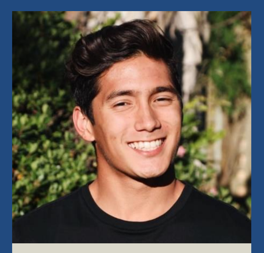
Biochar filters for the removal of trace organic contaminants from urban stormwater (RRS7)

Managed aquifer recharge technologies (SMART)

Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt)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Background

Changes in demand for water coupled with future scarcity in freshwater supplies necessitate that California adopt a new diversified water portfolio that meets long term needs. The L.A. Department of Water and Power aims to significantly increase stormwater by 2035 (Stormwater Capture Master Plan). We investigated the filter material, biochar, for stormwater purification, specifically for removal of trace organic contaminants such as pesticides and corrosion inhibitors.

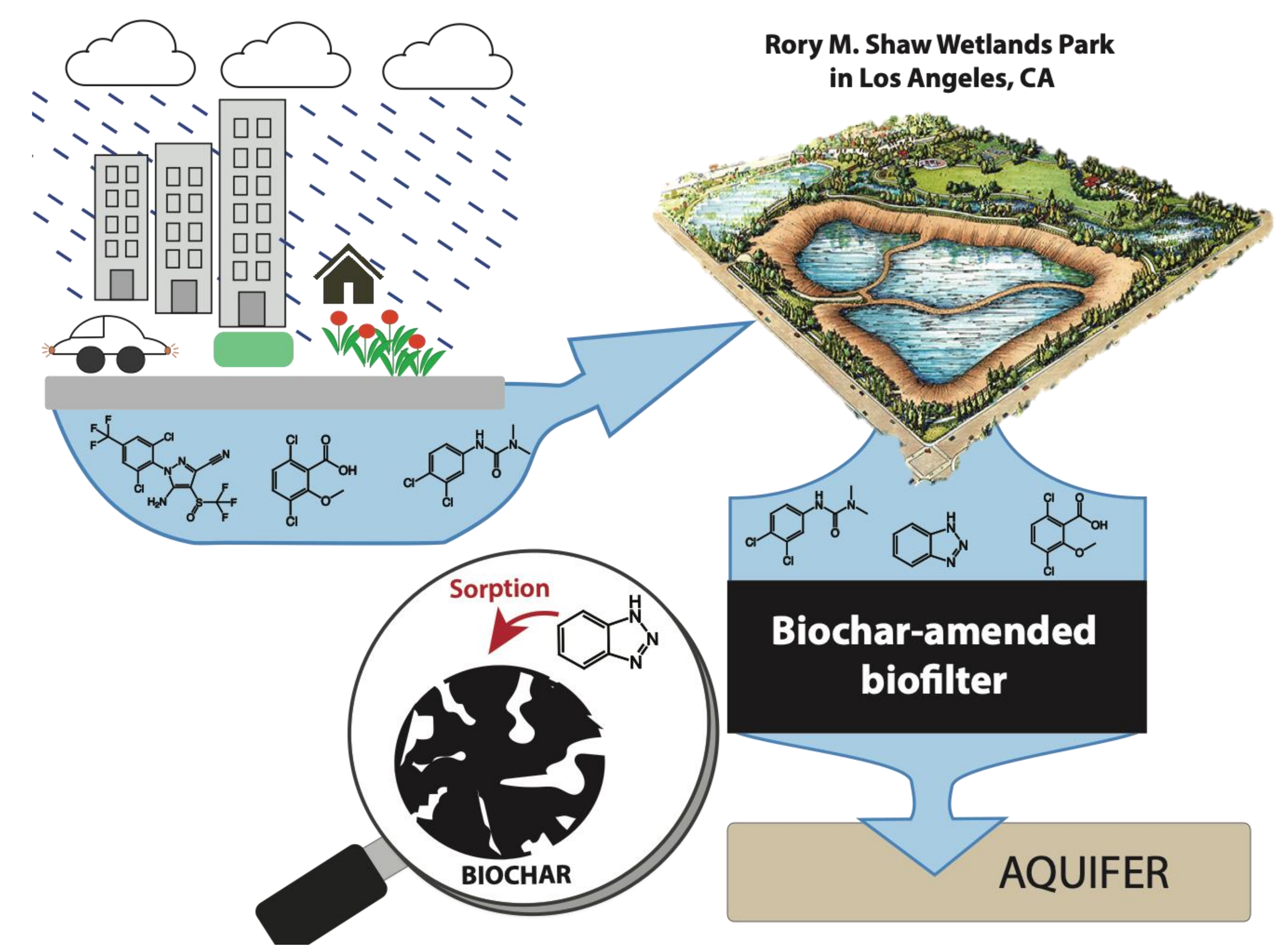


Figure 1: Model of Stormwater Capture Method

Approach

Twelve columns were subdivided into four different categories of filter material (Figure 2), (i) S: Ottawa sand as control, (ii) C: Ottawa sand mixed with 20 wt.% carbonate sand, (iii) SB: Ottawa sand mixed with 1 wt.% of gasification biochar, and (iv) CB: Ottawa sand with 20 wt.% of carbonate sand and 1 wt.% of the gasification biochar.

