CONFERENCE ON STORMWATER AND URBAN WATER SYSTEMS MODELING

Laboratory Column Experiment on Particle Trapping Capabilities of Various Biofilter Mixtures

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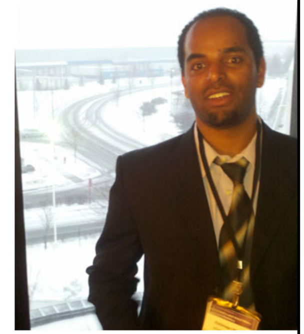
Educational Background

- **Postdoctoral Researcher**, *The University of Alabama, Tuscaloosa, AL, USA. Jan 2014 – present.*
- **Ph. D.,** *Water Resources Engineering. The University of Alabama, Tuscaloosa, AL, USA. Dec 2013.*
- **MSCE,** *Civil Engineering.The University of Alabama, Tuscaloosa, AL, USA. Dec 2010.*
- **M.S.,** *Applied Physics. Alabama A & M University, Normal, AL, USA. Dec 2008*
- **B.S.,** *Hydraulic Engineering. Arbaminch University, Ethiopia. July 2005.*



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Introduction

- Stormwater biofilters are widely used in urban areas to reduce runoff volume, peak flows and stormwater discharges and impacts to receiving waters. However, the performance of these systems in urban areas is affected by premature clogging of filtration media by incoming sediment, which in turn can decrease the life span of the device.
- Capture of fine particulates and eventual clogging is one of the most common causes of failure in stormwater infiltration devices.

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Introduction Cont.

- Controlled laboratory column tests were conducted to determine flow and particle trapping capabilities of sand-peat media mixtures, Tuscaloosa surface and subsurface soils, using challenge water made up of a wide range of particle sizes.

Sand media

Surface (a) and subsurface soil (b) media from Tuscaloosa, AL USA

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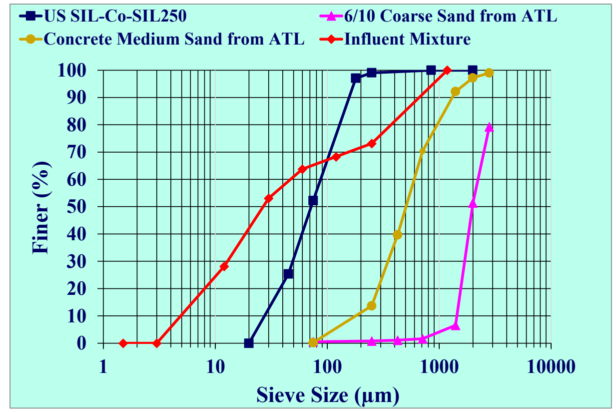
Introduction Cont.

- The test sediment added to the Black Warrior River Water (coarse sand: medium sand: fine Sil-Co-Sil250 = 10: 15: 75 by mass) resulted in a generally uniform particle size distribution.
- The resulting total concentrations of sediment in the influent challenge water were about 100 and 1,000 mg/L during the experiments.

Test Sediment Particle Distribution



Black Warrior River water was used as the test water to provide the smaller particles which are less than 20 µm in the challenge water mixture.

Particle Trapping Tests

- The influent dirty water samples were composited for analysis for each batch, while the column effluents were separated for suspended sediment concentration (SSC), total dissolved solids (TDS), particle size distribution (PSD), turbidity, and conductivity analyses.
- This influent solution was then split into ten 4 liter capacity containers for testing each of ten columns and were replicated three times.

Laboratory Column Tests

- Particle trapping tests were conducted in some of the sand- peat columns (selected to represent the overall range of conditions observed) and Tuscaloosa surface soil for hand and modified proctor compaction conditions.
- Both standard and modified proctor compactions follow ASTM standard (D 1140-54).
- 100 mm (4 in.) diameter PVC pipes 0.9 m (3 ft) long, were used for these tests

Lab column construction

Laboratory Column Tests Cont.

- The media layer was about 0.5 m (1.5 ft) thick.
- Four liters of challenge water was poured into each lab column that was filled with one of the media mixtures. Clean water was used for the flow test.
- 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.

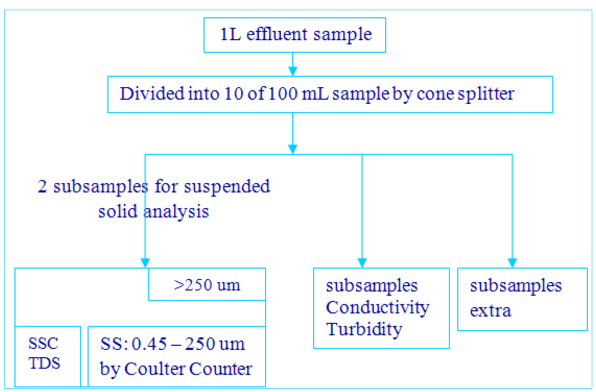
Effluent samples were collected from the bottom of the columns at the beginning, middle, and end of the drainage time and composted in clean 1 L bottles for the lab analyses.

