The Effects of Compost and Vegetation on Stormwater Treatment and Soil Nutrient Distribution Within Bioretention Cells

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Introduction

Bioretention cells are a form of GSI consisting of a depression in the ground, filled with high permeability soil, and planted with herbaceous vegetation or shrubs (NC Cooperative Extension 2004). Bioretention promotes stormwater infiltration and natural treatment, allowing impervious landscapes to more closely resemble their predevelopment past (Fig. 1) (Champagne 2008, Debusk and Wynn 2011).

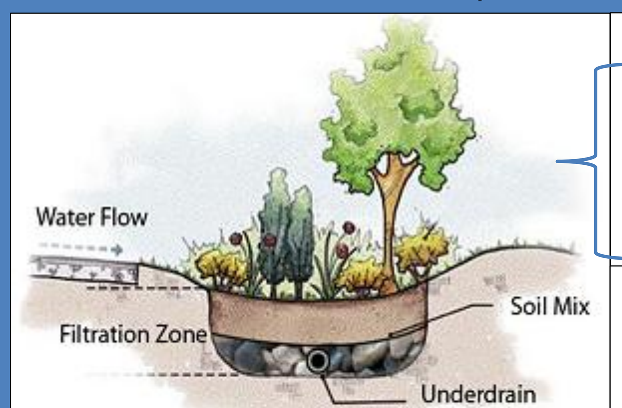

Figure 1 –Bioretention cell and treatments processes (UMD Sustainable Eng.)

While bioretention is commonly recommended as a BMP for stormwater treatment, there is a lack of regionally specific planting and soil amendment guidelines. **Our research will isolate the effects of compost and vegetation on the pollutant removal and the vertical distribution of nutrients of bioretention cells used to treat a mixed-use stormwater landscape .**

Experimental Treatments

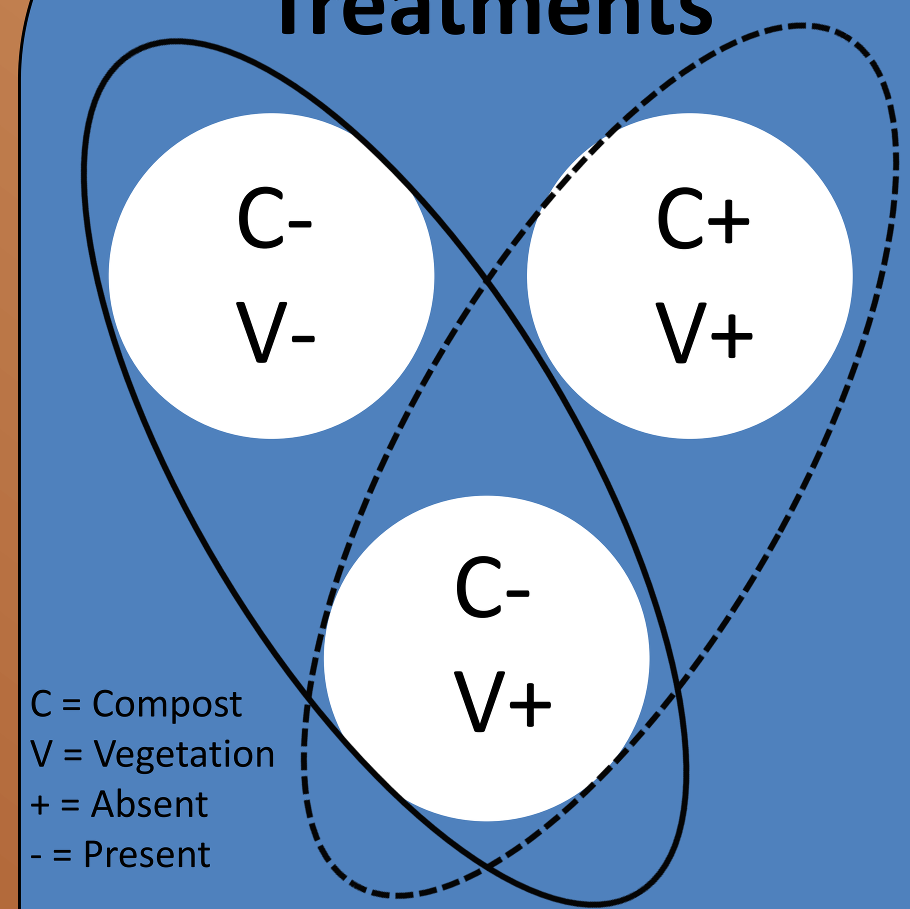

Figure 3 – Experimental amendments of Miller Farm Bioretention Cells. Two cells were vegetated, with one cell having compost added under the planting locations. Circled cells are experimentally paired to test the effects of compost (dashed) and vegetation (solid) on bioretention pollutant removal.

