The Effect of Flow Path on Nitrate and Atrazine Attenuation in a Bioretention Swale

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Export of nutrients and herbicides from tile-drained agricultural fields of the U.S. Midwest contributes to eutrophication and deterioration of water quality in the Mississippi River Basin.
Project Importance

• This project focuses on removal efficiency of both nutrients (nitrate) and herbicides (atrazine) in a constructed treatment wetland

• In the bioswale design we attempt to address several contaminants by using a combination of subsurface flow and surface flow cells
Monitoring Well and Piezometer Locations

Subsurface Flow Cell

Surface Flow Cell

Berm

Tile Riser Outlet

Water Control Structure

Bank

Stream

Inlet Tile

Seepage

14.5 m

4.4 m

2.7 m

Native Soil (0.6m depth)

Pea Gravel (0.3m depth)

Gravel (d 2.5cm) and Bark Mulch (0.6m depth)

Gravel (d 2.5cm)

*Drawing Not to Scale
One Month after Installation: July 11, 2011
April 2012 (4.53 cm of rainfall)
Discussion Points

• Water quality parameters measured and monitoring methodology

• Analysis of Results for NO$_3$ and atrazine
  – 3 storm events
    • November to December 2011
    • April 2012
    • May 2012
# Water Quality Analyses and Monitoring Methodology

<table>
<thead>
<tr>
<th>Parameters measured</th>
<th>Frequency of monitoring</th>
<th>Method</th>
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</thead>
<tbody>
<tr>
<td>Dissolved Oxygen, Temperature, Conductivity, pH, Oxidation-Reduction Potential, Discharge</td>
<td>Continuous monitoring</td>
<td>YSI 600XLM Multi-Parameter Water Quality Sonde</td>
</tr>
<tr>
<td>NO$_3$, NO$_2$, TKN, NH$_3$, SRP, Cl, SO$_4$</td>
<td>Select storm event sampling</td>
<td>Photometric method</td>
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<tr>
<td>Atrazine</td>
<td>Select storm event sampling</td>
<td>Enzyme-linked immunosorbent assay</td>
</tr>
<tr>
<td>DOC</td>
<td>Select storm event sampling</td>
<td>Elemental analyzer</td>
</tr>
</tbody>
</table>
Water Level in Bioswale and Sampling Events

- Nov/Dec Storm
- May Storm
- April Storm

Water Level in Subsurface Cell (m)
Rainfall (cm)
Sampling Date/Time
Low DO levels at T2 but not T3 during April storm due to backflow from surface cell
Nitrate – November Storm (6.35 cm rain event)

**Nitrate Concentrations**

- Average decrease in NO$_3$-N concentration: 2.0 mg N/L
- 20-70% NO$_3$-N removal

Continuous flow into bioswale and possibly longer HRT allowed for increased nitrate removal.

**Nitrate Percent Removal**

- 20-70% NO$_3$-N removal
Atrazine – November Storm (6.35 cm rain event)

**Atrazine Concentrations**

- Average decrease in atrazine concentration: 0.05 µg/L
- 10-70% atrazine removal

Continuous flow into bioswale and possibly longer HRT allowed for increased atrazine removal.
Nitrate – April Storm (4.53 cm rain event)

**Nitrate Concentrations**

The graph shows nitrate concentrations in mg N/L from 14-Apr to 24-Apr.

- **Average decrease in NO₃-N concentration**: 1.2 mg N/L
- **10-65% NO₃-N removal**

**Nitrate Percent Removal**

The graph displays the percentage of nitrate removal over the same period, with outlet flow (m³/s) on the right axis.

- Inlet and Outlet data points are indicated by blue diamonds and red squares, respectively.

- The graph highlights the removal efficiency over the April storm event.
Nitrate – May Storm (3.18 cm rain event)

Nitrate Concentrations

Average decrease in NO$_3$-N concentration: 1.1 mg N/L

Variable NO$_3$-N removal

Nitrate Percent Removal

Overland flow mixing with water in surface cell affects NO$_3$-N concentrations and removal results
Atrazine – May Storm (3.18 cm rain event)

Atrazine Concentrations

Average increase in atrazine concentrations from inlet to outlet of 0.14 µg/L

Variable atrazine removal

Atrazine Percent Removal

Particle associated atrazine in overland flow water affects results
Summary

• Continuous flow through system in Nov-Dec resulted in sustained and efficient \( \text{NO}_3 \) removal

• Overland flow water observed and appears to affect efficiency of system for both nitrate and atrazine attenuation

• Atrazine attenuation was variable, most likely due to bypassing the bioswale by overland flow
Future Work

• Adjust system to redirect overland flow

• Hydraulic retention time tracer tests and manipulation

• Run additional analyses for NO$_2$, NH$_3$, TKN, SRP, Cl, SO$_4$, DOC
Acknowledgements

• Aquisafe project is a collaboration between:
  – Indiana University-Purdue University Indianapolis, Indianapolis, IN, USA
  – The Wetlands Institute, Stone Harbor, NJ, USA
  – Umweltbundesamt, Berlin, Germany
  – Kompetenzzentrum Wasser Berlin, Germany
  – Veolia Water

• Thanks to IUPUI Center for Earth and Environmental Science staff and IUPUI students for their support on this project: Pamela Martin, Robert Hall, Robert Barr, Michael Stouder, Nicholas Clercin, Samantha Simpson, Ty Winslow, Lori Bebinger, Brittani Burton, Makenna Wesner, Lauren Thomas, Samapriya Roy, Deborah Piemonti