Does vegetation diversity in a bioretention cell affect soil microbial activity and nitrate levels in the effluent?

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Introduction

Mineralization rates can be used a mechanism for quantifying microbial activity and assessing the health of the soil (Lupon et al., 2016). The rates of nitrogen fixation and mineralization can show the level of microbial activity in a soil, which can in turn be used to further the greater understanding of C/N cycling through soils in bioretention cells (Zaman et al., 1999). Vegetation in bioretention cells function as biofilters for nutrients and sediments that would otherwise run off into the storm water basins and then into various reservoirs, in this case Lake Champlain.

The bioretention cells slow stormwater flow rates allowing the vegetation, microbial communities, and (if present) Sorbtive Media™ to remove nutrients and filter suspended sediments that would otherwise contaminate the water flowing into Lake Champlain. We believe that a higher rate of mineralization will lead to higher levels of nitrate being released into the water (Lupon et al., 2016). Understanding how different vegetation can produce different levels of activity in microbial communities will lead to a further comprehension of the limiting factors that affect plant growth and function in these vegetative dependent bioretention cells. We hypothesize that cells with a high diversity of plant species as a treatment will increase N mineralization rates and therefore effluent concentrations of nitrate.

Fig. 1 Left two pictures : high diversity (HD) cells 2 and 6. Right two pictures: low diversity (LD) cells 7 and 8.

Methods

- In-field incubation (21 days)
- KCl extraction for NO_3^- and NH_4^+ (initial on the first day on fresh soils and after 21 days on incubated soils)
- Difference is mineralization rate
  - (ug N g dry soil^{-1} day^{-1})
- Soluble NO_3 measured by filtering water samples through 0.45 micron filters and analyzed concentrations on Lachat flow analyzer.

Experimental Design and Sampling

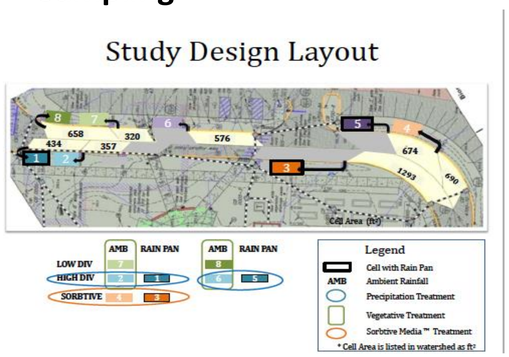

Fig. 2 UVM Bioretention project study design layout (Cording et al. In Prep).

- Run-off storm water flows into the bioretention cells where it passes through soil layers, different vegetative treatments, and in some cases a sorptive media treatment.

Fig. 3 ISCO auto-sampler used to collect effluent that has passed through the bioretention cell.

- *Fig. 4* Soil KCL extractions were performed to sample for NO_3^- and NH_4^+

- *Fig. 5* The LaChat flow analyzer was used to measure soluble NH_4^- and NO_3^- in water.

Results

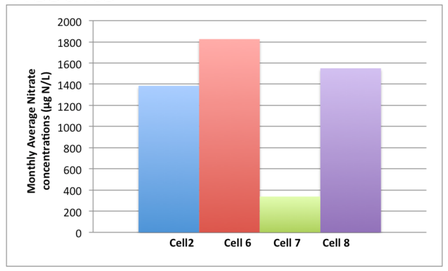

Fig 6. Effluent monthly averages of NO_3^- for all cells in the month of July.

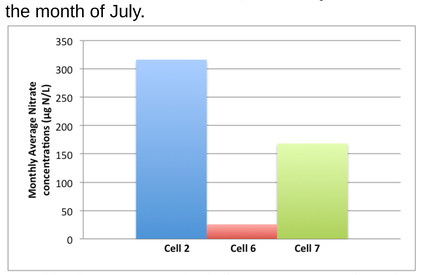

Fig. 7 Average NO_3^- influent concentrations for July.

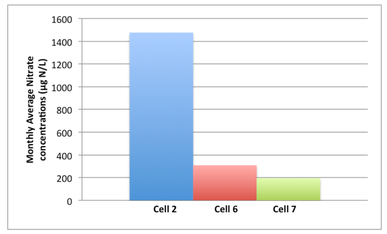

Fig. 8 Average NO_3^- effluent concentrations for July.

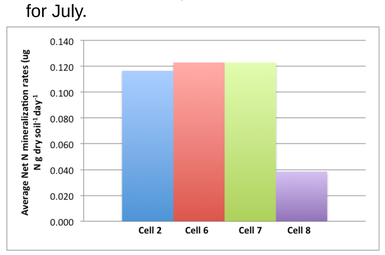

Fig. 9 Average net N mineralization rates.

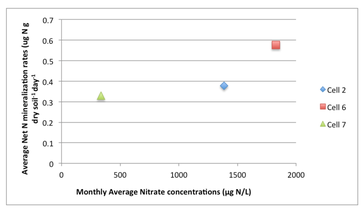

Fig. 10 Average monthly nitrate concentrations compared to monthly average mineralization rates.

Discussion

- No significant conclusions can be drawn due to lack of data from lack of rainfall and time constraints.
- Initial results indicate that low diversity cells typically have less nitrate in their effluent but similar net N mineralization rates (excluding cell 8 due to lack of data).
- Preliminary results also show that an increase in the rate of N mineralization may lead to increases in nitrate found in the effluent.
- Issues with water bypassing cell 8 stunted plant growth and contributed to soil dryness, which might account for low mineralization rates and lack of nutrient analysis data.

Future experiments

- Larger sampling efforts in order to increase dataset
- Measure N reductions via gaseous transport out of the system.

Literature cited

Lupon, A., Sabater, F., Miñarro, A., & Bernal, S. (2016). Contribution of pulses of soil nitrogen mineralization and nitrification to soil nitrogen availability in three Mediterranean forests. *European Journal of Soil Science Eur J Soil Sci, 67*(3), 303-313. doi:10.1111/ejss.12344

Zaman, M., Di, H. J., Cameron, K. C., & Frampton, C. M. (1999). Gross nitrogen mineralization and nitrification rates and their relationships to enzyme activities and the soil microbial biomass in soils treated with dairy shed effluent and ammonium fertilizer at different water potentials. *Biology and Fertility of Soils, 29*(2), 178-186. doi:10.1007/s003740050542

Acknowledgments

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•Further information about the Bioretention Project at the University of Vermont can be found at http://www.uvm.edu/~pss/?Page=bioretention project.html