Total Phosphorus and Total Suspended Solids removal by Bioretention Systems

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Introduction

Stormwater runoff creates problems within our watersheds, including flooding, erosion, reduced recharge of groundwater and aquatic habitat destruction . Phosphorus is a pollutant of concern in stormwater runoff and is known to cause eutrophication in lakes and rivers. Green Stormwater Infrastructure can be used to help remove phosphorus from runoff (Davis et al. 2010). The impact of these pollutants includes closing of shellfish waters, fish kills, and degradation of water bodies, reducing the value of fisheries and groundwater (Hunt et al. 2008). Bioretention raingardens are a form of Green Stormwater Infrastructure (GSI) a low-impact-development best-management practice that has the potential to improve stormwater quality from developed areas by processes that may be physical, chemical, or biological (Hsieh et al. 2008). These systems detain and treat runoff from paved surfaces, using soils, sand, organic matter, and vegetation-based storage and infiltration to slow the stormwater flow, infiltrate runoff and rainfall, recharge groundwater, increase evapotranspiration and capture pollutants. This research utilizes the Bioretention Laboratory as study area where three of eight bioretention cells (cell 2, cell 3, and cell 4) were studied. Results showed 49-100% removal for TSS, 38-98% peak flow reduction, while the TP removal varied with the soil media treatment.

Objective: Investigate the performance of bioretention systems reducing TP and TSS from stormwater runoff.

Methodology

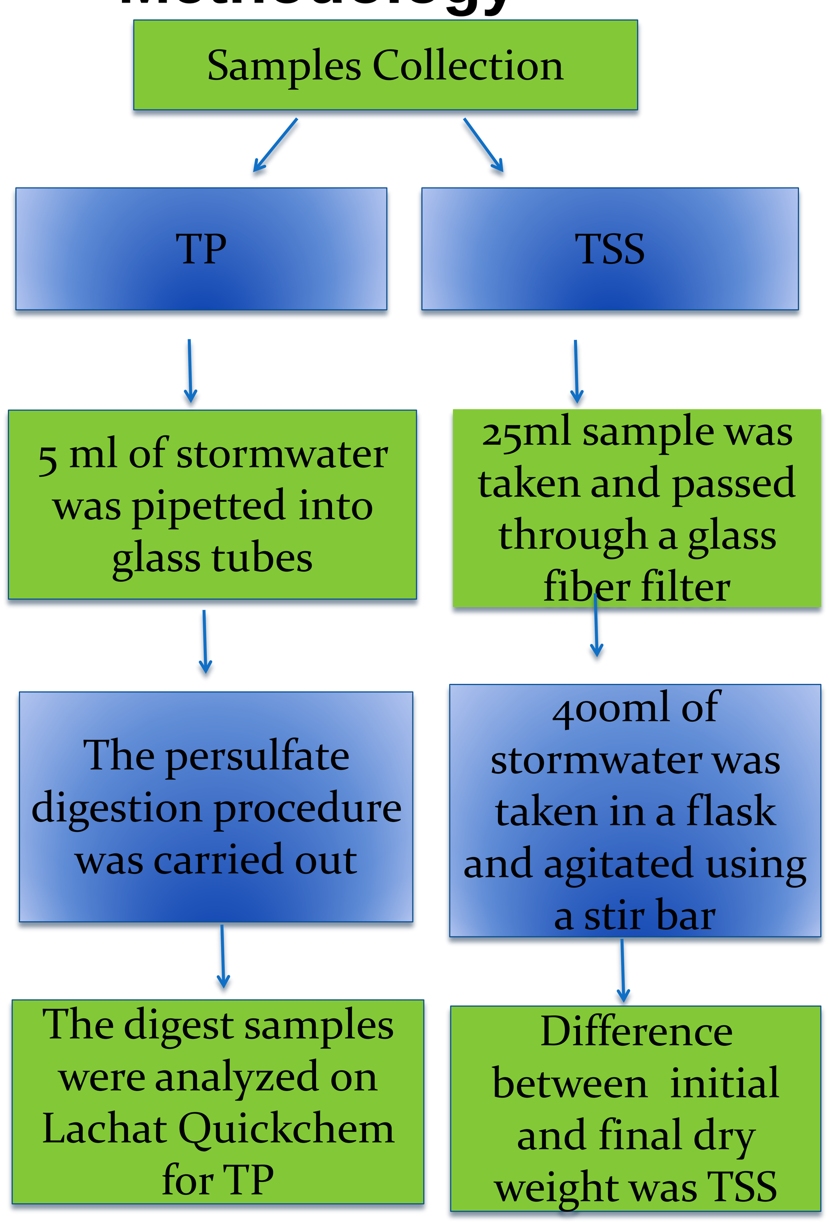

Figure 1. Cell 2 has typical bioretention soil and vegetative treatment. Cells 3 and 4, both containing Sorbtive Media Treatment, were different in that cell 3 has an additional rain pan.

