Minimizing Environmental Risks of the Drainage Water

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What is the Risk of Drainage Water?
Depends on what it will be used for
What is the Risk of Drainage Water? Impacts on Downstream Uses
What is the Risk of Drainage Water?
Depends on where it comes from
The Risk of Drainage Water From manured agricultural fields
Manure application studies

Fall applied 5000 gal./acre

Experiments: Surface applied only and w/disk or plow incorporations

Then flow monitoring and sampling

Plus other controlled drainage studies
Manure application studies

What did we find out?
How does tile contamination occur?

1) Nutrient overload can contaminate tile drain discharges in all soils (dissolved, i.e., nitrate)

2) Many soils have preferential flow paths that do not effectively filter out contaminants (i.e., P, NH4, bacteria)
The Smoking Gun

Shipitalo and Gibbs
Smoking Wormholes (Macropores)
Infiltration Test
Fecal Coliform Concentrations in Tileflow Immediately after Surface Manure Application and No Incorporation

Similar concentrations for Wet & Dry Plots
Cumulative Fecal Coliforms and Tileflow Immediately after Surface Manure Application and No Incorporation

But faster breakthrough & more flow with wet plots
Risk of P transport increased when manure was surface applied to wet soil, due to the increased likelihood for drain discharge.
Plow incorporation of manure decreased the risk of P and fecal coliform transport to tile drains by decreasing the concentration and disrupting preferential transport.
Nitrate-Nitrogen concentrations responded quickly to fertilizer, whereas N loss from manure appears sensitive to complex N transformation processes.
Ways to Minimize the Risk

I. Non-structural Strategies to minimize environmental impacts

   A. Pay attention to weather, soil conditions
   B. Evaluate crop nutrient needs
   C. Determine best timing and method of nutrient applications

II. Strategies with tile systems

   A. Retrofit tile systems with controls and/or treatment options
   B. Develop alternative tile drainage designs
Manure can be applied without adverse impacts to water quality IF weather, soils, and rates are properly accounted for.
Management options: Weather and soil moisture status is key!

Risk of transport increased when manure was surface applied to wet soil, due to the increased likelihood for drain flow or runoff
Weather conditions - Avoid applying when rain or snowmelt is predicted, eminent, (i.e., more than ½ inch rain or prolonged warming trend)

Or, identify lowest risk fields for manure application, use setbacks, and have an emergency plan.

Soil moisture status -
Determines if soil can absorb (store) rain or liquid manure and how much.

If soil is at or above field capacity, drains are flowing, and liquid manure can’t be retained.

Drain outlets should be identified, and monitored before, during, and after application.

Water table control structures can help!
Identifying tile outlets, monitoring and evaluation

Tile outlets flowing directly into waters of the State should be identified and observed during times of liquid manure application. If manure breakthrough occurs, application should be stopped immediately, and a contingency plan should be implemented.

Observations (?) – prior to spreading and then depending on the application rate, every 1-2 hours (i.e., breakthrough often occurs within hours).

The contingency plan should include emergency measures (tile plug), documentation, spreading alternatives, and evaluation for developing remedial measures.
Soil moisture content affects the rate of liquid manure that can be applied and retained.

Table: Maximum Available Water Holding Capacity of Soils

<table>
<thead>
<tr>
<th>Available Moisture in the Soil</th>
<th>Sands and Loamy Sands</th>
<th>Sandy Loam and Fine Sandy Loam</th>
<th>Very Fine Sandy Loam, Loam, Silt Loam, Silty Clay Loam, Clay Loam, Sandy Clay Loam</th>
<th>Sandy Clay, Silty Clay, Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>50–75% Soil Moisture Amount to Reach AWC</td>
<td>Appears to be dry; does not form a ball under pressure.</td>
<td>Balls under pressure but seldom holds together.</td>
<td>Forms a ball under pressure; somewhat plastic; slicks slightly under pressure.</td>
<td>Forms a ball; ribbons out between thumb and forefinger.</td>
</tr>
<tr>
<td>75% to Field Capacity Amount to Reach AWC</td>
<td>Sticks together slightly; may form a weak ball under pressure.</td>
<td>Forms a weak ball that breaks easily, does not stick.</td>
<td>Forms ball; very pliable; slicks readily if relatively high in clay.</td>
<td>Ribbons out between fingers easily; has a slick feeling.</td>
</tr>
<tr>
<td>100% Field Capacity Amount to Reach AWC</td>
<td>On squeezing, no free water appears on soil, but wet outline of ball on hand.</td>
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With available nutrients in liquid manure its difficult to meet crop nutrient needs without splitting applications.

