure Application on Drained Cropland in the Midwest

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Abstract. *The movement of manure to surface water from artificially drained cropland is a concern. A Liquid Animal Manure Application on Drained Cropland: Preferential Flow Issues and Concerns Workshop was held in Columbus, Ohio (November, 2004). The objectives of this workshop were: (1) integrate state guidelines and recommendations for mitigating liquid manure discharges from artificially drained cropland; (2) identify and prioritize extension and outreach needs related to* *manure application and pollution of water resources; (3) identify and prioritize research needs related to the downward movement of animal manure on artificially drained cropland. Regional guidelines for drained fields include monitoring outlets/inlets; matching manure application rates with soil infiltration rates, water-holding capacity of the soil, and crop/soil nutrient needs; and not applying manure when subsurface drains are flowing. Avoid applying manure to flood prone fields, adjust application rates to environmental conditions and ability of the soil to store and utilize manure nutrients (based on nitrogen and phosphorous), and apply manure at a uniform rate and volume to avoid ponding and manure runoff. Extension activities include developing simple rules for manure application and management; requiring producer certification/education for manure application; developing web based fact sheets, video clips, photographs and demonstrations for preventing manure runoff; promoting partnerships with agencies and animal industry; and educating agency personnel on manure runoff issues. Research needs are summarized in a companion paper in this session. Research is needed on pathogen transport and fate; soil preferential flow characteristics; evaluating manure management and equipment application; total manure characteristics (solids content, viscosity, nutrients, pathogens, color); and developing liquid manure testing methods, quick tests, and sensors.*

Keywords. preferential flow, liquid manure, subsurface drainage, macropores, manure runoff

Introduction

Subsurface drainage improves crop growth and soil productivity, but can have detrimental environmental effects by increasing the movement of agri-chemicals and nutrients to surface water supplies (Kladivko et al., 2001; Zucker and Brown, 1998)). Frequently, this increased movement is attributed to preferential flow in soil macropores. Factors such as high intensity rainfall, dry soil, and conservation tillage, because it can contribute to the formation and preservation of soil macropores, increase the potential for preferential flow processes to occur (Shipitalo et al., 2000).

Liquid animal manures are a valuable source of nutrients and organic matter for crop production and can be applied by a variety of methods including spray irrigation, surface spreading, and subsurface injection. Because of their low solids and nutrient content, liquid animal manures are usually applied at relatively high volumes, but it is generally recommended that it not be applied at rates that would exceed the amount needed to bring the soil to field water holding capacity (Johnson and Eckert, 1995). Nevertheless, even when similar guidelines are followed, contamination of drain line effluent has been reported in soils with subsurface drainage due to macropore flow (Geohring et al., 2001).

Application of liquid animal manures to soils with subsurface drainage has been linked to contamination of the effluent with nutrients (Cook and Baker, 2001; Geohring et al., 2001; Stamm et al., 2002), particulate organic matter (Barkle et al., 1999), estrogens (Burnison et al., 2003), bacteria (Bicudo and Goyal, 2003; Cook and Baker, 2001; Dean and Foran, 1992; Jamieson et al., 2002; Joy et al., 1998), and veterinary antibiotics (Kay et al., 2004). These findings are not universal, however, as liquid animal manures can be applied without any detectable adverse effects on water quality. For instance, Randall et al. (2000) noted no difference in nitrogen, phosphorus, or fecal indicator bacteria losses in drainage water when they compared plots that received liquid dairy manure to plots that received equivalent amounts of mineral fertilizer. The fact that liquid animal manures can be safely land applied in some instances, but can cause contamination of subsurface drainage water under different circumstances suggests that the properties of the soil, such as soil texture, initial water content, and tillage history as well as the amount of manures applied, application method, water content of manures, and the amount of rainfall after application may all play a role in determining the fate of the applied material.

Materials and Methods

A workshop on Liquid Animal Manure Application on Drained Cropland: Preferential Flow Issues and Concerns was held in Columbus, Ohio on November 9-10, 2004. The objectives of this workshop were: (1) Integrate state guidelines and recommendations for mitigating liquid manure discharges from artificially drained cropland; (2) identify and prioritize extension and outreach needs related to manure application and pollution of water resources; and (3) identify and prioritize research needs related to the downward movement of animal manure on artificially drained cropland. Preferential flow and the fate of liquid animal manure on drained cropland presentations were conducted and discussed the first day. The second day, participants divided into three groups and discussed developing regional guidelines, future research needs for preventing preferential flow of liquid manure on drained cropland, and possible extension and outreach programs that need to be conducted. The focus of this paper is the integration of state guidelines and recommendations for mitigating liquid manure discharges from artificially drained cropland.