Compost - Bioretention cells are usually designed to have mulch or compost in their upper horizon for the purpose of quickly establishing vegetation and soil microbial communities (NC Cooperative Extension 2004). However, some bioretention cells with added organic matter have been shown to export nutrients several years after installation (Hunt et al. 2008). We will test the effects of an **organically made, low phosphorus compost (P<0.2%)** on bioretention pollutant removal and soil nutrient distribution (Fig. 4).

Earthwise Organic Compost	
pH	7.5
Total Nitrogen	1.2%
Organic N	1.1%
Total Phosphorus	0.2%
Total Potassium	0.5%
C:N ratio	14:1
Organic Matter	30.0%
Density	+/- 1350lbs/cy
Conductivity	1.1 mmhos/cm
Particle size	screened <1/2"

Figure 4 – Specifications of Low-P organic compost used in Miller Farm Bioretention Cells (Casella Organics)

Vegetation – hardy plants, with extensive root systems have been shown to be effective in bioretention cells (NC Cooperative Extension 2004). **Switchgrass (*Panicum virgatum*)** is a perfect candidate, and has been successfully used in previous bioretention projects (Rusciano and Obropta 2007). In our project, we will test the effectiveness of a Switchgrass monoculture on bioretention pollutant removal and soil nutrient distribution (Fig. 5).

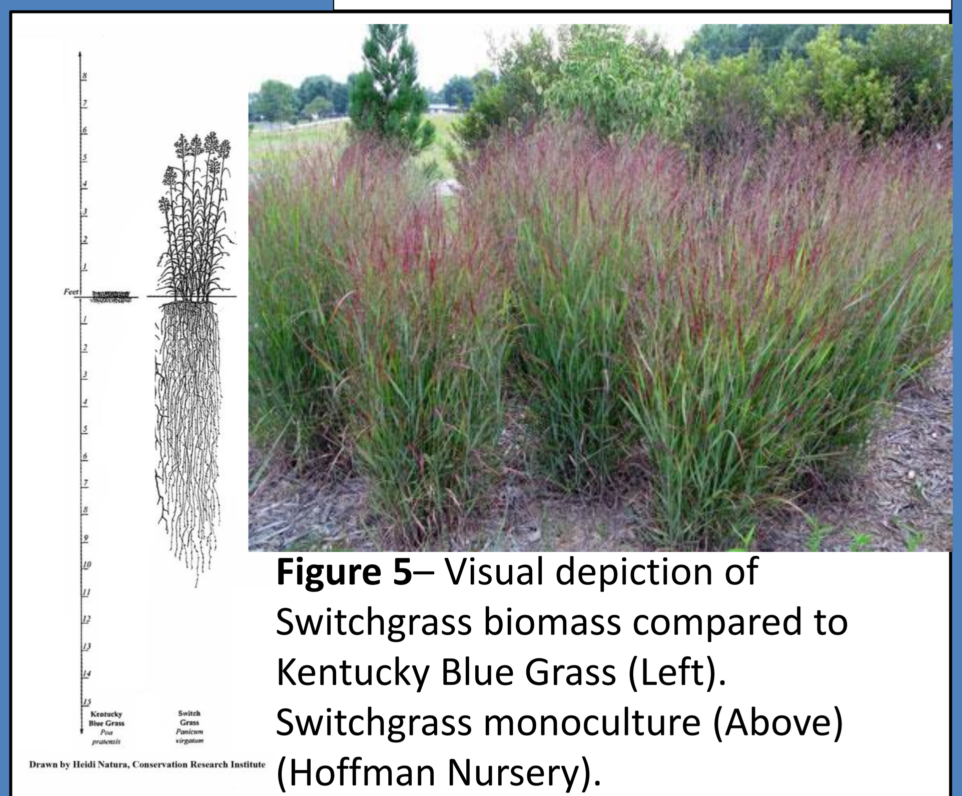

Figure 5– Visual depiction of Switchgrass biomass compared to Kentucky Blue Grass (Left). Switchgrass monoculture (Above) (Hoffman Nursery).