The columns were challenged by continuously pumping a mixture of seven trace organic contaminants and five metals in synthetic stormwater (pH 7.5) through the columns at a flow rate of 1.3 mL/min. The concentration of the contaminants was 60µg/L and the columns were operated in upflow mode.

Each of the twelve column effluents were sampled for trace organic contaminant and metal analysis over a time period of 9 months. Trace organic contaminants were quantified using liquid chromatography mass spectrometry (LC-MS/MS).

Figure 2: Twelve columns subdivided into different filter material groups

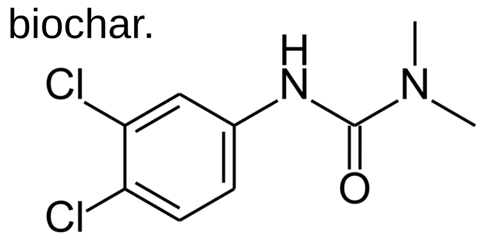
Results

Trace Organic Contaminant Removal

Figures 3 and 4 depict the breakthrough curves for diuron and dicamba. Both the S (Ottawa sand) and C (Ottawa sand with 20% carbonate sand) columns showed almost immediate breakthrough, within 1 to 2 pore volumes. For the S and C columns, this was true for all of the trace organic contaminants.

Biochar effectively enhanced the removal of all select trace organic contaminants. Diuron was retained for more than 3000 pore volumes in both the SB (Ottawa sand mixed with 1 wt.% of gasification biochar) and CB (Ottawa sand with 20 wt.% of carbonate sand and 1 wt.% of the gasification biochar) filters. Dicamba, which is negatively charged at pH 7.5, started to break through after approximately 800 pore volumes of the synthetic stormwater mixture were treated. Full breakthrough of dicamba was reached after 3000 pore volumes.

These results suggest that organic compounds are removed to various extents in biochar filters depending on their tendency to sorb onto biochar. Highly water soluble and anionic species such as dicamba are especially challenging to remove.



Diuron (herbicide)

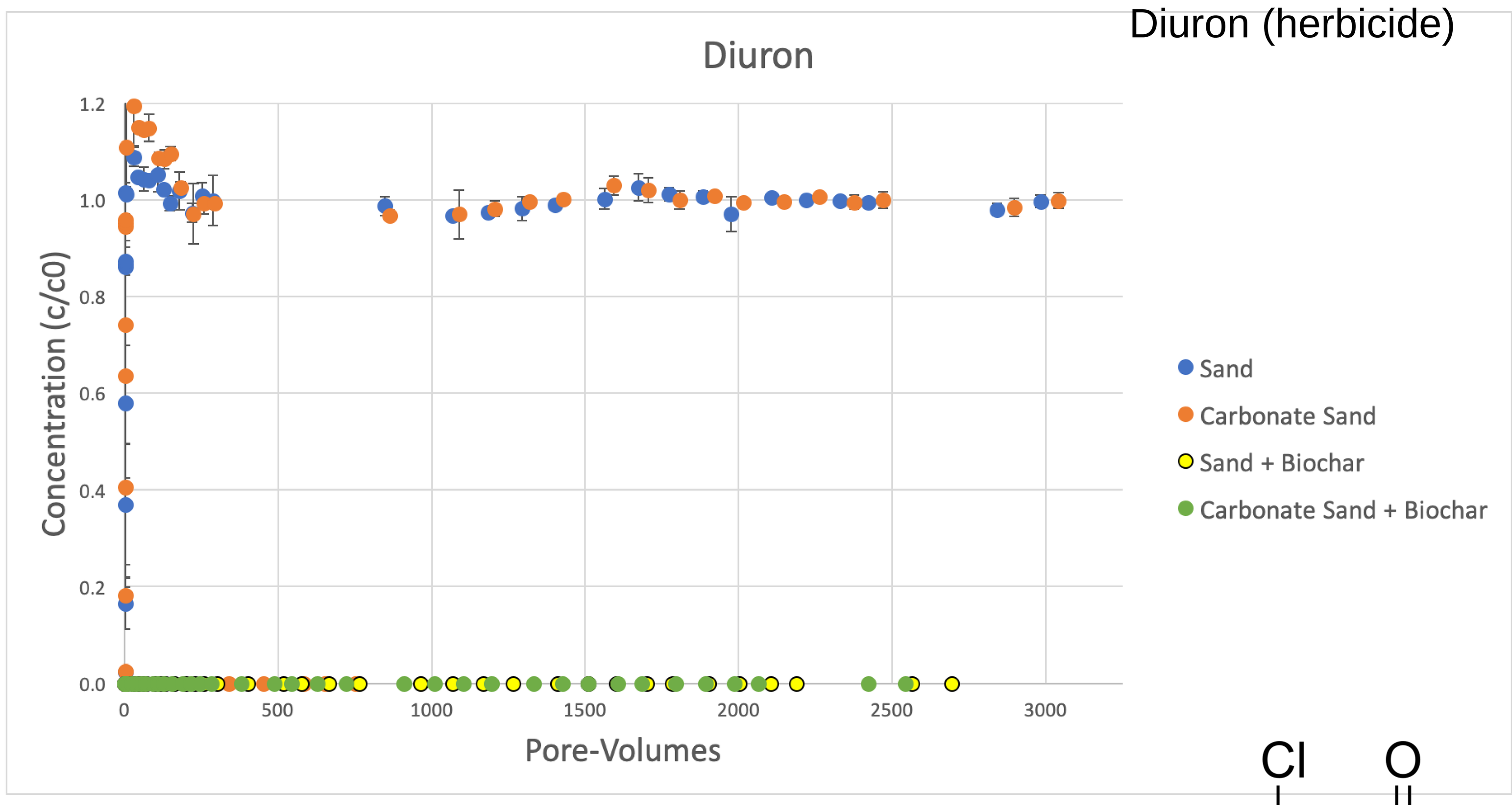
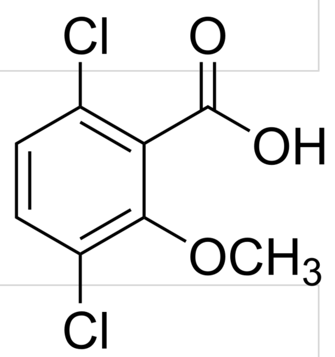


