

# **Report as of FY2008 for 2008MN235B: "Enhanced Degradation of Stormwater Petrochemicals within the Rhizosphere of Raingarden Bioretention Cells"**

## **Publications**

- Conference Proceedings:
  - ◆ Hozalski, R., G. LeFevre,, and J. Gulliver. 2009. Assessment of the Stormwater Infiltration and Pollutant Removal Capacities of Rain Gardens. Proceedings of the EWRI of ASCE Thailand 2009: An International Perspective on Environmental and Water Resources. Bangkok, Thailand, January 5-7, 2009.
- Other Publications:
  - ◆ Weiss, P., G. LeFevre,, and J. Gulliver. 2008. Contamination of Soil and Groundwater Due to Stormwater Infiltration Practices: A Literature Review. University of Minnesota, St. Anthony Falls Laboratory Project Report No.515. Available June 23, 2008.

## **Report Follows**

# **Enhanced Degradation of Stormwater Petrochemicals within the Rhizosphere of Raingarden Bioretention Cells**

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## **ABSTRACT**

Traditional approaches to stormwater management, such as curb and gutter, fail to provide infiltration or water quality improvements and can act as conduits for pollutants. More municipalities and developers are turning to Low Impact Development (LID), which promotes on site infiltration as alternative stormwater management approaches. Raingardens (small, on-site, vegetated depressions to which runoff is directed) are a popular and promoted Best Management Practice (BMP) for urban stormwater quality. However, there is concern that contaminants present in runoff may accumulate and cause pollution of soil or groundwater. Little research has been done to examine the fate of hydrocarbons in alternative stormwater systems or to understand raingardens as a pollution control device. In order to truly be effective as a pollution control BMP, a raingarden must not only trap and detain, but degrade petrochemicals routed to them. Because most raingardens are vegetated, it is also vital to understand the role of plants in pollution control applications of raingardens.

We proposed to create simulated raingarden systems in columns and analyze the fate of benzene and toluene (gasoline components), and to determine what effects varying vegetation have upon the degradation capacity of these hydrocarbons. It was our hypothesis that legumes, which possess an enhanced microbial community in the rhizosphere of their roots, will facilitate an environment leading to greater biodegradation of these compounds.

## **PROGRESS REPORT**

Petroleum hydrocarbons are a known constituent of urban stormwater, but little research has been conducted regarding their fate in bioretention areas. Hydrocarbon pollutant sources include leaking automobiles and leachate from asphalt sealants (van Metre et al. 2009); many of these compounds are carcinogenic, harmful to aquatic life, and carefully regulated. Therefore, determining the efficacy of bioretention treatment systems (raingardens) for the removal of petroleum hydrocarbons in stormwater is vital. Little is known about the ultimate fate of these contaminants in raingardens; therefore, initial work on this project has focused on determining whether biodegradation appears to be active in field-scale systems.

Soil samples were collected from raingardens at 75 sites in the Twin Cities metro area (Minneapolis/St. Paul, MN). Hexane extractions (Mohn and Stewart 2000) were performed on each sample, and the extracts were analyzed for petroleum hydrocarbons using gas chromatography. Results indicated that the total petroleum hydrocarbon (TPH) concentration in soil was very low (approximately 0.001 mg TPH / kg dry soil), and that there was no clear

correlation between soil TPH and land use, loading factor (ratio of catchment area to infiltration area), or moisture content. Because the residual concentrations are lower than would be predicted based upon typical stormwater values, and concentrations observed do not correlate to loading, it is suspected that biodegradation may be an important removal mechanism in these raingarden systems.

Currently, molecular biology methods are being adapted and optimized to allow for the quantification of the functional genes required for breakdown of petroleum hydrocarbons. This will help establish if raingardens with higher loading factors respond with higher populations of petroleum-degrading bacteria. Bacterial DNA was extracted from the raingarden soil samples analyzed above. Primer sets were chosen from the literature that had been developed and/or used to enumerate BTEX (benzene, toluene, ethylbenzene, and xylene)-degrading genes (Baldwin et al. 2003). Positive control organisms (*Pseudomonas putida* strains) were obtained and conventional polymerase chain reaction (PCR) performed on each of the target genes to test the primers. Although amplification of the functional genes was successful using conventional PCR, optimization with quantitative PCR yielded poor results. An alternative primer set is now being investigated and will be tested within the month.

In addition to the analysis of the field samples, laboratory column and batch reactors have been set up to test biodegradation of hydrocarbons in model raingardens. First, a naphthalene sorption equilibrium experiment was conducted to establish the sorption isotherm of naphthalene to a typical raingarden soil media mix. Biometer tests have been initiated and preliminary degradation experiments have also been conducted using radiolabelled naphthalene as a tracer. Finally, enclosed soil columns ("raingarden reactors") containing typical raingarden plants have been set up and will begin receiving naphthalene-contaminated feed this summer. These experiments will provide information on the fate of naphthalene in a model raingarden.

## References

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## **PUBLICATIONS**

Two publications (not peer reviewed) from the last year related to the project are listed below:

Weiss, P., G. LeFevre,, and J. Gulliver. 2008. *Contamination of Soil and Groundwater Due to Stormwater Infiltration Practices: A Literature Review*. University of Minnesota, St. Anthony Falls Laboratory Project Report No.515. Available June 23, 2008.

Hozalski, R., G. LeFevre, and J. Gulliver. 2009. *Assessment of the Stormwater Infiltration and Pollutant Removal Capacities of Rain Gardens*. Proceedings to EWRI of ASCE Thailand 2009: An International Perspective on Environmental and Water Resources. Bangkok, Thailand, January 5-7, 2009.

## **PRESENTATIONS**

Two presentations were made during the past year related to this research:

2009 Minnesota Ground Water Association Conference: Impacts of Stormwater Infiltration on the Groundwater System (*Almer and LeFevre*).

2008 23<sup>rd</sup> Annual Conference on the Environment: Water Environment Association, Air & Waste Management Association (Minneapolis, MN). *Petrochemical Runoff into Raingarden Soils—Remediation or Residuals?* (*LeFevre, Novak, and Hozalski*)

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## **AWARDS**

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