Rain Garden Research and Current Issues

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Managing Stormwater from Impervious Surfaces: Green Infrastructure Solutions for New Jersey
The Heldrich | New Brunswick, NJ

January 27, 2011
Monitoring-Began November 2002
Installation: 9-19-02
Rain Garden Materials Detail
(Based on PGC RG Manual, 2001)

• Three native shrub species:
  – Chokeberry (*Aronia prunifolia*)
  – Winterberry (*Ilex verticillata*)
  – Compact inkberry (*Ilex glabra compacta*)

• Native soil mix
  – Loamy sand

• Roughly 5 cm of bark mulch
Monitoring Equipment
Methods

- Lab analysis of water samples for:
  - Nitrate-N, ammonia-N, total Kjeldahl-N, total phosphorus, copper, lead, zinc

- Water level in each garden measured

- Temperature measured at inlet and outlet (underdrains)

- Weekly measurements of soil moisture, redox potential ($E_h$), and frost depth
# Flow balance

<table>
<thead>
<tr>
<th></th>
<th>cm</th>
<th>% of Inflow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inflow</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof Runoff</td>
<td>1202</td>
<td>79.7</td>
</tr>
<tr>
<td>Precipitation</td>
<td>306</td>
<td>20.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1507</td>
<td></td>
</tr>
<tr>
<td><strong>Outflow</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underdrain</td>
<td>1438</td>
<td>95.4</td>
</tr>
<tr>
<td>Overflow</td>
<td>13</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1451</td>
<td></td>
</tr>
<tr>
<td><strong>Residual</strong></td>
<td>56</td>
<td>3.7</td>
</tr>
</tbody>
</table>

99% of inflow retained!
**Percent retention**

<table>
<thead>
<tr>
<th></th>
<th>NO$_3$-N</th>
<th>NH$_3$-N</th>
<th>TKN</th>
<th>TP</th>
<th>TN</th>
<th>ON</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total In</strong></td>
<td>388</td>
<td>30</td>
<td>250</td>
<td>9</td>
<td>647</td>
<td>211</td>
</tr>
<tr>
<td><strong>Total Out</strong></td>
<td>128</td>
<td>5</td>
<td>186</td>
<td>20</td>
<td>316</td>
<td>181</td>
</tr>
<tr>
<td><strong>% Retention</strong></td>
<td>67</td>
<td>82</td>
<td>26</td>
<td>-108</td>
<td>51</td>
<td>14</td>
</tr>
</tbody>
</table>

-Two years of results (year 1 much less)

-Remember: 99% of inflow was retained
Total Phosphorus

- Roof runoff
- Underdrain average
- Exponential (Underdrain average)
- Linear (Roof runoff)

$R^2 = 0.47$

$R^2 = 0.06$
Comparison with other research

• **Consistent with North Carolina**

• **Consistent (N) & inconsistent (P) with Maryland**

• **Consistent with New Hampshire**

• **Lots of variability in results!**
Second year

• Modification to encourage denitrification and increase treatment of NO$_3$-N

• Saturated zone created in bottom of rain garden (after Kim, et al., 2004)
Modification

Ponding depth
Saturated zone

Monitoring tank

Underdrain

1 m
Impact on NO$_3$-N

• No statistically significant reduction in NO$_3$-N concentrations
  – Lots of samples below detection limit

• Percent of outflow samples below detection before/after change:
  – Before = 19%
  – After = 56%
  – Significant using chi-square statistic
What happens in the winter?
Frost Tube

After Ricard, et al. (1976)
Frost Tube Detail
Winter performance

• Measured frost depth
• Did not impact annual performance

• http://www.youtube.com/watch?v=cq6WB6VKeac

• Similar findings at UNH Stormwater Center
Some Current Issues

• Filter fabric use
  – DON’T USE IN BIORETENTION!
  – Prone to clogging

• Sizing
  – Water quality volume vs. curve number vs. ?
Thank You!!

Questions??

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Two year ANOVA/mean separation

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Unit</th>
<th>Bulk Deposition</th>
<th>Roof Runoff</th>
<th>Underdrain Treatment</th>
<th>Underdrain Control</th>
<th>Overflow Treatment</th>
<th>Overflow Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₃-N</td>
<td>73</td>
<td>mg L⁻¹</td>
<td>0.7 bcd</td>
<td>0.9 abc</td>
<td>0.2 d</td>
<td>0.4 cd</td>
<td>2.0 ab</td>
<td>2.1 a</td>
</tr>
<tr>
<td>NH₃-N</td>
<td>78</td>
<td>mg L⁻¹</td>
<td>0.04 a</td>
<td>0.04 a</td>
<td>0.01 b</td>
<td>0.01 b</td>
<td>0.08 a</td>
<td>0.04 a</td>
</tr>
<tr>
<td>TKN</td>
<td>79</td>
<td>mg L⁻¹</td>
<td>0.5 a</td>
<td>0.6 a</td>
<td>0.4 a</td>
<td>0.5 a</td>
<td>0.6 a</td>
<td>0.3 a</td>
</tr>
<tr>
<td>TN</td>
<td>72</td>
<td>mg L⁻¹</td>
<td>1.3 abc</td>
<td>1.6 ab</td>
<td>0.7 c</td>
<td>0.9 bc</td>
<td>2.7 a</td>
<td>2.4 a</td>
</tr>
<tr>
<td>TN</td>
<td>77</td>
<td>mg L⁻¹</td>
<td>0.4 a</td>
<td>0.5 a</td>
<td>0.4 a</td>
<td>0.5 a</td>
<td>0.5 a</td>
<td>0.2 a</td>
</tr>
<tr>
<td>TN</td>
<td>80</td>
<td>mg L⁻¹</td>
<td>0.009 b</td>
<td>0.015 b</td>
<td>0.039 a</td>
<td>0.043 a</td>
<td>0.009 b</td>
<td>0.016 b</td>
</tr>
<tr>
<td>Cu_total</td>
<td>26</td>
<td>µg L⁻¹</td>
<td>3 a</td>
<td>5 a</td>
<td>3 a</td>
<td>4 a</td>
<td>3 a</td>
<td>-</td>
</tr>
<tr>
<td>Pb_total</td>
<td>26</td>
<td>µg L⁻¹</td>
<td>3 a</td>
<td>3 a</td>
<td>3 a</td>
<td>3 a</td>
<td>3 a</td>
<td>-</td>
</tr>
<tr>
<td>Zn_total</td>
<td>26</td>
<td>µg L⁻¹</td>
<td>11 a</td>
<td>9 a</td>
<td>10 a</td>
<td>5 a</td>
<td>8 a</td>
<td>-</td>
</tr>
</tbody>
</table>

*** p=0.001  
ns=ANOVA comparison non significant  
¹n=4 for overflow samples

Means followed by the same letter are not significantly different at p=0.05