

# The Effects of Compost and Vegetation on Stormwater Pollutant Removal in a Mixed-Use Agricultural Landscape

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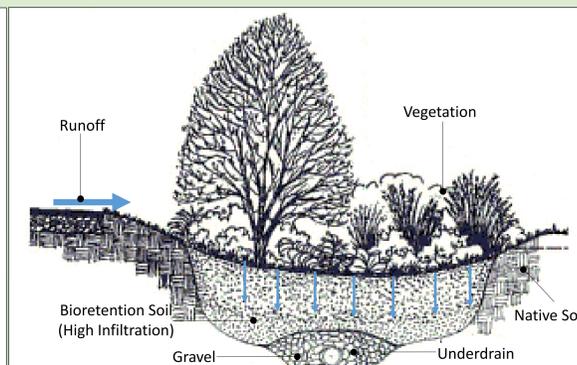
**research**  
green stormwater infrastructure

## Introduction and Background

- Bioretention cells are a stormwater management BMP that promotes the infiltration and treatment of runoff on site using natural vegetative and soil processes (Fig. 1).
- While bioretention has been shown effective at the removal of heavy metals, sediments, pathogens, and hydrocarbons from stormwater, nutrient (Nitrogen and Phosphorus) treatment has varied in success (Davis et al. 2009).
- Two critical design components of bioretention that can influence the treatment of nutrients are the selection of vegetation and organic soil amendments. Compost and other organic soil amendments can leach excess nutrients causing a total net export in bioretention effluent (Mullane et al. 2015), while the presence of vegetation may influence nutrient treatment through plant uptake and complimentary biological processes (Lucas and Greenway 2008). The effects of the presence of each of these individually on stormwater treatment has so far been unstudied in any bioretention field experiment.

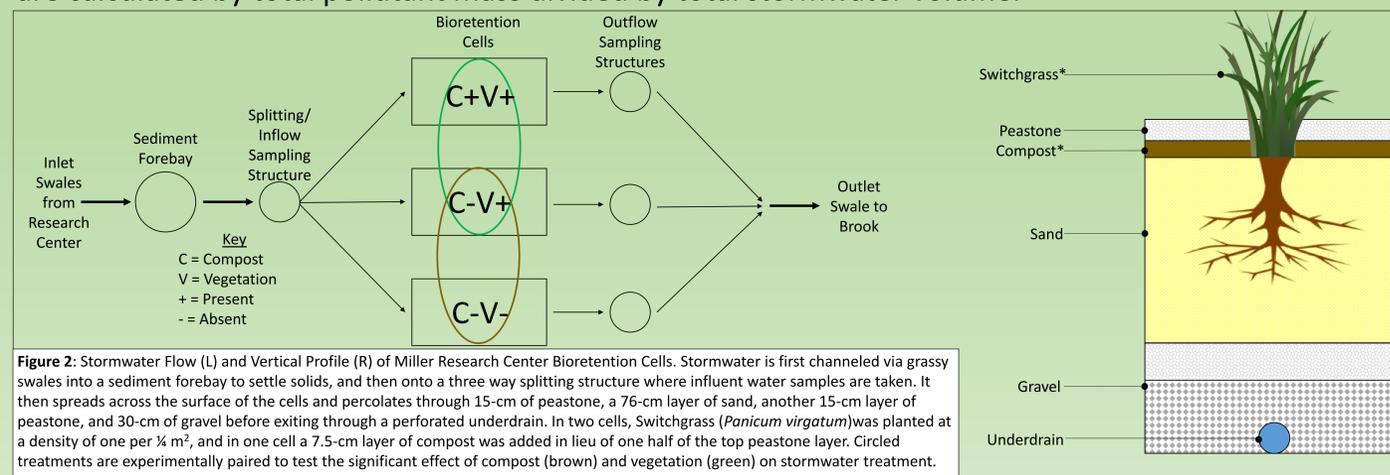
- **Objective:** Determine the extent to which the presence of compost or vegetation in bioretention cells affect the treatment of nutrients and total suspended solids from mixed urban/agricultural runoff

**Figure 1:** Diagram of a typical bioretention cell. Runoff is channeled into a depression in the ground filled with high permeability (i.e. sand or sandy loam) soil and planted with woody or herbaceous vegetation. Influent stormwater is treated by filtration, sedimentation, adsorption, plant uptake, and microbial decomposition. Treated effluent will either infiltrate and recharge groundwater or be discharged by an underdrain pipe. (P.G. County Bioretention Manual)