Figure 3: Diuron breakthrough curves



Dicamba (herbicide)

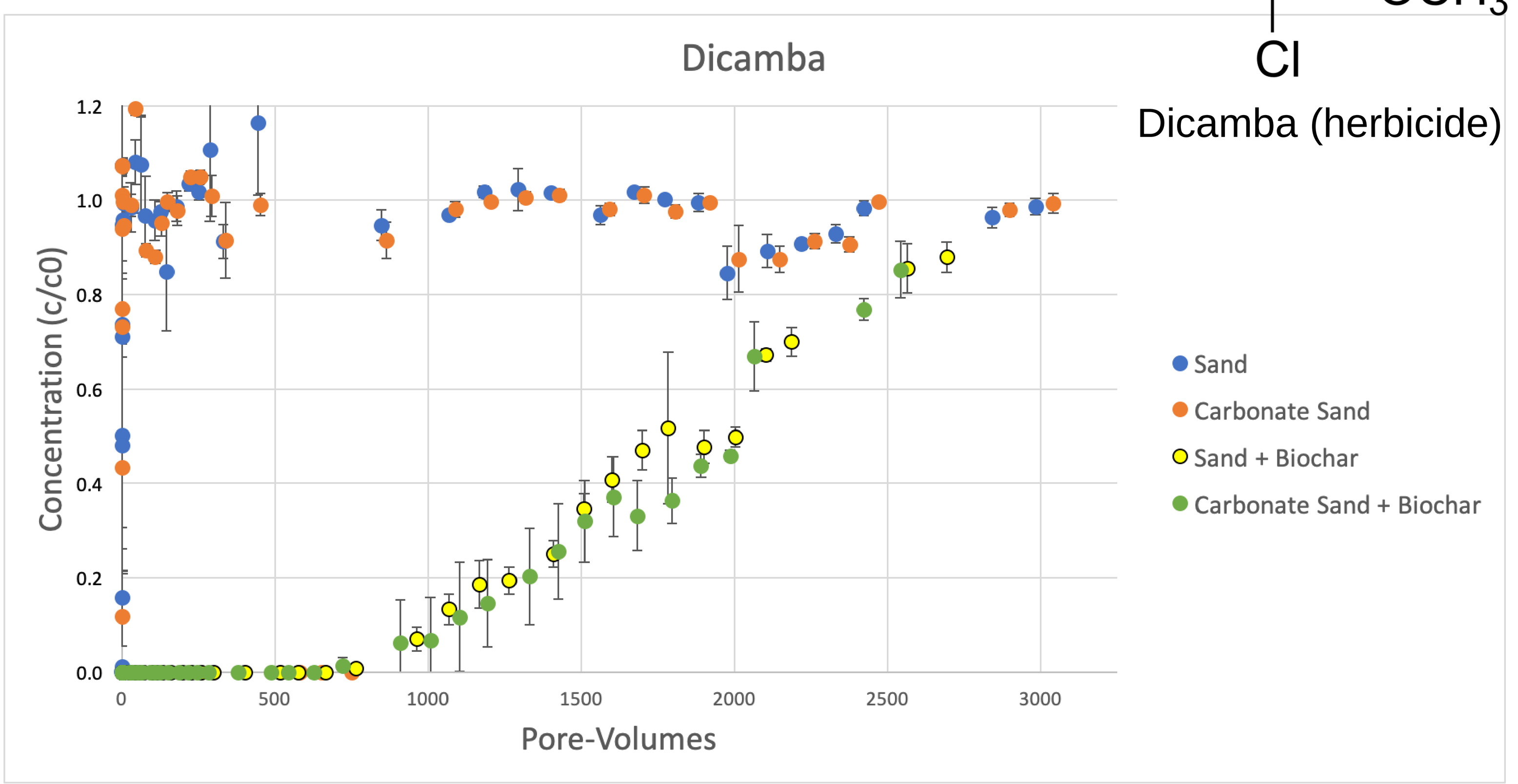


Figure 4: Dicamba breakthrough curves

Conclusions

Four different configurations of sand, carbonate sand, and biochar were investigated to determine the most effective filter material for the removal of trace organic contaminants from urban stormwater, specifically for the Rory M. Shaw Wetland Park in L.A. The removal of seven trace organic contaminants, ranging from pharmaceuticals to herbicides to industrial chemicals, was analyzed for each column in order to infer the effectiveness of each filter material. Compared to the sand control columns, the columns amended with biochar performed much more effectively in the removal of hydrophilic trace organic contaminants.

The efficacy of biochar to remove trace organic contaminants depends on the physicochemical properties of the contaminants. While diuron was retained for more than 3000 pore volumes of water treated, dicamba showed much earlier breakthrough and neared full breakthrough by the 300th pore volume.

