A Longitudinal Study of Redox Sensitive Elements (RSE) Along a Regenerative Stormwater Conveyance (RSC) System

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Introduction

Increasing urbanization and impervious surface coverage contributes to the degradation of streams through increased streambank erosion and decreasing water quality. A Regenerative Stormwater Conveyance (RSC) system is a novel stormwater control measure and stream restoration practice that aims to slow water flow and increase groundwater recharge in streams through the creation of a series of step pools that the water flows through. An RSC can facilitate denitrification and anaerobic bacterial reduction in the stream water through increased microbial activity, releasing various redox sensitive elements (RSE) into solution and removing nitrogen.

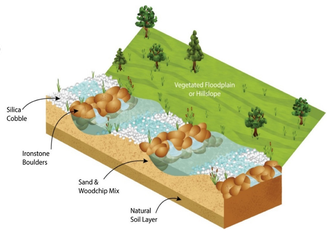

Figure 1: Diagram of a typical RSC system. (Williams, 2016)

Study Sites and Methodology

Overarching Questions:

1. How do RSE concentrations change along the length of an RSC?
2. How are RSE concentrations impacted by seasonality?

Methodology:

Seasonal sampling of an RSC along Campus Creek in College Park, MD.

- Sampled in Oct. '20, Feb, '21, and April '21
- Analysis of Iron (Fe) and Manganese (Mn) concentrations using ICP-OES
- Analysis of total dissolved nitrogen (TN), dissolved organic carbon as non-purgeable organic carbon (NPOC), and inorganic carbon (IC) using TOC-L analyzer

Data Analysis:

- Linear Regression
- Comparison of seasonal variations

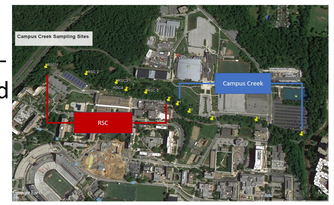

Figure 2: Map of sampling locations of RSC (red) and unaltered portion of stream (blue)

Results

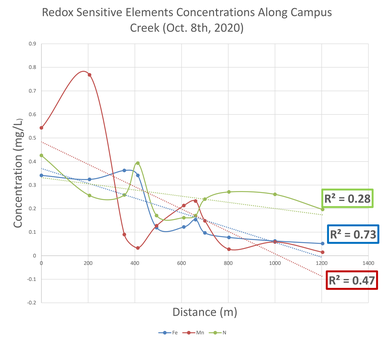

Figure 3: RSE concentrations versus distance from first sampling locality

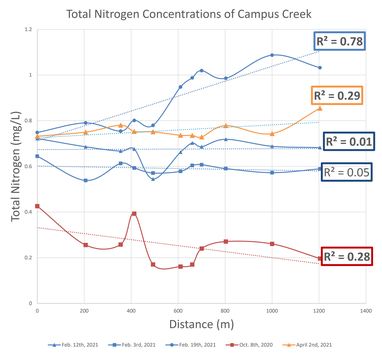

Figure 4: TN concentrations versus distance from first sampling locality

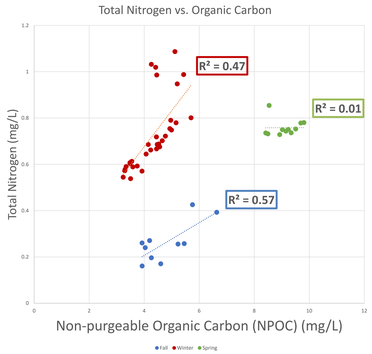

Figure 5: TN versus NPOC concentrations

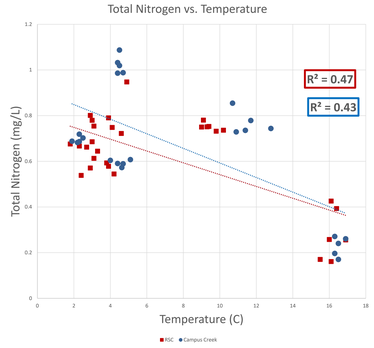

Figure 6: TN concentrations versus temperature

Discussion

Figure 3: Dissolved Fe and Mn concentrations (likely reduced forms of Fe and Mn) are elevated with the RSC and N concentrations is decreased in RSC

- RSCs are effective at retaining and/or transforming dissolved N in streamwater
- RSCs can mobilize trace metals such as dissolved Fe and Mn into solution, an unintended consequence of increased denitrification
- Changes in water quality are localized to the area in which the RSC is constructed

Figure 4: Total dissolved nitrogen (TN) concentrations were elevated in winter (Feb.) and spring (April) compared to fall (Oct.)

- Lowered TN in fall can be attributed to increased plant uptake and/or denitrification

Figure 5: TN increases with increasing organic Carbon

- Relationship could be explained from breakdown of organic matter releasing nitrogen containing amino acids and/or mineralization to NH_4^+ and NO_3^-

Figure 6: TN decreased with increasing temperature

- Increased microbial activity at higher temperatures increases denitrification rates and/or biotic uptake

When compared to pre-restoration data (Fig. 7), total nitrogen concentrations have decreased up to 1 mg/L over the entire stream length 1.5 years after the RSC was initially constructed.

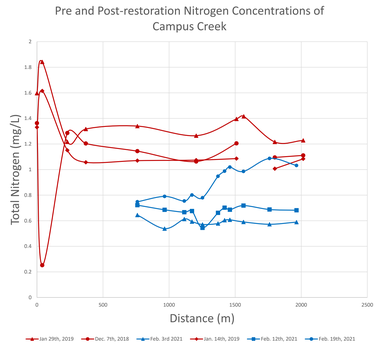

Figure 7: Total nitrogen concentrations pre-restoration and post-restoration

*Pre-restoration data from Silberstein senior thesis (2019).

Conclusions

- Fe and Mn concentration are elevated in RSC's
- N concentrations are decreased in the RSC compared to sites downstream
- N is retained in the RSC compared to downstream sites
- N concentrations are decreased in the RSC and overall stream compared to pre-restoration values
- Seasonal factors (temperature and organic carbon) have a large impact on the concentration of N in the RSC and throughout the entire stream

Acknowledgements and References

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Silberstein, D. (2019). A Synoptic Survey of Campus Creek. University of Maryland Geology Senior Thesis

Williams, M. R., Wessel, B. M., & Filoso, S. (2016). Sources of iron (Fe) and factors regulating the development of flocculate from Fe-oxidizing bacteria in regenerative streamwater conveyance structures. *Ecological Engineering*, 95, 723-737.