Results

In this study all storm samples were taken in the period of June-July 2015. All the analysis were in the Water Quality and Climate Change Laboratory at University of Vermont.

• Phosphorus removal was variable. Treatments with P-sorptive media (Cell 3 & 4) exhibited greater TP removal **(Fig. 2).**

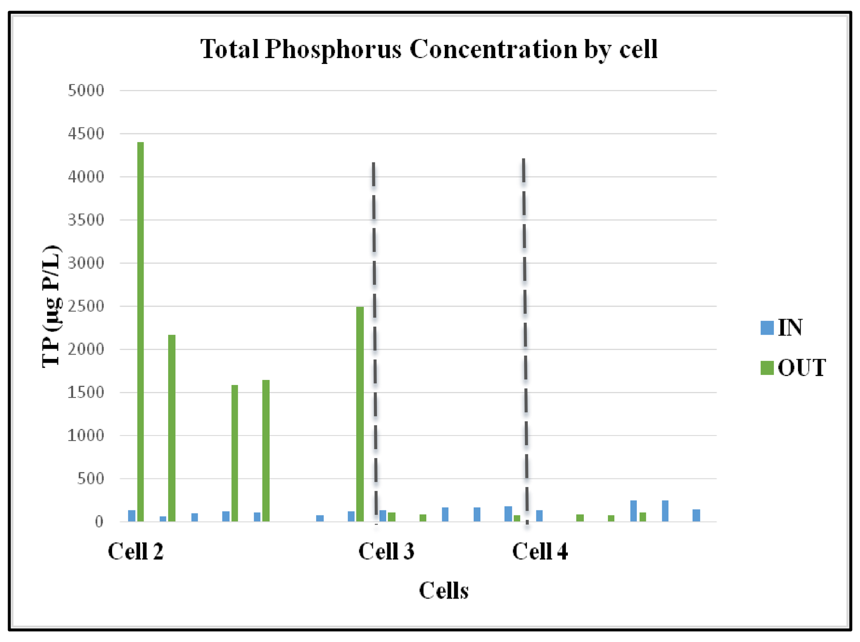

Figure 2. Total phosphorus concentration in the inflow and outflow of each cell by storms.

- a) Majority of TSS concentration in cell 2 IN is between 0 to -20, and -10 to -30 for cell 2 Out **(Fig. 3a)**
- b) Majority of TSS concentration in cell 3 IN is between 0 to -100 and -15/-30 for cell 3 OU T **(fig. 3b)**
- c) Majority of TSS concentration in cell 4 IN is between 0 to -25 and -30 to -40 for cell 4 OUT **(fig.3c)**

