Amendments to Filtration for Improving Water Quality Treatment

Andy Erickson, Research Fellow
St. Anthony Falls Laboratory
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Amendments to Filtration

• What’s in Stormwater?
• Dissolved pollutants
• Current treatment methods
• Compost for Metal Sorption
• Compost for Hydrocarbon Degradation
• Iron for Phosphorus Sorption
• Field applications and results
• Questions

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What’s **IN** Urban Stormwater?

- Solids (inorganic, organic)
- Nutrients (nitrogen, phosphorus, etc.)
- Metals (copper, cadmium, zinc, etc.)
- Deicing Agents (chloride, salts, etc.)
- Hydrocarbons
- Bacteria/Pathogens
- Others
Pollutant Spectrum

- Al-Hamdan et al. (2007) - Miami
- Al-Hamdan et al. (2007) - Orlando
- Al-Hamdan et al. (2007) - Tallahassee
- Andral et al. (1999)
- Anta et al. (2006)
- Cleveland and Fashokun (2006) - Storm
- Cleveland and Fashokun (2006) - Non-storm
- Driscoll (1986)
- EPA (1983)
- Kayhanian et al. (2004) UGB
- Kayhanian et al. (2004) DGB
- Kayhanian et al. (2004) FBoE
- Li et al. (2006)
- MRSC (2000)
- Roger et al. (1998)
- Sansalone et al. (1998)
- Walker and Wong (1999)
- Westerlund and Viklander (2006)
- Zanders (2005)

$d_{50} = \text{Silt/Sand}$

Particle Size (microns)

- Colloids
- Soluble / Dissolved
- Clay
- Silt
- Sand
- Gross Solids
- Organic / Float

Percent passing

- 0%
- 20%
- 40%
- 60%
- 80%
- 100%

Particle Size (microns)

- 0.001
- 0.01
- 0.1
- 1
- 10
- 100
- 1000
- 10000

- 0.005 μm
- 0.2 μm
- 2 μm
- 75 μm
- 4250 μm

http://stormwater.safl.umn.edu/
Are Dissolved Pollutants Significant?

Median Pollutant Concentration

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Median Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0</td>
</tr>
<tr>
<td>Chromium</td>
<td>0</td>
</tr>
<tr>
<td>Copper</td>
<td>0</td>
</tr>
<tr>
<td>Lead</td>
<td>0</td>
</tr>
<tr>
<td>Nickel</td>
<td>0</td>
</tr>
</tbody>
</table>

Dissolved Fraction

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Dissolved Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>45.5%</td>
</tr>
<tr>
<td>Cadmium</td>
<td>50.0%</td>
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<tr>
<td>Chromium</td>
<td>29.7%</td>
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<tr>
<td>Copper</td>
<td>50.0%</td>
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<tr>
<td>Lead</td>
<td>18.9%</td>
</tr>
<tr>
<td>Nickel</td>
<td>44.4%</td>
</tr>
</tbody>
</table>

Phosphorus

Dissolved Fraction 44.4%

Zinc

Dissolved Fraction 45.5%

Are Dissolved Pollutants Important?

- More Bioavailable
- Nutrients $\rightarrow$ eutrophication
- Metals $\rightarrow$ bioaccumulation, toxicity
- Petroleum hydrocarbons $\rightarrow$ toxicity

Current Treatment Practices

How Soil Amendments Improve Water Quality

- **Physical Processes (i.e., hydraulics):**
  - Better infiltration results in more water treated (less overflow)
  - Better filtration results in more particles captured

- **Chemical Processes:**
  - Sorption or precipitation to bind dissolved pollutants

- **Biological Processes:**
  - Vegetation uptake to capture or bacterial degradation to transform pollutants
Metals sorption to Compost


Source: http://stormwater.safl.umn.edu/
Metals sorption to Compost

Biodegradation of petroleum hydrocarbons

- Petroleum Hydrocarbons are captured in rain gardens through sorption and biodegradation
- Biodegradation prevents accumulation of petroleum hydrocarbons
- Rain gardens are an effective option for sustainably treating petroleum hydrocarbons in stormwater

