Nitrate Removal by Bioretention Cells

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Introduction

Bioretention cells are intended to slow the rate of stormwater flow from impervious surfaces, reduce runoff volumes, and retain stormwater pollutants such as nitrogen, phosphorus, total suspended solids, heavy metals, and fecal coliform (Davis et al. 2009, 110-113).

Nitrate is a highly mobile form of nitrogen, and is generally not as well retained by bioretention cells, however, ammonia is well retained (Dietz 2007, 353). One possible reason for this is that ammonia and organic nitrogen may convert to nitrate over time (Davis et al. 2009, 113).

Questions

- Does Sorbtive Media™, a proprietary media that is added to soils to increase phosphorus retention, also increase nitrate retention?
- Is there a measurable relationship between nitrate and ammonia in the inflow and outflow of the stormwater?

Methods

The Bioretention Cells

- Eight bioretention cells were established as part of the UVM Bioretention Lab.
- ISCO automated sampling machines were placed at the inflow and outflow of four of the eight cells at any given time. Each sampling machine had 24 1-liter bottles, which sampled consecutively. Two cells, Cells 3 and 4, had a layer of Sorbtive Media, which is intended to retain phosphorus. All of the other cells did not.
- For the purposes of examining nitrate removal, cells 4 and 6, were used, for they had a sufficient number of storm events for which both inflow and outflow were sampled. Cells 4 and 6 are referred to as the Sorbtive Media Cell and Non-Sorbtive Media Cell, respectively.

Stormwater Sampling for Nitrate & Total Nitrogen

Five hundred seventy samples were collected from ISCO autosamplers from four cells over the course of six storm events from May 17, 2014 to July 3, 2014. In order to test for nitrate, 15 mL of each water sample were filtered using 0.45 micrometer filters inserted into plastic syringes. Between each sample the syringe used was rinsed using deionized water. These samples were analyzed using the Lachat colorimetric device.

Soil Sampling

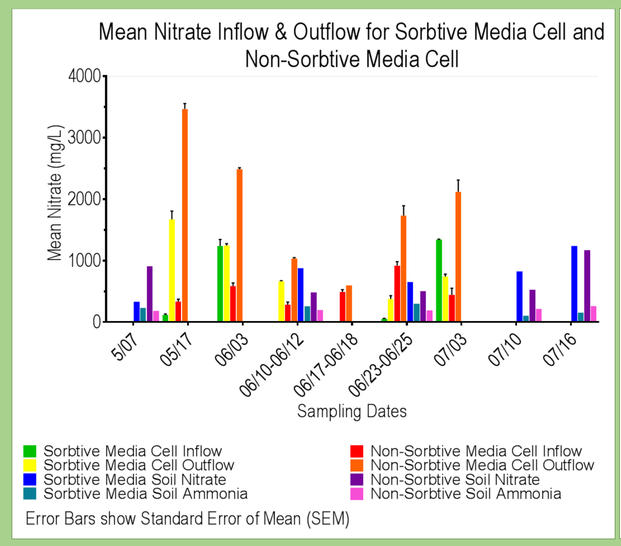
Three soil samples were collected from each cell on a weekly or biweekly basis following gas sampling, so as to avoid disturbing the soil of the cells beforehand. They were dried, combined and sifted. Small samples were oven-dried and extracted using a potassium chloride then analyzed for nitrate and ammonium on the Lachat.

