Enhanced Removal of Stormwater Contaminants using Amended Biofilters in CTR Systems

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Objective:

Evaluate the removal of dissolved organic carbon (DOC) and its biodegradable fraction (BDOC) (linked to trace organic contaminant attenuation) in stormwater runoff by geomedia-amended columns

Introduction:

When storms occur in urban areas, water doesn't percolate into the ground as easily as in nonurban areas, because of all the impervious material on the ground such as asphalt. This causes the stormwater to run through the streets, collecting pollutants along the way, before finally discharging into surface water. Additionally, stormwater is increasingly being seen as a potential local source of water in water scarce urban areas of the West. If properly treated, stormwater could be a valuable source of drinking water.

Recent studies have shown that redox conditions and levels of BDOC can have a significant effect on the removal of trace organic contaminants (TrOCs). In addition, removal of BDOC is a measure of filter performance, improves the biological stability of the effluent and minimizes problems (e.g., metal mobilization) during recharge. For the reasons listed above, in this study BDOC was chosen as a metric of the column system's removal efficacy.

CTR Set up:

The City of Los Angeles is going to set up a stormwater capture, treatment and recharge (CTR) system to augment local drinking water supplies called Rory M. Shaw wetland Park. First, the Stormwater is collected in a detention pond and sent through a Then the stormwater is then percolated through a passive filtration system.

The geomedia that is typically used is sand. In this study biochar and manganese oxide (MnOx) coated sand, which are both low-cost and sustainable geomedia, are being compared to sand for their removal abilities.

After being run though the column system, the stormwater is then used to recharge a local aquifer that is used as a drinking water supply.

Figure 1. Drawing of Rory M. Shaw Wetlands Park in Los Angeles, CA

Column Set Up:

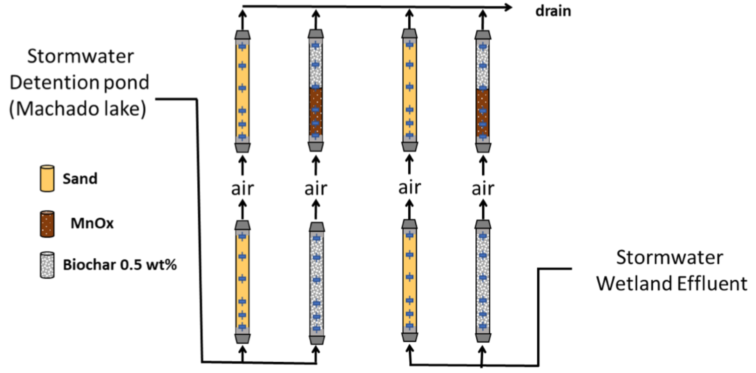

Figure 2. Diagram of the column Setup

Stormwater from the detention pond was pumped to a sequential column system of either sand, an aeration flask (intended to return oxygen to the water to allow aerobic microbes to grow in the second column), followed by another column of sand or 0.5 wt.% biochar, an aeration flask, the a mix of 0.5 wt.% biochar and MnOx-coated sand. Stormwater from wetland effluent was passed through the same set up.

BDOC and SUVA Experiment Methodology:

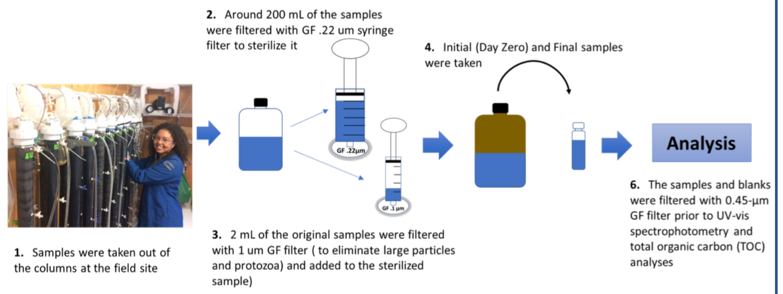

Figure 3. Diagram of experimental procedures

BDOC and SUVA calculations

The following equation was used to calculate the BDOC concentration (mg L^{-1}):

$$\text{BDOC} = (\text{DOC}_{\text{initial,sample}} - \text{DOC}_{\text{final,sample}}) - (\text{DOC}_{\text{initial,blank}} - \text{DOC}_{\text{final,blank}}) \quad (1)$$

The Specific Ultraviolet absorbance (SUVA, m^{-1} L mg^{-1}) is then calculated from the UV and DOC data:

$$\text{SUVA} = \frac{UVA_{254}}{\text{DOC}} \quad (2)$$

Results and Discussion

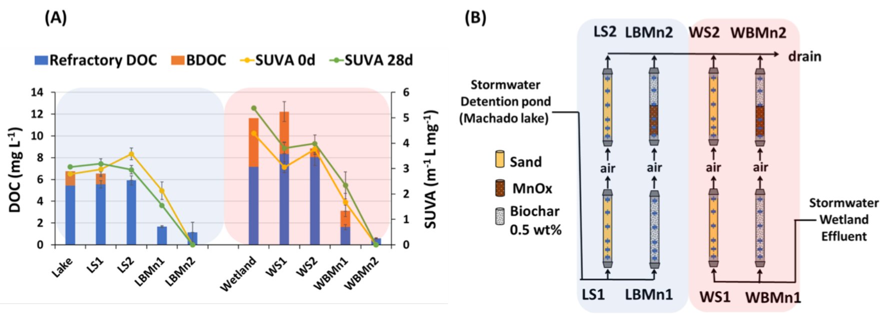

Figure 4. (A) BDOC Results. (B) Column Diagram for the field setup

Results showed that the wetland sample had significantly more DOC than that of the lake (Figure 1, A). This indicates that the wetland leaches DOC, including BDOC, as the concentration of DOC and BDOC were over twice and four-fold than the lake, respectively. This demonstrates that even though a wetland can add contaminant treatment to the lake captured stormwater, its effluent requires an extra unit-process to lower the DOC content. Additionally, geomedia chosen for this study clearly outperformed sand in DOC removal. Geomedia-containing columns were able to achieve >70% DOC reductions. Although sand columns showed no or very little DOC removal, they successfully removed most of the BDOC (especially in the re-aerated second columns). The sequential sand system treating lake water, with less initial BDOC than the analogous wetland water, completely removed BDOC.

Regarding geomedia columns, UVA and DOC values decreased simultaneously. Hence, both initial SUVA (0-day) and DOC decreased during the passage through the sequential system. This behavior may be attributed to refractory DOC adsorption onto biochar while BDOC fraction was consumed by microorganisms. In most cases when effluents still contained BDOC, the SUVA for the 28-day sample was higher than the SUVA for the 0-day sample. A higher SUVA, at the wavelength used (254 nm), implies a higher proportion of aromatic functional groups in the DOC, which in turn indicates that a higher portion of the DOC remaining is refractory. Results from this experiment support the idea that including a geomedia-amended biofilter to polish stormwater wetland effluent prior to managed aquifer recharge practices could be beneficial.

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References

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