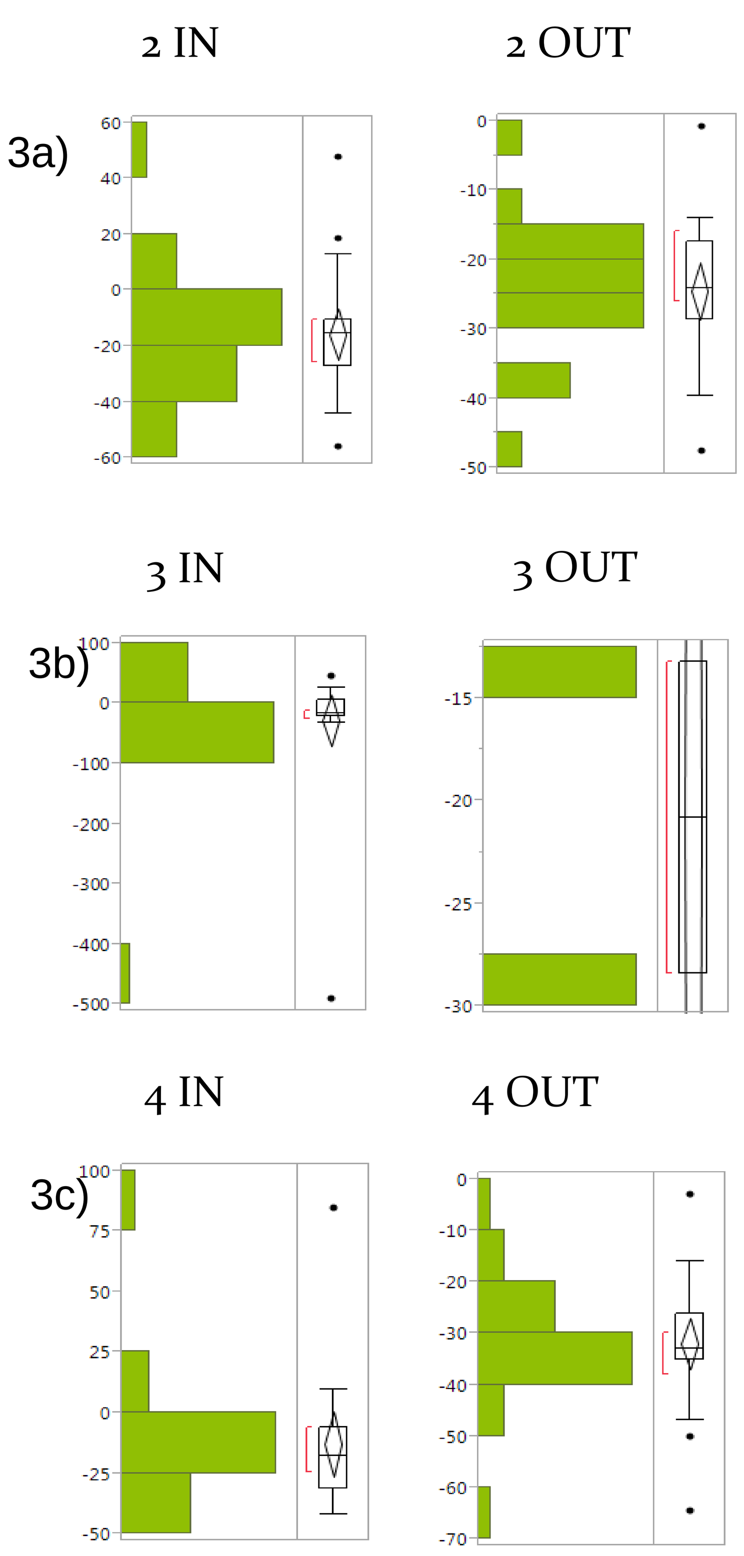

Figure 3. Distribution of total suspended solids in the inflow and outflow of each cell.

- The samples taken in the period of June 2015-July 2015 showed 49-100% removal for Total Suspended Solids, but the TP removal varied with the soil media treatment. **(Table 1)**

	CELL 2		CELL 3		CELL 4	
Date of Storm	**TP**	**TSS**	**TP**	**TSS**	**TP**	**TSS**
June 8, 2015	-3173	96	18	97	N/A	N/A
June 15, 2015	-3624	100	-	-	-	-
June 16, 2015	100	100	-	-	-	-
June 18, 2015	-1185	-	N/A	-	N/A	-
June 21, 2015	-1453	49	100	100	56	302
June 23, 2015	N/A	-	100	100	100	100
June 27, 2015	100	100	100	100	100	N/A
July 1, 2015	-1956	100	62	63	76	691
July 15, 2015	-	-	-	100	-	92

Table 1. Removal and/or export percentage by cell.

- Bioretention cells in the period of June 2015-July 2015 showed 38% -98% peak flow reduction. **(Figure 4, Figure 4, Figure 5)**