Hypotheses/Expected Results

Vegetation will have a significant positive effect on bioretention nutrient removal, and negative effect on fecal coliform removal. (Fig. 7)

Compost will have a significant negative effect on bioretention nutrient removal, and positive effect on fecal coliform removal.

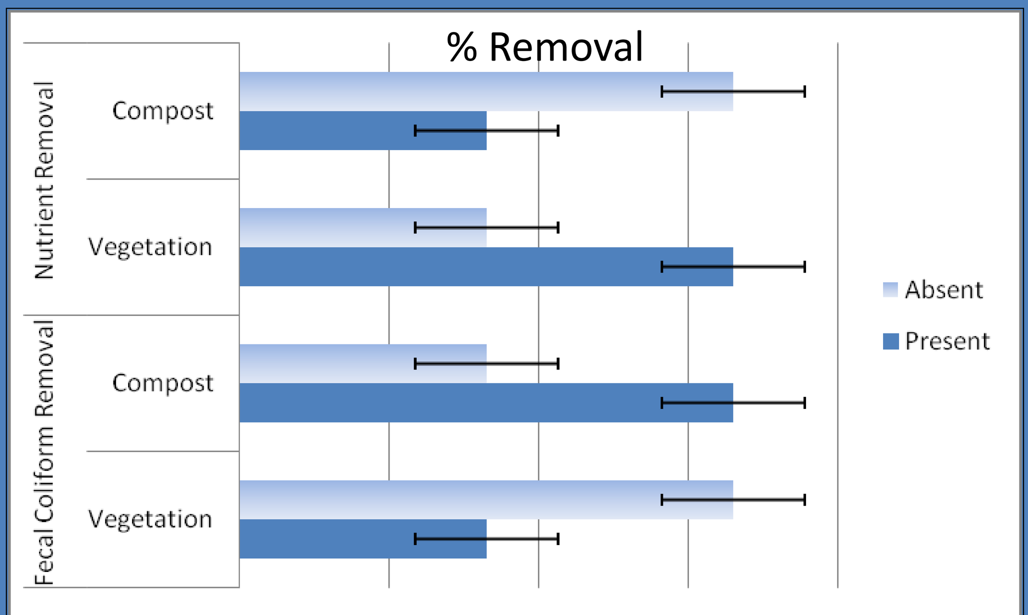

Figure 7 – Expected comparison of bioretention pollutant removal rates with compost and vegetation absent or present.

Vegetation will have a homogenizing effect on nutrients in the soil while compost will have a differentiating effect. (Fig. 8)

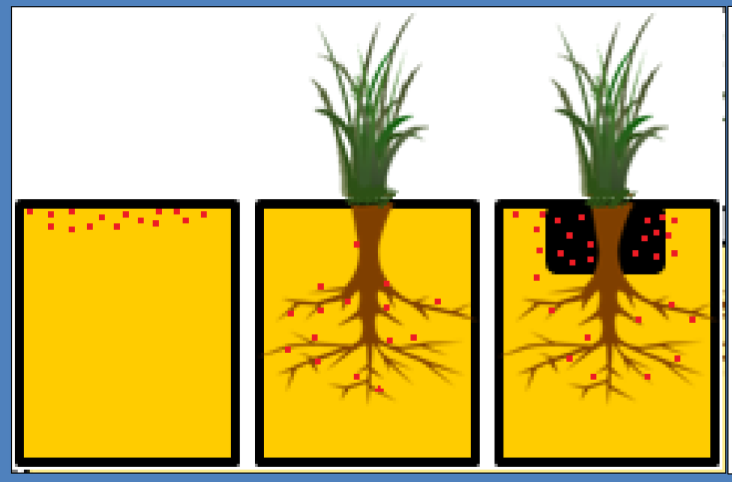

Figure 8 – Expected abundance and distribution of nutrients (red) among experimental treatments: vegetated and compost (black).