NO Manure!

Soil moisture determination

**Feel**

**Method**

**Example**

**Appearance of clay, clay loam, and silty clay loam soils at various soil moisture conditions.**

**Available Water Capacity**

1.6-2.4 inches/foot

<table>
<thead>
<tr>
<th>Percent Available</th>
<th>0-25 percent available</th>
<th>2.4-1.2 in./ft. depleted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry, soil aggregations separate easily, clods are hard to crumble with applied pressure. (Not pictured)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent Available</th>
<th>25-50 percent available</th>
<th>1.8-0.8 in./ft. depleted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Percent Available</th>
<th>50-75 percent available</th>
<th>1.2-0.4 in./ft. depleted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moist, forms a smooth ball with defined finger marks, light soil/water staining on fingers, ribbons between thumb and forefinger.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent Available</th>
<th>75-100 percent available</th>
<th>0.6-0.0 in./ft. depleted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily between thumb and forefinger.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent Available</th>
<th>100 percent available</th>
<th>0.0 in./ft. depleted (field capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wet, forms a soft ball, free water appears on soil surface after squeezing or shaking, thick soil/water coating on fingers, slick and sticky. (Not pictured)</td>
<td></td>
</tr>
</tbody>
</table>
Dealing with dry silty clay soils and those exhibiting macropores

Plow incorporation of manure decreased the risk of P and fecal coliform transport to tile drains by decreasing the concentration and disrupting the occurrence of preferential transport. Pre-till or small applications can help lower risk.
Application methods

Pre-tillage or incorporating liquid manure reduces the level of contamination in tile discharges resulting from preferential flow. Tillage disrupts pore continuity, but more importantly, the mixing of manure with the soil provides more sorption (binding) of non-soluble contaminants.

The downside of tillage, especially in the fall, is that surface residues are reduced and the soil may be more vulnerable to erosion. Fall tillage should be followed with a cover crop. Tillage will not eliminate this problem if application rates are too high.
To Summarize Non-Structural Options

- Weather not controllable but somewhat predictable (>1/2 inch leads to leaching)
- Soils are widely varied, complex, and respond differently to contaminant loss
- Avoid excess nutrient applications
- Crop nutrient needs = manure (nutrient) application rates but may need multiple applications to reduce losses
- Nutrient losses typically higher with fall manure applications but loss is primarily event driven (cover crops may help)
- Tillage useful to reduce P/coliform losses (especially with fine-textured soils)
II. Strategies with tile systems

Drainage Water Management is controlling the removal of drainage discharge with water-control structures. Controlled drainage can reduce contaminated drain discharges.

Control setting during manure applications or off-season field use

Control setting for maximum drainage
Retrofitting tile systems with controls

Tile plugs may cause blowouts from back pressure when pipe is closed
Retrofitting tile systems with controls
Retrofitting tile systems with controls

Since level setting is flexible and overflow is possible, this type of control structure is less risky than using a tile plug.

1. Set control prior to liquid manure spreading
2. Leave in control mode for about a week
3. Slowly remove control level back to free drainage
Retrofitting tile systems with ‘AUTO’ controls
Retrofitting tile systems with ‘AUTO’ controls

For sloping field conditions, one can add more water table control valves, about one for every 2 to 3 feet in elevation drop, AND then design and install the tile laterals on the contour.
Another option is to install a treatment component in-line near the tile outlet.
Denitrifying Bioreactor
Flow Diversion

Inlet Control Structure ($940.00)

$Q_{\text{by-pass}}$

$Q_{\text{main Drain}}$

$Q_{\text{Bioreactors}}$
Adding BioChar to remove P
II. Strategies with tile systems

Alternative designs for tile outlets should consider directing the discharge to ‘on-farm’ open ditches, retention basins, or to wetlands for further treatment.
The End?

Questions?