Results and Discussion

The content for developing regional guidelines to prevent preferential flow of manure to subsurface drains were identified and discussed.

Regional Guidelines:

The major objective of this workshop was to integrate state guidelines and recommendations for mitigating liquid manure discharges from artificially drained cropland and develop regional guidelines. Four major recommendations highlighted were:

1) Observation and Monitoring of Subsurface Drain (Tile) Inlets and Outlets

Any field where agricultural subsurface (tile) drains discharge into ditches that flow to surface water should be considered a high-risk field that is monitored carefully before, during and after a manure application. Apply, observe and monitor drain outlets, evaluate the results, and make adjustments as needed to develop a site-specific manure application plan. Do not apply manure to subsurface drained fields when the drains are flowing. **Field/soil conditions the day of application will dictate the maximum application volume that can be applied, and liquid manure**. The suggested schedule for observing and monitoring drainage outlets follows:

a) 10-20 minutes after start of any liquid manure application.
b) Once each 20,000 gallons, and Once each hour, if application rate is 20,000 gal/hr.
c) Stop application immediately if discharge and/or discoloration observed, implement contingency plan.

2) Liquid Manure Applied to Subsurface Drained Fields

The available water holding capacity of the upper 8 inches of soil (Table 1) provides the approximate volume of water and/or liquid manure that can be applied before water, manure and nutrients begin to move through the soil profile. Manure application rates may need to be adjusted the day manure is applied to avoid reaching and/or exceeding the available holding capacity of the soil. Soils are better able to absorb multiple smaller liquid manure applications than a single large volume application. Field/soil conditions the day of application will dictate the maximum application volume that can be applied. A summary of the guidelines from he workshop follow:

a) Liquid manure should not to be applied on soils that are prone to flooding, as defined by the National Cooperative Soil Survey (or in the Flooding Frequency Soil List posted in

Section II eFOTG), during the period when flooding is expected. Manure can be applied if incorporated immediately or injected below the soil surface during periods when flooding is not expected;

b) Liquid manure application rates should be adjusted to consider the most limiting factor and include the ability of the soil to accept, store and hold liquid manure, water and nutrients and the ability of the plants to utilize these nutrient.
c) Liquid manure should be applied in a manner that will not result in ponding or runoff to adjacent property, drainage ditches, or surface water regardless of crop nutrient need/requirement;
d) Liquid manure should be uniformly applied at a known rate or volume. Do not apply at rates (volume) that exceed the lesser of the AWC in the upper 8 inches or an effective rate of 13,000 gallons/acre per application. The effective rate is used for application equipment with concentrated flows. For example, an injection toolbar with four (4) nozzles on 30 inch spacing. Each nozzle has a concentrated flow over a small area. The effective rate is calculated as the volume of manure applied per area for one (1) nozzle. If injection is desired consider using straight points and spaced closer (< 30 inches, 10-15 inches would be better) to reduce the volume of liquid manure coming out of each knife point (or a disk type implement with a distribution manifold for even distribution across the swath). This helps to reduce the volume that can reach the preferential flow channels. If injection is used, it should only be deep enough to cover the manure with soil;
e) Prior to liquid manure application, use surface tillage to disrupt the continuity of worm holes, macropores and root channels (preferential pathways) to reduce the risk of manure reaching tile lines, or till the surface of the soil 3-5 inches deep to a condition that will absorb the volume of liquid manure being applied. This is especially important if shallow tile (drains) are present (< 2 feet deep). Any pre-application tillage should leave as much residue as possible on the soil surface to minimize soil erosion;
f) If injection is used, inject liquid manure only deep enough to cover the manure with soil. Till the soil at least 3 inches below the depth of injection prior to application, or control outflow from all subsurface drain outlets prior to manure application;
g) Identify subsurface (tile) outlets, and control or regulate discharge prior to application, or have on-site a means of stopping the discharge from subsurface drains (e.g., tile plugs, tile stops, or water control structures). Use caution not to back-up water where it may impair the functioning of an offsite subsurface drainage system;
h) For perennial crops (hay or pasture), or continuous no-till fields where tillage is not an option, all subsurface (tile) outlets coming from the application area should be identified and flow should be controlled or captured prior to application;
i) Repair broken subsurface drains and blowholes prior to application, and follow recommended/required minimum setback requirements (setback distances vary from state to state) for surface inlets;
j) Do not apply liquid manure to artificially drained fields when the outlets are flowing;
k) Should an off-site discharge of liquid manure occur, have a plan for dealing with any manure that may reach subsurface drains, such as blocking outlets or blocking the flow once it reaches the ditch;
l) Avoid applying liquid manure before or after a rain. Keep log of weather forecasts and actual weather conditions 24 hours before and after a manure application with manure application records;
m) Bare/Crusted soils may require some tillage to improve infiltration. Determine the most limiting application rate base on the field condition and other limitations (may vary from state to state).