Miller Farm Bioretention Cells

Three bioretention cells were constructed at the UVM Paul R. Miller Agricultural Research Complex (Miller Farm). The cells accept runoff from existing and newly retrofitted buildings, rooftops, paved and dirt parking and driving lanes, and some areas where dairy cows cross paths between paddocks and the dairy barn. It is therefore a **mixed stormwater runoff "category" between urban developed and agricultural pollutant sources**. The cells, located on the southwest end of the Farm, are 1200 ft^2 each, and together treat 147060 ft^2 of the surrounding watershed (cells : watershed area = ~1:40) (Fig. 2A). Runoff from the Farm is first channeled by two two grassy swales into a common sediment forebay (Fig. 2B). From here, it enters a three-way splitting structure that directs equal volumes to the three cells. Stormwater then spreads across the surface of the cells, and percolates through layers of peastone, sandy bioretention media, and gravel before exiting through underdrain pipes into separate outflow sampling structures (Fig. 2C). Outflow structures discharge stormwater to a grassy swale that ultimately feeds the Potash Brook, a tributary of the Winooski River.

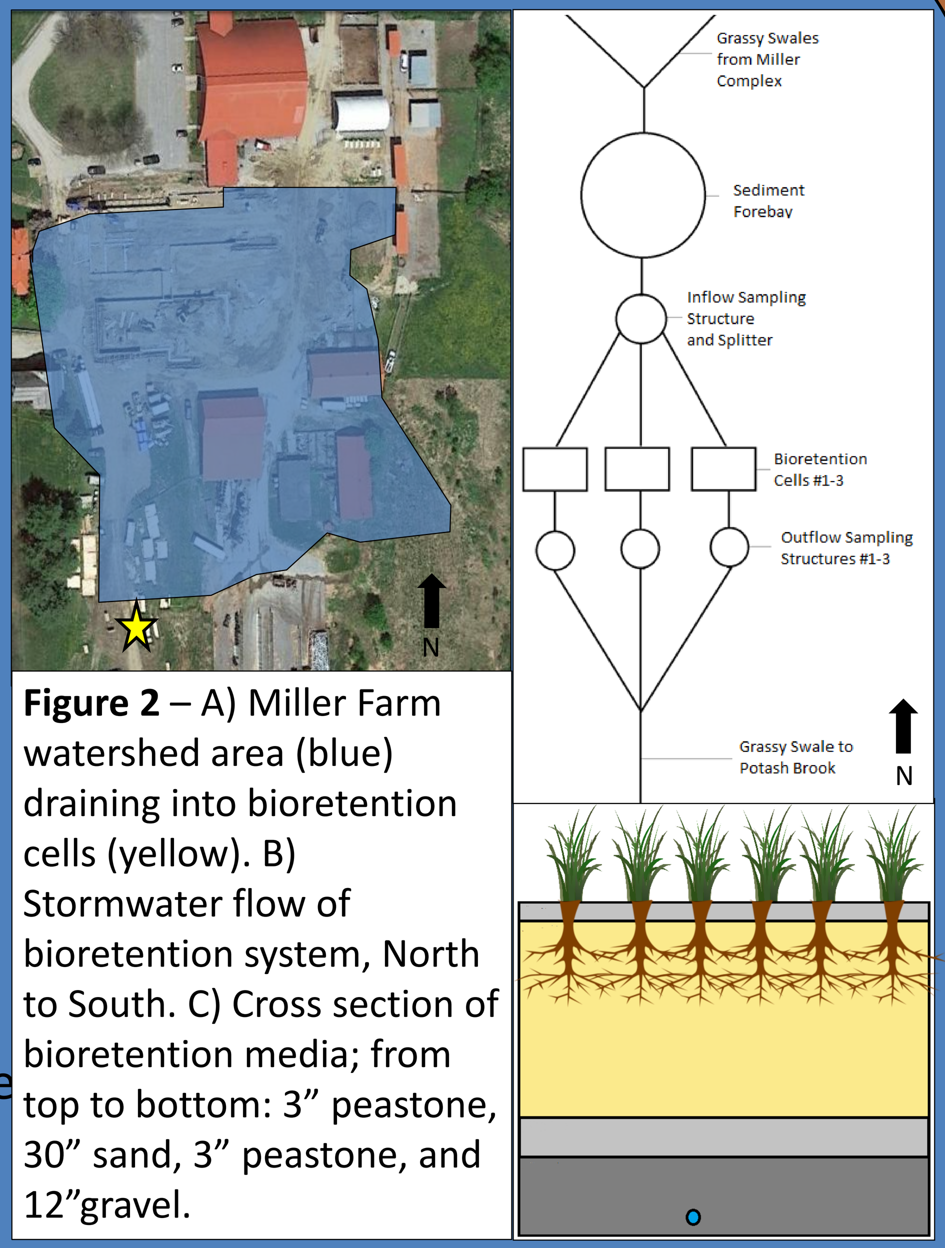

Figure 2 – A) Miller Farm watershed area (blue) draining into bioretention cells (yellow). B) Stormwater flow of bioretention system, North to South. C) Cross section of bioretention media; from top to bottom: 3" peastone, 30" sand, 3" peastone, and 12"gravel.

Methods

Water Quality - **Twelve storms** will be analyzed using a **flow-based grab sampling method**, filling up to 24 bottles in each sampling structure. **Fecal coliform concentration** will be measured in the first bottle; total and dissolved **nutrient concentrations (TN, TP, NOx, SRP)** will be measured for each bottle (Fig. 6). Nutrient concentrations will be multiplied by stormwater volume to obtain a measure of mass. Changes in pollutant concentration and mass between influent and effluent will be compared across treatments using Analysis of Covariance (ANCOVA).