Through careful control of the composition and control of the flow of water through each column, the field environment of the Rory M. Shaw Wetland Park was imitated as closely as possible, suggesting that biochar may serve as an effective filter media in the removal of trace organic contaminants prior to aquifer recharge.

Next Steps

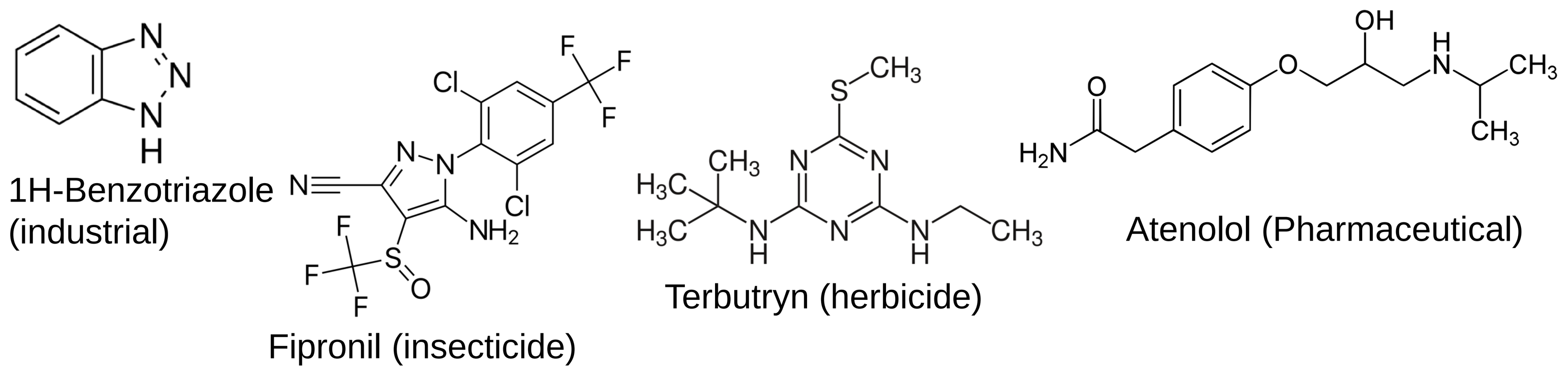


Figure 5: Other studied trace organic contaminants

1. Evaluation of breakthrough curves for all studied trace organic contaminants (Figure 5)
2. Evaluation of removal of heavy metals (cadmium, copper, nickel, lead, and zinc) contained in the synthetic stormwater mixture
3. Creation of a model of the longevity of filter materials for each trace organic compound and metal
4. Field tests of biochar-amended filters with actual stormwater
5. Implementation of biochar-amended filters in the Rory M. Shaw Wetland Park

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