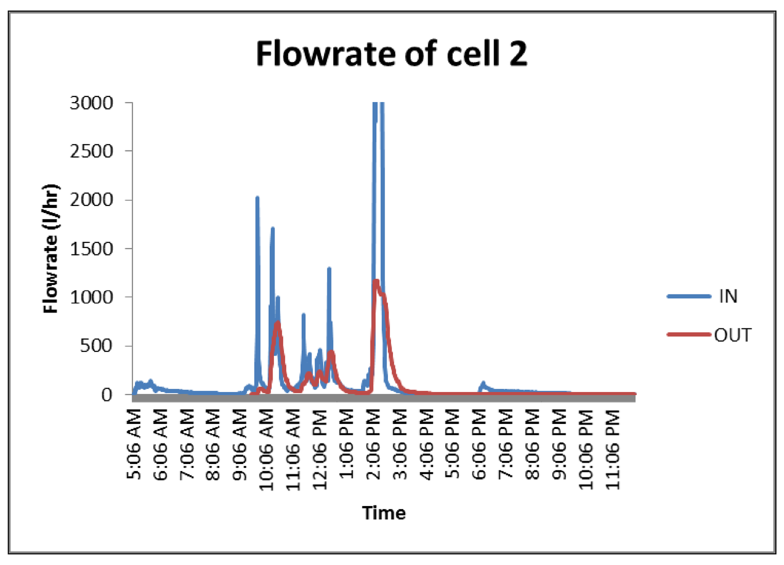

Figure 4. Flowrate of the inflow and outflow of cell 2 in July 1, 2015

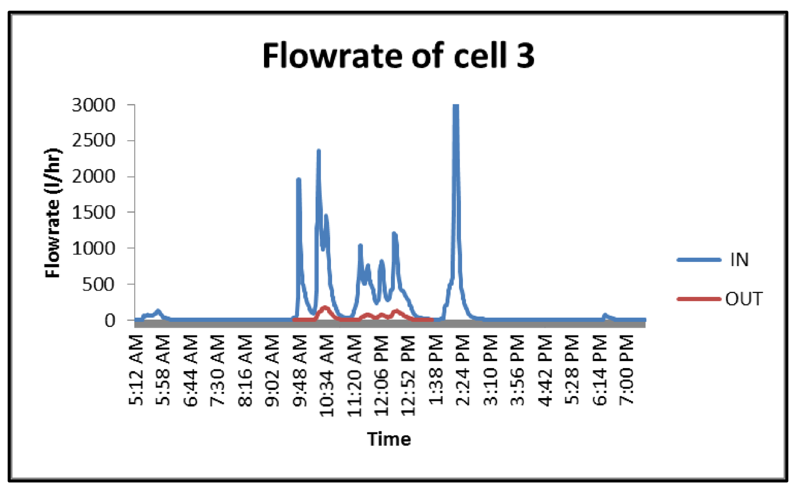

Figure 5. Flowrate of the inflow and outflow of cell 3 in July 1, 2015

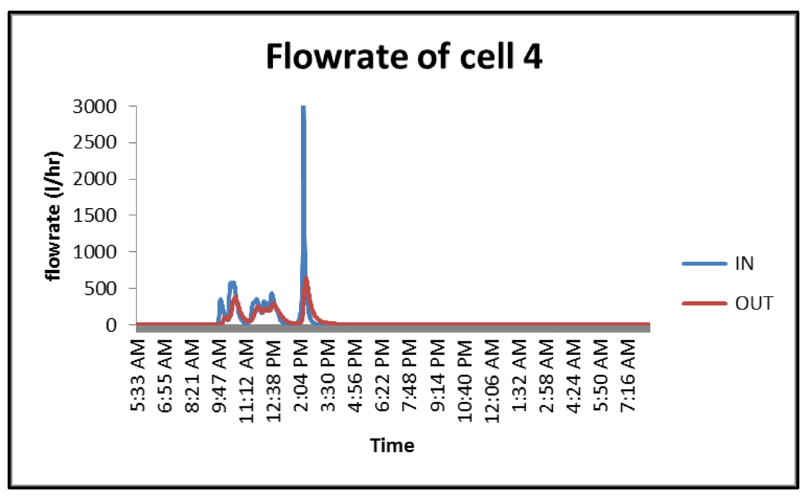

Figure 6. Flowrate of the inflow and outflow of cell 4 in July 1, 2015

	Cell 2	Cell 3	Cell 4
Date of Storm			
June 8, 2015	67	94	**No measure (weir box was leaking)**
June 15, 2015	62	-	-
June 16, 2015	N/A	-	-
June 18, 2015	98	N/A	N/A
June 20, 2015	-	38	86
June 21, 2015	81	78	65
June 23, 2015	-	91	38
June 28, 2015	76	92	77
July 1, 2015	96	97	79

Table 2. Percentage of peak flow reduction

Discussion

•Total phosphorus concentrations has statistical differences (T-test; <.0001) in cells 2 and cell 4 and also in cell 3 and cell 4 (T-test; 0.0424).

•Cells 3 (Additional layer of P sorbtive media with added precipitation treatment) and 4 (Additional layer of P Sorbtive Media treatment) removed TP concentrations because the inflow concentrations were higher than outflow concentrations. Cells 2 (General soil Media with added precipitation treatment) exported TP concentrations (Figure 2 & table 1).

• No statistical difference were found in TSS concentrations between cell 2 and cell 4 (T-test; 0.4894) or in cell 3 and cell 4 (T-test; 0.4197).

The percentages removal in cells 3 and 4 for TP concentrations could were attributed to the aluminium and iron oxide granules in the Sorbtive Media which is known to remove phosphorus out of the dissolve phase.

• The statistical differences between cell 3 and cell 4 for TP could be attributed to the added precipitation treatment (60% more rain) in cell 3.

• TP exportation in cell 2 could be attributed to the general soil media without the additional layer of P sorbtive media. The descomposition reactions of organic matter results in leaching of phosphorus (Bratieres et al. 2008).

•TSS removal could be attributed to mechanisms like sedimentation, interception and filtration. These tehnologies will filter fine particles.

• The three cells showed 38-98% peak flow reduction.

Literature cited

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Acknowledgments

We thank Joel Tilley for laboratory assistance. Funding for this project was provided by NSF Grants EPS-1101317.