Soil Analysis - At the beginning and end of the sampling season we will take **soil auger samples** from three random locations within each cell. From each auger sample, subsamples will be taken from **two depths (shallow: 6", deep: 24")**, for a total of 18 paired samples. The samples will be analyzed for Total and Bioavailable nutrient concentrations (Nitrogen and Phosphorus). We will compare the difference in concentration of each depth across treatments using a one-way Analysis of Variance (ANOVA) with replication. Additionally, we will estimate the total nutrients within the bioretention media of each treatment and its relative saturation.

Pollutants of Interest

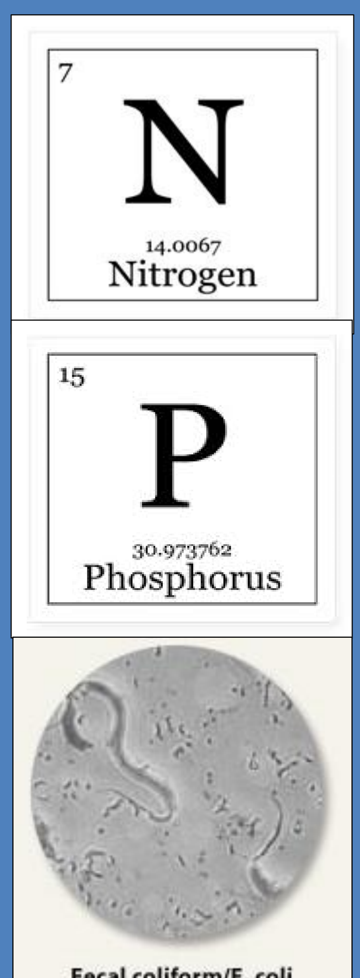

Figure 6 – Pollutants measured in Bioretention Water Quality Study (Clean Water Education Partnership)

Citations

1) Hunt, W. Smith, J. Jadlocki, S. Hathaway, J. and Eubanks, P. 2008. Pollutant Removal and Peak Flow Mitigation by a Bioretention Cell in Urban Charlotte, N.C. J. Environ. Eng., 134: 403-408

2) Champagne, P. 2008. "Wetlands: *Natural processes and systems for hazardous waste treatment*" ASCE. Reston, Virginia 189–256.

3) Rusciano,G. And Obropta, C. Bioretention Column Study: Fecal Coliform and Total Suspended Solids Reductions. Transactions of the ASABE. 50: 1261-1269.

4) North Carolina State Cooperative Extension. 2004. Bioretention Performance, Design, Construction, and Maintenance.

5) Debusk , K. and Wynn, T. Storm-Water Bioretention for Runoff Quality and Quantity Mitigation. J. Environ. Eng137 : 800-808