Flow Rate and Sediment Trapping Laboratory Experiments using Various Biofilter Media

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Controlled fill-factorial lab column tests were conducted to determine flow and particle trapping capabilities of sand-peat media mixtures, Tuscaloosa surface and subsurface soils, and media samples from biofilter facilities, along with very coarse media as used in supporting layers and underdrains.
The median sizes of the biofilter sand-based media mixtures ranged from 400 to 2,000 μm and the uniformity coefficients ranged from 5.5 to 40.

<table>
<thead>
<tr>
<th>Example Media Mixtures</th>
<th>D$_{50}$ (um)</th>
<th>Uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% Peat and 90% sands</td>
<td>350 to 1875</td>
<td>up to 22</td>
</tr>
<tr>
<td>25% Peat and 75% sands</td>
<td>300 to 1875</td>
<td>up to 16</td>
</tr>
<tr>
<td>50% peat and 50% sands</td>
<td>300 to 1625</td>
<td>up to 20</td>
</tr>
<tr>
<td>Tuscaloosa surface soils</td>
<td>270</td>
<td>6</td>
</tr>
<tr>
<td>Tuscaloosa subsurface soils</td>
<td>1300</td>
<td>33</td>
</tr>
</tbody>
</table>

**Standard biofilter media**

<table>
<thead>
<tr>
<th>Location</th>
<th>D$_{50}$ (um)</th>
<th>Uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kansas City</td>
<td>2000</td>
<td>40</td>
</tr>
<tr>
<td>North Carolina</td>
<td>700</td>
<td>6</td>
</tr>
<tr>
<td>Wisconsin (avg.)</td>
<td>500</td>
<td>5.5</td>
</tr>
</tbody>
</table>
Laboratory Column Tests

- More than 100 column tests were conducted during full-factorial experiments to identify the most significant factors affecting media performance.

- The media layers were about 0.5 m (1.5 ft) thick.

- Four liters of test water were poured into each lab column that was filled with one of the media mixtures.

- The surface ponding depths in the columns ranged between 28 cm (11 in.) and 36 cm (14 in.) to correspond to the approximate maximum ponding depths at biofilters.

Effluent samples were collected from the bottom of the columns at the beginning, middle, and end of the drainage time and composted in clean 1 L bottles for the lab analyses.
Surface 3D plot of uniformity and texture vs. final infiltration rates for hand compacted conditions. Higher infiltration rates were observed for mixtures having low uniformity and higher median size values, as expected.
Particulate Trapping Experiments

- Full factorial tests examined particulate trapping for median particle size, uniformity, compaction, organic content, and sediment concentrations for each particle size category.
- Challenge water was made by adding sediment to Black Warrior River water (coarse sand: medium sand: Sil-Co-Sil 250 = 10:15:75 by mass) along with fines from the river water, resulted in a particle size distribution covering a wide range of particle sizes.
- The concentrations of sediment in the influent challenge water ranged from about 100 to 1,000 mg/L during the different experiments.
The challenge water covered a wide range of particle sizes, with a median size of about 25 µm. This mixture was not intended to represent stormwater, but to provide sufficient particulate samples in each particle range that were individually examined.
The constituents analyzed included:

- SSC (complete sample volumes were split using USGS/Dekaport cone splitter)
- TDS (< 0.45 um particles)
- PSD (by sieves and Coulter Counter)
- turbidity (continuous and for each sample)
- conductivity (continuous and for each sample).
Example line performance plots for sand-peat media mixtures for different particle size ranges. Significant reductions occurred during most of the lab column tests, with somewhat better removals for finer media and slower infiltration rates. No reductions were observed for very coarse materials.
Conclusions

- Controlled flow studies using full factorial analyses indicated that texture and uniformity of the media mixture have the greatest effect on the measured final infiltration rates of the media.

- The organic matter in the biofilter media did not have a significant effect by itself on the infiltration rates compared to the other factors (texture, uniformity, and compaction). However the organic matter serves as a reservoir of nutrients and water in the biofilter media enhancing plant growth that enhances long-term performance.
Conclusions

- Compaction did not significantly affect the infiltration rates for the mixtures having large amounts of sand and little peat; however, infiltration studies conducted previously indicated that compaction significantly affected typical soil infiltration rates having normal organic content, especially if high in fines content.

- The particle trapping experiments using sand-peat mixtures and Tuscaloosa surface soil samples indicated that significant reductions occurred for most sand-based media mixtures.

- Coarse media (pea gravel and larger did not indicate any significant particulate removals).
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