Optimization of Biofiltration for Highway Stormwater Runoff Treatment through Vegetation Selection

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Introduction

Stormwater runoff is a nonpoint source of nutrients that may cause eutrophication of the water bodies in which the runoff is discharged. Biofilters are BMPs designed to remove nutrients, total suspended solids, and heavy metals while maintaining an aesthetically pleasing environment.

Design guidance for biofiltration basins for nutrient removal typically recommend planting numerous species of plants including both warm and cool season grasses, but ideal species are untested in the majority of the United States.

Studies have shown:

- Inclusion of plant species in a filtration column decreases the discharge concentrations of total nitrogen and total phosphorous (Davis et al. 2001; Lucas and Greenway 2008).
- Native grasses vary in nutrient uptake efficiency (Read et. al. 2008; Barrett et al. 2013).
- Excess organic matter in the filter media may not be necessary for growth as it may be an additional source of nitrogen and phosphorous contributing to higher effluent concentrations than influent (Bratieres et al. 2008).
- Saturated anaerobic zones with a carbon source may enhance the removal of nitrates in a biofilter as well as aid plant survival in dry conditions (Zinger et al 2007; Kim et al. 2003).

Objectives of this research include the identification of efficient Georgia native grasses for the uptake of nutrients as well as the optimization of a saturated anaerobic layer for denitrification.

Plant Species

Six grass species were chosen based on optimum living conditions and availability.

These include *Andropogon gerardii* (Big Bluestem), *Muhlenbergia capillaris* (Pink Muhly), *Panicum virgatum* (Switchgrass), *Sorghastrum nutans* (Yellow Indiangrass), *Chasmanthum latifolium* (River Oats), and *Carex cherokeensis* (Cherokee Sedge). Each species will be planted with four replicates and compared to an unplanted column as well as the GDOT grass seed mix. Each species will also be planted outdoors in a biofiltration setting to observe growth in the environment.

Switchgrass (Virginia Tech, Impact of Using Switchgrass as a biofuel, Virginia Tech, www.vt.edu)

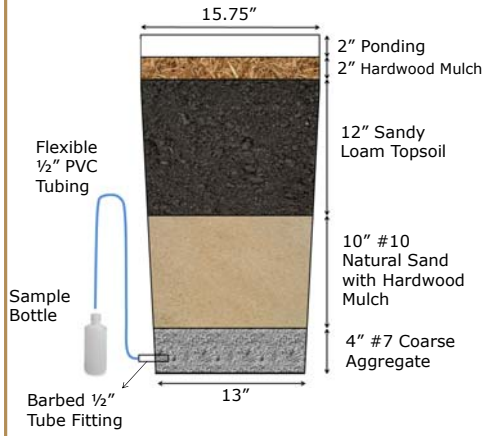
Synthetic Runoff

A synthetic highway runoff formula has been created to minimize interference during testing (Burns 2012; Driscoll 1990).

Pollutant	Concentration (mg/L)	Chemical used
TSS	100	Local soil
Nitrate	0.60	$NaNO_3$
Ammonia	0.45	NH_4NO_3
Organic Nitrogen	1.60	$C_2H_5NO_2$
Dissolved Phosphorous	0.65	Na_2HPO_4
Copper	0.05	$Cu(NO_3)_2$
Lead	0.35	$Pb(NO_3)_2$
Zinc	0.20	$Zn(NO_3)_2$
Dechlorinating Agent	4	$NaHSO_3$

Experimental Setup

Columns will be constructed from a 2.5 ft tall LDPE column with the dimensions and stratification shown below.



- Flexible PVC tubing allows adjustment or removal of the saturated anaerobic zone.
- Sand and coarse aggregate will be obtained from GDOT approved sources.
- Samples of commercially available planting soil will be collected and tested to determine the optimum material.
- Hardwood mulch will be utilized on the surface to contain moisture as well as in the sand layer (approximately 5% by volume) as a carbon source to facilitate denitrification.

Gallon sized grasses will be purchased from local nurseries. Plants will be watered with tap water for one month to equilibrate to new living conditions. Columns will be grown indoors under metal halide lights designed for vegetative growth. After one month, columns will be dosed with synthetic stormwater runoff every 3 to 4 days.

Future Expectations

At the end of this study, columns may be subject to drought and flood conditions to monitor treatment efficiency in extreme situations. Plants may be removed from their columns for growth and root analysis as physiology of root systems may explain treatment efficiencies (Read et. al. 2008).

If grass species are shown to exhibit highly variable nutrient uptake efficiencies as expected, more species may be considered in future work. Once grass species are identified, further considerations for the competition among these species will be necessary to ensure optimal species are not removed from the ecosystem over time.

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Acknowledgments

This study is made possible by the Georgia Department of Transportation and the continued support of Mr. Jon D. Griffith, P.G., P.E. The authors also thank Ms. Christina Gibson of Trees Atlanta and Ms. Elaine Nash of the Georgia Native Plant Society for their recommendations.