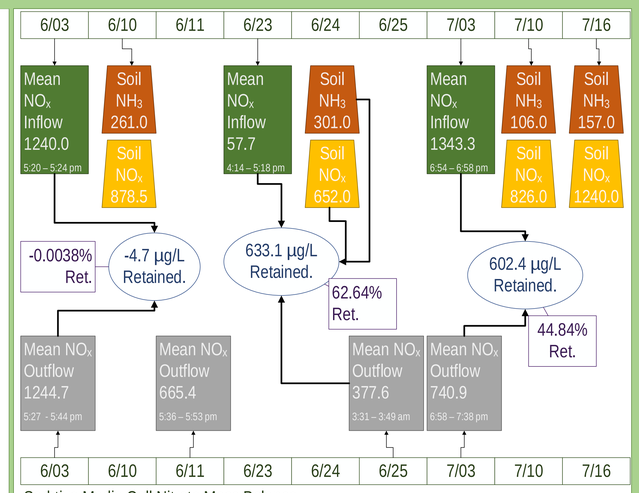
Results

Sorbtive vs. Non-Sorbtive Soil Media

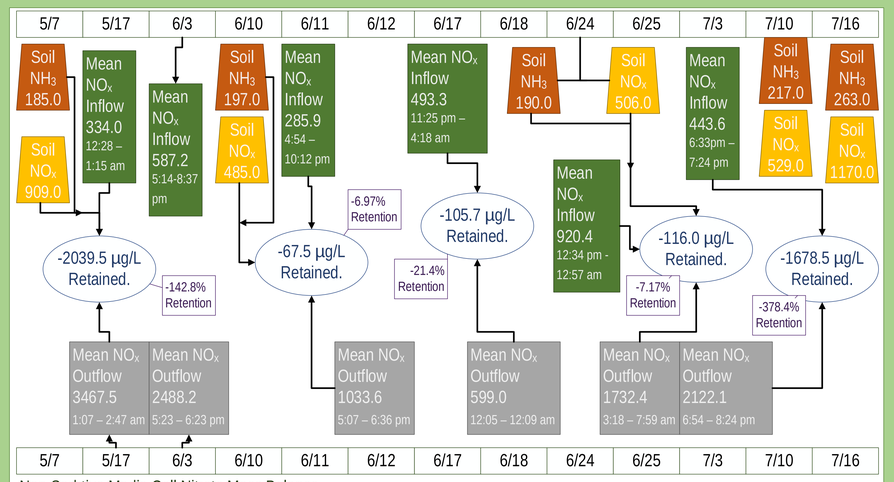
The mean nitrate inflow and outflow of the water samples were compared to the ammonia and nitrate of the soil samples. Soil nitrate and ammonia concentrations were added to the nitrate from incoming stormwater samples to determine the total nitrate inflow. This was then subtracted from the next nitrate outflow to determine the percentage of nitrate retained. The following flowcharts and bar graphs illustrate this process for the Sorbtive Media Cell and Non-Sorbtive Media Cell. Both cells sampled on May 17 and June 3; however, on May 17 the Sorbtive Media Cell sampled outflow before inflow. Likewise, on June 3 the Non-Sorbtive Media Cell sampled outflow before or concurrently with inflow. Therefore, the May 17 storm is not included in the mass balance for the Sorbtive Media Cell, and neither is the June 3 storm included in the mass balance for the Non-Sorbtive Media Cell.

- Soil Sample Dates: May 7, June 10, June 24, July 10, July 16
- Sorbtive Media Cell Storms: May 17, June 3, June 24, July 3
- Non-Sorbtive Media Cell Storms: May 17, June 3, June 11, June 17, June 24, July 3





Sorbtive Media Cell Nitrate Mass Balance
All units are in µg/L, unless stated otherwise.



Non-Sorbtive Media Cell Nitrate Mass Balance
All units are in µg/L, unless stated otherwise.

Discussion & Conclusions

- The mass balance approach provided significant insight into nitrogen dynamics within bioretention cells studies. The results indicated that the Sorbtive Media Cell had far greater nitrate retention than the Non-Sorbtive Media Cell, when the nitrate and ammonia from soil were considered. The Sorbtive Media Cell initially appeared to export nitrate between May 7 and June 3, but during the next two periods it appears to retain it. In addition, the Non-Sorbtive Media Cell did not appear to retain nitrate from the inflow.
- There are certain environmental effects that have not been fully accounted for in this analysis. There were rain events that weren't sampled in some cases between soil sampling events which may have removed soil nitrogen. There was also a four-week gap between soil-sampling in May and in June. In addition, on May 17 the outflow from the Sorbtive Media Cell was sampled before the inflow, whereas on June 3, the outflow from the Non-Sorbtive Media Cell was sampled before the inflow.

References

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Acknowledgements

Further information on the Bioretention Project at UVM can be found at http://www.uvm.edu/~pss/?Page=bioretentionproject.html

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