## Experimental Design and Methods

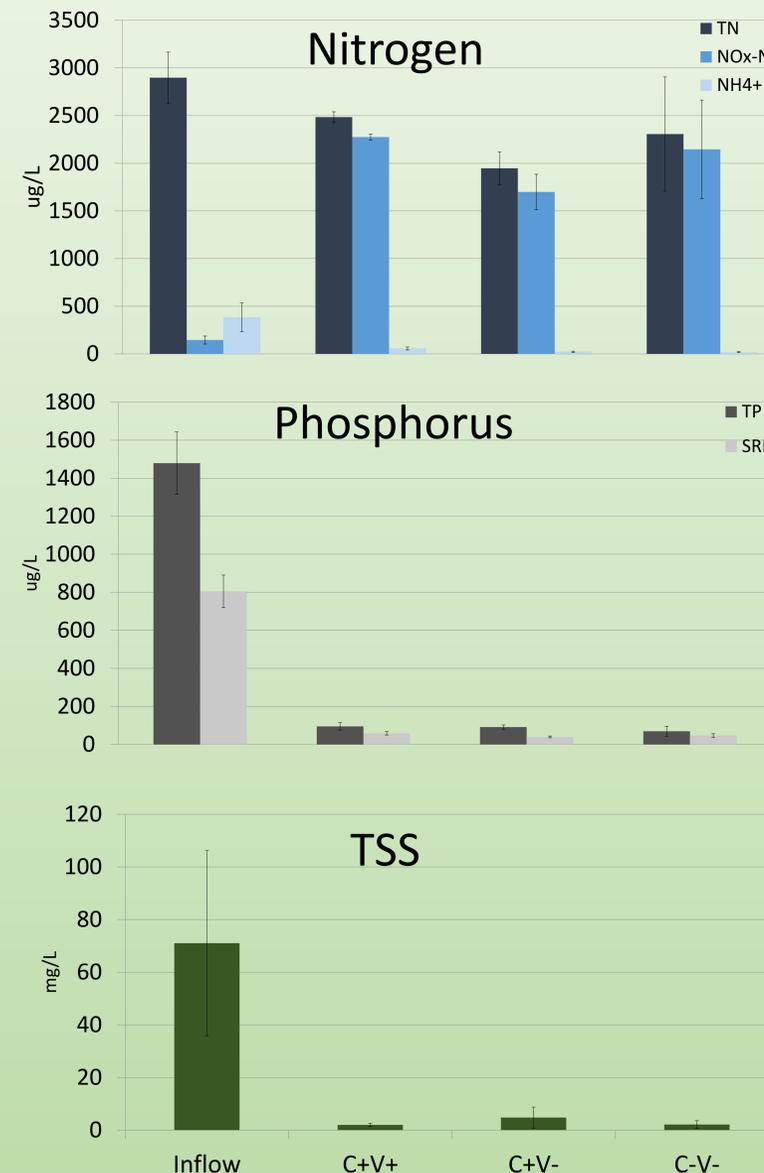
In June 2016, three large, unlined bioretention cells were installed to treat stormwater runoff from 13,662 m<sup>2</sup> of the UVM Miller Research Complex, a mixed urban/institutional and agricultural watershed. In this system, influent runoff is split equally among the cells and allowed to percolate through layers of peastone, sand, and gravel before being discharged through underdrain pipes (Fig. 2). Each cell has a unique treatment designed to isolate the effects of compost and vegetation on pollutant removal. Water samples were taken at discrete times during a storm event from the inflow and separate outflows and analyzed for concentrations of Total Suspended Solids (TSS) and nutrient species. Total stormwater flow and volume was recorded every storm event and factored by pollutant concentrations measurements to obtain a measure of mass. Storm Event Mean Concentrations (EMC) are calculated by total pollutant mass divided by total stormwater volume.



**Figure 2:** Stormwater Flow (L) and Vertical Profile (R) of Miller Research Center Bioretention Cells. Stormwater is first channeled via grassy swales into a sediment forebay to settle solids, and then onto a three way splitting structure where influent water samples are taken. It then spreads across the surface of the cells and percolates through 15-cm of peastone, a 76-cm layer of sand, another 15-cm layer of peastone, and 30-cm of gravel before exiting through a perforated underdrain. In two cells, Switchgrass (*Panicum virgatum*) was planted at a density of one per ¼ m<sup>2</sup>, and in one cell a 7.5-cm layer of compost was added in lieu of one half of the top peastone layer. Circled treatments are experimentally paired to test the significant effect of compost (brown) and vegetation (green) on stormwater treatment.

## Preliminary Results

### Event Mean Concentrations



**Figure 3:** Average Event Mean Concentrations and Standard Error of shared influent and separate effluent from each treatment in the Miller Research Center Bioretention Cells. TN = Total Nitrogen, NOx-N = Nitrate-Nitrite, NH4+ = Ammonia, TP = Total Phosphorus, SRP = Soluble Reactive Phosphate. EMC's were calculated for eight storm events between June and August 2016.

## Discussion

- Cells effectively reduce concentrations of TSS and particulate nutrients regardless of treatment, underscoring the importance of filtration in this technology.
- The majority of Nitrogen enters these cells in particulate form and is discharged as Nitrate-Nitrite, possibly suggesting a decomposition of organic material and subsequent nitrification.
- Treatments appear to have an effect on Nitrate-Nitrite treatment, as the presence of compost results in higher effluent concentrations and the presence of vegetation results in lower effluent concentrations.
- Results support previous findings that effective phosphate reduction can be achieved without the presence of vegetation (Lucas and Greenway 2008), but refute assumptions that compost will leach excess phosphate. This may be due to the nature of the compost used as a leaf mix blend with relatively low (0.19%) TP concentration, when compared with other bioretention projects.

## Citations

Davis, A., Hunt, W., Traver, R. and Clar, M. 2009. Bioretention Technology: Overview of Current Practice and Future Needs. *Journal of Environmental Engineering* 135:109-117.

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Mullane, J., Flury, M., Iqbal, H., Freeze, P., Hinman, C., Cogger, C., and Shi, Z. 2015. Intermittent Rainstorms Cause Pulses of Nitrogen, Phosphorus, and Copper from Compost in Bioretention Systems. *Science of the Total Environment* 537: 294-303.

Lucas, W. and Greenway, M. 2008. Nutrient Retention in Vegetated and Nonvegetated Bioretention Mesocosms. *Journal of Irrigation and Drainage Engineering* 134: 613-623

### University of Vermont Miller Research Center Bioretention Cells