These recommendations may not apply if the producer or applicator is certain there is no prior history of manure discharge via subsurface (tile) drains or discharge is captured. However, if there is a discharge, the producer is liable for damages and is at risk of being classified as a CAFO (Concentrated Animal Feeding Operation).

3) Liquid Manure Applied to Systematic Surface Drained Fields

Fields or areas of fields that have systematic "surface drainage" systems (e.g., shallow surface drains spaced 100 to 200 feet apart) are considered concentrated flow areas. However, if special precautions are taken, liquid manure can be applied in the surface drains with minimal risk of runoff. This does not apply to the collector surface drains (mains) or drains bordering the fields. The following special manure application techniques shall be used:

a. Till the surface at least 3 to 5 inches deep prior to liquid manure surface application. Pre-till within 7 days of application.
b. Surface-apply liquid manure uniformly over the entire soil surface on the freshly tilled soil to allow the liquid manure to be absorbed into the soil surface.
c. For fields with no subsurface drainage, liquid manure can be injected directly without prior tillage.
d. Manure application rates should be adjusted to consider the most limiting factor and include the ability of the soil to accept, store and hold liquid manure, water and nutrients. The Nitrogen and Phosphorus Application Criteria for manure, Organic By-Products and Biosolids contained in NRCS Nutrient Management Standard 590 are to be followed to limit transport and leaching.

4) Other Management Criteria

a. Maximize liquid manure storage structures available holding capacity through frequent manure applications under optimal weather conditions. (Do not let manure storage structures get too full.)
b. Size manure application equipment to meet equipment and labor (time) constraints.
c. Calibrate equipment frequently and follow a regular repair/maintenance schedule.
d. Modify crop rotations to fully utilize manure nutrients during the growing season. Plant cover crops after harvest to hold available soil nutrients.

Conclusion

Good management is a key issue in preventing preferential flow of manure to surface water. While weather and some environmental conditions cannot be controlled, producers can control when and how they apply liquid manure. Educational programs and guidelines based upon good research focusing on how to prevent the movement of manure to water resources are needed. This paper outlines the content of recommendations for developing regional guidelines to prevent the downward movement of liquid manure on artificially drained cropland.

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Appendix A

Table 1. Available Water Capacity (AWC) Practical Soil Moisture Interpretations for Various Soils Textures and Conditions to Determine Liquid Waste Volume Applications not to exceed AWC.

This table shall be used to determine the AWC (upper 8 inches) at the time of application and the liquid volume in gallons that can be applied not to exceed the AWC. To determine the AWC in the upper 8 inches use a soil probe or similar device to evaluate the soil to a depth of 8 inches.

Available Moisture in the Soil	Sands and Loamy Sands	Sandy Loam and Fine Sandy Loam	Very Fine Sandy Loam, Loam, Silt Loam, Silty Clay Loam, Clay Loam, Sandy Clay Loam	Sandy Clay, Silty Clay, Clay
< 25% Soil Moisture Amount to Reach AWC	Dry, loose and single-grained; flows through fingers. 20,000 gallons/ac	Dry and loose; flows through fingers. 27,000 gallons/ac	Powdery dry; in some places slightly crusted but breaks down easily into powder. 40,000 gallons/ac	Hard, baked and cracked; has loose crumbs on surface in some places. 27,000 gallons/ac
25-50% or Less Soil Moisture Amount to Reach AWC	Appears to be dry; does not form a ball under pressure. 15,000 gallons/ac	Appears to be dry; does not form a ball under pressure. 20,000 gallons/ac	Somewhat crumbly but holds together under pressure. 30,000 gallons/ac	Somewhat pliable; balls under pressure. 20,000 gallons/ac
50 - 75 % Soil Moisture Amount to Reach AWC	Appears to be dry; does not form a ball under pressure. 10,000 gallons/ac	Balls under pressure but seldom holds together. 13,000 gallons/ac	Forms a ball under pressure; somewhat plastic; slicks slightly under pressure. 20,000 gallons/ac	Forms a ball; ribbons out between thumb and forefinger. 13,000 gallons/ac
75% to Field Capacity	Sticks together slightly; may form a weak ball under pressure.	Forms a weak ball that breaks easily, does not stick.	Forms ball; very pliable; slicks readily if relatively high in clay.	Ribbons out between fingers easily; has a slick feeling.

Amount to Reach AWC	5,000 gallons/ac	7,000 gallons/ac	11,000 gallons/ac	7,000 gallons/ac
100% Field Capacity	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.
Above Field Capacity	Free water appears when soil is bounced in hand.	Free water is released with kneading.	Free water can be squeezed out.	Puddles: free water forms on surface