Phosphorus Leaching from Compost

Designing for Metals and Petroleum Hydrocarbon capture with Rain Gardens

- Compost can capture metals and petroleum hydrocarbons but can release phosphorus, therefore:
  - Incorporate compost in treatment practices to capture metals and hydrocarbons
  - Ensure aerobic conditions to promote biodegradation
  - Incorporate another process to capture any phosphorus that passes through or is leached from the compost
Phosphorus Sorption with Iron

- Sand Filtration
  - Particulate capture > 80%

- Enhanced Sand Filtration
  - Steel wool increases dissolved phosphorus capture via surface sorption to iron oxide

Experimental Results
(Iron Enhanced Sand Filtration, SAFL)

Detection limit

Dissolved phosphorus concentration (mg/L)

Influent 100% Sand 0.3% iron 2% iron 5% iron
Iron Enhanced Filter
(5% iron filings, Maplewood, MN)

Photo Courtesy: A. Erickson
Field Monitoring Results (Iron Enhanced Filter Basin, Maplewood)

- 75.1% Total Phosphorus Removal
- 29.2% Dissolved Phosphorus Removal

Phosphorus Concentration (mg/L)

- Influent
- Effluent
- Detection limit
Iron Enhanced Filter Trenches
wet detention ponds (Prior Lake, MN)
Filter Trenches around wet detention ponds (Prior Lake, MN)

- Volume Treated by Trenches (Filter Volume)
- Normal Water Surface Elevation
- Drain tile
- Iron Enhanced Filter
- Water Level Control Weir
- Overflow Grate
- Drain tile

http://stormwater.safl.umn.edu/
Field Testing Results
(Iron Enhanced Filter Trenches, Prior Lake)

Dissolved Phosphorus Concentration (mg/L)

- Influent
- 7% Iron Filings
- Detection limit

73.1% Removal
Designing for Phosphorus Capture with Iron

- As iron rusts, sorption sites for phosphorus are created, therefore:
  - Design Iron Enhanced Filter systems for watersheds with significant dissolved phosphorus fraction
  - Ensure the system is oxygenated to ensure iron oxides remain aerobic
  - Design systems with 8% or less iron by weight to prevent clogging
Other Amendments

• Alum (water treatment residual) & Hardwood Bark Mulch – Phosphorus sorption (A. Davis, Univ. of Maryland)
• Commercial products (various)
• Internal Submerged Zone for denitrification (W. Hunt, North Carolina State University)
Conclusions

• Dissolved Stormwater Pollutants are important
  – Approx. 45% of total concentration is dissolved
• Physical methods are not enough
  – Chemical and biological mechanisms can be used to capture dissolved fractions
• There are field-tested solutions!
  – Minnesota Filter (iron-enhanced sand) → phosphorus
  – Compost-amended bioretention → metals & petroleum hydrocarbons
Stormwater UPDATES Newsletter

Welcome Andy!

Thank you for reading our newsletter! Our purpose is to create opportunities for partnerships which are crucial to our quest for improving the methods for assessment and maintenance of stormwater treatment practices.

For past newsletters, publications, presentations and more information, please visit our website.

If you have any questions, please contact us.

Third Party Testing at the St. Anthony Falls Laboratory
Contributed by Craig Taylor, Associate Engineer, St. Anthony Falls Laboratory, University of Minnesota

Third-party testing is a service provided by the St. Anthony Falls Laboratory (SAFL) to evaluate a stormwater product's operational effectiveness. The goals of third-party testing are to:

1. Confirm or refute that a manufacturer's product works as they expect it to.
2. Verify that a product will work in a specific watershed or under unique conditions.
3. Help manufacturer and practitioners visualize the mechanisms by which a product functions, and

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Thank you for your attention! Questions?

For more information, contact:
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