Laboratory Solids Analysis

- The constituents analyzed included:
  - SSC
  - TDS (< 0.45 um particles)
  - PSD (by sieves and Coulter Counter)
  - turbidity (continuous and for samples)
  - conductivity analyses (continuous and for samples).

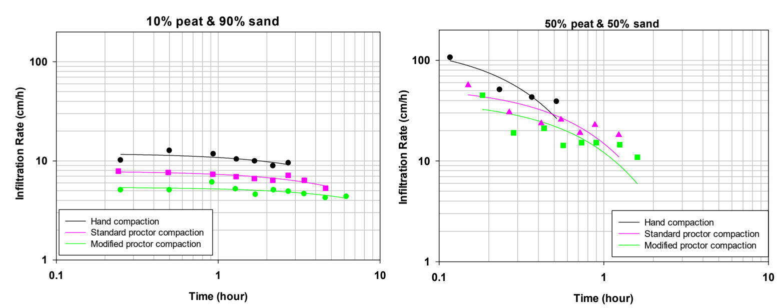
USGS/Dekaport cone splitter.

Laboratory Solids Analysis Cont.



Solids analysis flow sheet

Infiltration Test Results

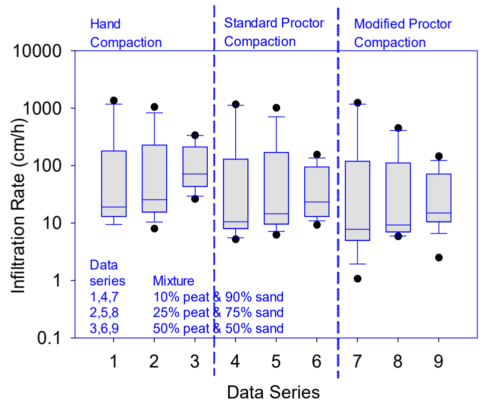


Example infiltration data for different test trials were fitted to Horton's equation to estimate f_c (final infiltration) based on the observed data

Infiltration Test Results

Box and Whisker plots of the different test conditions, comparing different compaction conditions with varying amounts of peat amendments.

- The avg. infiltration rates of the saturated mixtures indicated that the infiltration rates through the mixtures increased with increases in the percentage of peat.



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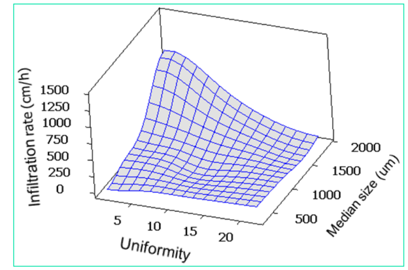
Infiltration Test Results Cont.

- An example surface plot for uniformity and texture vs. final infiltration rate for low organic content conditions. Higher infiltration rate values were observed for a mixture having low uniformity and higher median size values, as expected.



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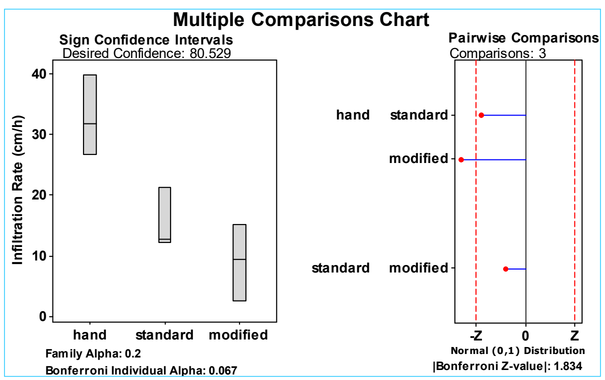
Infiltration Test Results Cont.

Kruskal-Wallis multiple pairwise comparisons test of different levels of compaction using 50% peat and 50% sand mixture (mixture D_{50} = 1250 um and C_u = 19).



There are significant differences (p = 0.02) between the saturated infiltration rate values using hand vs. modified proctor compaction methods.

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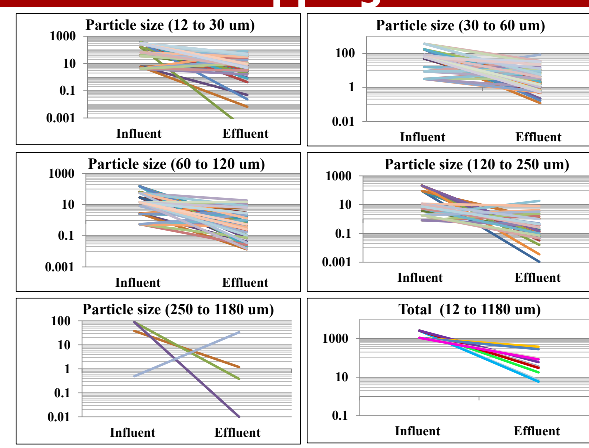
Particle Trapping Test Results



Example line performance plots for sand-peat media mixtures for different particle ranges. Reductions occurred for most of these lab column tests, with relatively consistent effluent conditions.

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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 lab columns, with relatively consistent effluent conditions.

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Conclusions

- Controlled flow studies conducted by the authors previously, and analyzed 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 and increases water infiltration into the media.

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Acknowledgments

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Questions ????

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