SAFL Seminar Series

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St. Anthony Falls Laboratory ~ Auditorium

Bioretention Cells: A Sustainable Solution for Stormwater Pollution?

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Abstract: Bioretention cells are increasingly popular in low-impact development as a means to sustainably mitigate the environmental problems associated with stormwater runoff. Yet, much remains to be known regarding the removal and ultimate fate of pollutants such as toxic metals and petroleum hydrocarbons in bioretention cells. In this presentation, I will discuss the results of field sampling and laboratory experiments performed to evaluate the effectiveness of bioretention systems at treating petroleum hydrocarbon-contaminated stormwater. For the field sampling, 75 soil samples were collected from 58 raingardens and 4 upland (i.e., control) sites in the Minneapolis, Minnesota area, representing a range of raingarden ages and catchment land uses. Total petroleum hydrocarbon (TPH) concentrations in the samples were quantified, as were 16S rRNA genes for Bacteria and two functional genes (phenol hydrolase or PHE and naphthalene dioxygenase or NAH) that encode for enzymes used in the degradation of petroleum hydrocarbons. TPH levels in all of the raingarden soil samples were low (< 3 µg/kg) and not significantly different from one another. All soil samples contained substantial quantities of 16S rRNA, PHE, and NAH genes, suggesting that bacteria in the soils have the capacity to biodegrade petroleum hydrocarbons (which was confirmed by batch experiments). Furthermore, the number of copies of Bacteria 16S rRNA genes and functional genes were greater in the raingardens planted with deeply-rooted natives and cultivars than in raingardens containing simply turf grass or mulch ($p<0.036$), suggesting that planted raingardens may be better able to assimilate TPH inputs. Next, laboratory-scale bioretention cells were constructed inside sealed glass columns. The columns were periodically spiked with 14C-naphthalene over a 5-month period and the fate of this representative hydrocarbon and the influence of vegetation on naphthalene fate was studied. Three column setups were used: one planted with a legume (Purple Prairie Clover, Dalea purpureum), one with grass (Blue-Joint Grass, Calamagrostis canadensis), and one unplanted (i.e., control). Overall naphthalene removal efficiency was 93% for the planted columns and 78% for the control column. Adsorption to soil was the dominant naphthalene removal mechanism (56-73% of added naphthalene), although degradation (i.e., mineralization, 12-18%) and plant uptake (2-23%) were also important. Volatilization was negligible (<0.04%). Significant enrichment of naphthalene-degrading bacteria occurred over time due to contaminant exposure and plant growth as evidenced by increased biodegradation activity and increased NAH gene concentrations in the bioretention media. Overall, this research suggests that bioretention is a viable solution for sustainable petroleum hydrocarbon removal from stormwater, and that vegetation can enhance overall performance and stimulate biodegradation.