Bunker Silage Storage
Leachate and Runoff Management

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Bunker Silage Storage
Silage Leachate

(Silage) leachate – liquid produced in feed storage systems from compaction and ensilage of harvested crops.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Leachate(^1)</th>
<th>Liq. Dairy Manure(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter</td>
<td>2-10%</td>
<td>5%</td>
</tr>
<tr>
<td>Total N (mg/L)</td>
<td>1,500-4,400</td>
<td>2,600</td>
</tr>
<tr>
<td>P (mg/L)</td>
<td>300-600</td>
<td>1,100</td>
</tr>
<tr>
<td>K (mg/L)</td>
<td>3,400-5,200</td>
<td>2,500</td>
</tr>
<tr>
<td>pH</td>
<td>3.6-5.5</td>
<td>7.4</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>12,000-90,000</td>
<td>5,000-10,000</td>
</tr>
</tbody>
</table>

\(^1\)Cornell 1994
\(^2\)Clarke and Stone 1995
Leachate Production

Recommended harvest moisture
- 65 - 70% Corn Silage
- 60 - 65% Hay Silage

McDonald 1981, Referencing Bastiman 1976
Leachate
Leachate
Runoff

(Feed storage) runoff – precipitation induced flow from feed storage systems as a result of rain/snowmelt flowing through stored feed, litter, and spoilage piles; essentially “diluted leachate”.

[Images of runoff situations]
Litter and Spoilage
# Runoff Concentrations

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Leachate(^1)</th>
<th>Liq. Dairy Manure(^2)</th>
<th>Runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter</td>
<td>5% (2-10%)</td>
<td>5%</td>
<td>0 - 4.6%</td>
</tr>
<tr>
<td>Total N (mg/L)</td>
<td>1,500-4,400</td>
<td>2,600</td>
<td>20 - 1,356</td>
</tr>
<tr>
<td>P (mg/L)</td>
<td>300-600</td>
<td>1,100</td>
<td>8 - 659</td>
</tr>
<tr>
<td>K (mg/L)</td>
<td>3,400-5,200</td>
<td>2,500</td>
<td>n/a</td>
</tr>
<tr>
<td>pH</td>
<td>3.6-5.5</td>
<td>7.4</td>
<td>4 - 7</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>12,000-90,000</td>
<td>5,000-10,000</td>
<td>500 - 61,210</td>
</tr>
</tbody>
</table>

\(^1\) Cornell 1994  
\(^2\) Clarke and Stone 1995
Impacts of Runoff
Rain Water Infiltration
Minimizing Runoff Concentrations

- **Protect** from water
  - Cover when filling if rain is forecast
  - Cover/wrap side walls
  - Cover and seal edges
  - Divert clean water away
  - Minimize exposure when feeding
- **Clean** pad (remove litter) particularly if rain event is forecast
- **Cover** spoilage and litter piles until removal
Collection System Design

• **Objectives**
  - Minimize collection volumes
    - Reduce storage and hauling requirements
  - Reduce environmental impact
    - Collect high strength waste
    - Low strength waste to treatment systems

• **Current System Design**
  - Capture 1\textsuperscript{st} flush, unconfirmed
    - Exists in urban runoff, why not here?
Collection Designs are Numerous
Treatment Using Filter Strips
Does a First-Flush Exist?

(Taebi & Droste, 2004)
Normalized Phosphorus Data
• Why is it that only ~10% of the events have characteristics of a 1st flush?

<table>
<thead>
<tr>
<th>% of Events</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear:</td>
<td>73%</td>
<td>75%</td>
</tr>
<tr>
<td>Delayed flush:</td>
<td>17%</td>
<td>23%</td>
</tr>
<tr>
<td>1st flush:</td>
<td>10%</td>
<td>3%</td>
</tr>
</tbody>
</table>
Concentration-Flow Relationship
All constituent data (TKN, TP, TS, COD, BOD) was statistically correlated EXCEPT pH which was negatively correlated.
Annual Loading

• Investigate
  • Timing
  • Load collected vs. load to VTA
  • Volume collected vs. load collected

• Seasonality and a few events
  • Snowmelt
  • Big rains
  • Filling
Nitrogen Loading

2014 Cumulative Total Kjeldahl Nitrogen Loading: Farm A

Load (lbs)

- Collected
- To VTA

- 2901 lbs
- 2235 lbs
Collection Design Recommendations

• First flush rarely exists!
  • Not the greatest load per volume
  • Collect low flow only
  • Or continuous throughout

• Additional collection within 2 weeks of filling
Collection Design Recommendations

• All flow to single collection point
• Provide subsurface drainage

• Inspect and Maintain facilities
  • Feed storage area
  • Collection system
  • Filter strip
  • Address potential issues
Design Concepts

- 1st Flush
- Low Flow only
- Continuous

Diagram showing the relationship between flow and time with categories for different flow rates:
Low Flow Collection

- Greater loading collected when collecting the low flow.

- Low flow collection uses peak flow rate of a designed storm.
  - 1% of the peak flowrate from a 2-year 24-hour design storm

- Peak flow rates can be calculated using one of many methods, e.g. Rational Method.
  - By hand or with software, e.g. HydroCAD
Conductivity Metering

Example Event with Conductivity: COD

- Flow (gal/min) & Conductivity (us/cm/10)
- Concentration (mg/l)

Hours

0  4  8  12  16  20  24  28  32

Flow: 100  200  300  400  500  600  700  800

Conductivity: Mid-pt Discrete

Discovery Farms Wisconsin

University of Wisconsin-Extension

Biological Systems Engineering

University of Wisconsin-Madison
Key Filter Strip Design Components

- Soil profile provides treatment
  - Complex
    - Soil type
    - Soil depth
    - Slope
    - Vegetation
    - Etc

- Avoid high groundwater table or shallow depth to bedrock
Key Filter Strip Design Components

• Ensure even application across filter strip
  • Irrigation pods
  • Grade evenly (difficult to achieve, need to supervise)
  • Rock checks for spreading
    • Impermeable membrane
    • 2-4 inch round stone
    • Every 100 feet of length

• Spreader at point of discharge to filter strip
Inefficient Filter Strip
Spreader at Discharge
To be continued…

• Other analysis being conducted
  • Recommended loading: filter strips
  • Timing and variation
  • Effect of feed volume and area covered
  • Conductivity metering

• Low flow collection = greater load collected
  • Loading with same volume
  • Volume with same loading
  • Effects
    • Economics
    • Designs
Thank You!

Questions/ Comments

http://www.uwdiscoveryfarms.org

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