Pre-remediation Nutrient Cycling in the Pickle Pond AOC

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Introduction

A history of contamination and separation from the greater estuary marked Pickle Pond as an Area of Concern (AOC) in the St. Louis River Estuary (SLRE). Scheduled remediation in 2022 will address the historic damages and attempt to transform Pickle Pond into a healthy part of the SLRE.

The micro biotic community can be viewed as a functional indicator of how nutrients cycle in an aquatic ecosystem. Focus is given to Nitrogen and Phosphorus as the common limiting nutrients. Figures 1 and 2 demonstrate the respective nutrient cycle in an aquatic ecosystem.

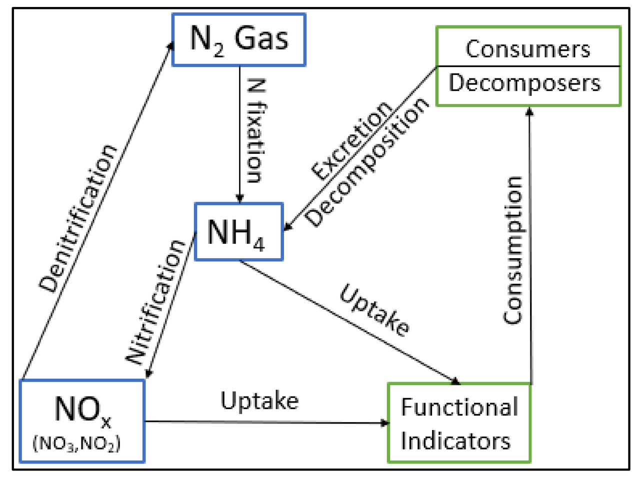

Fig 1. Visual representation of the Nitrogen cycle in an aquatic ecosystem. Blue designates inorganic N and Green designates Organic N.

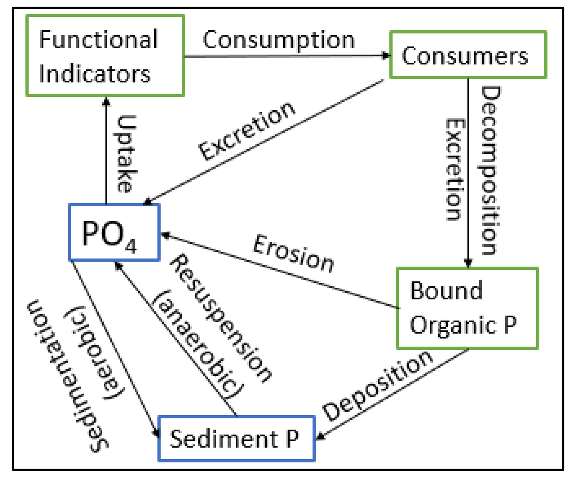

Fig 2. Visual representation of the Phosphorus cycle in an aquatic ecosystem. Blue designates inorganic N and Green designates Organic N.

The same factors that make Pickle Pond an AOC could impact the microbial community within the water column. Future remediation actions could also influence these microbes.

Objectives

A comparison of the nutrient cycling between pre-remediation Pickle Pond and a nearby control site within the SLRE. Examine initial nutrient concentrations between sites as well as nutrient uptake rates between sites and within each site. Nutrient cycling is expected to be higher at the control site if contamination has had a negative impact on the functional indicators.

Materials & Methods

Study Sites

- **Pickle Pond** is a 9-acre pond separated from the bay by a railroad line with only two small openings connecting it to the bay. Historically, sewage outfalls were in Pickle Pond. Today, stormwater outfalls are present. Both have contributed to the accumulation of contaminates and gradual filling in of the pond.
- **Loon's Foot Landing** is located ~1.4 miles from Pickle Pond. The landing is near a retired taconite dock and now serves as a boat launch. Selected as the control site due to the proximity to Pickle Pond and natural connection to the estuary. Additionally, it does not have the direct contamination impacts that Pickle Pond has. Sites are displayed in Figure 3.

Fig 3. Map of the Pickle Pond (PP) and Loon's Foot (LF) sampling sites

Nutrient Uptake Assay

Used to measure the rate that nutrients are cycled by the functional indicators living in the water from each site.

- 5L biotainer of water was collected from each site
- Water temperature and weather conditions noted
- Assay is done on all biotainers simultaneously
- Nutrients (**KNO_3, $NH_4H_2PO_4$**) were added to each biotainer at 10:00am
- Initial 200ml sample collected directly after nutrients were mixed in
- Biotainers are incubated in water (Fig 4A) for four hours with a sample point every hour
  - Half of each sample is filtered with 60ml syringe and attachable 0.45µm acetate filter (figure 4B)
  - Remaining portion is labeled as unfiltered
- Samples put on ice until frozen back at the lab.

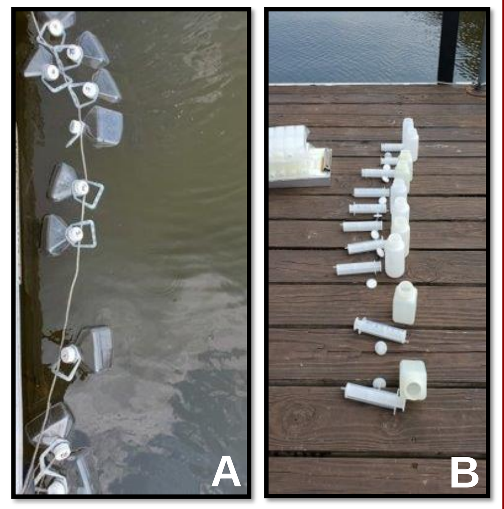

Fig 4. A) Biotainers incubating off the dock at Loon's Foot Landing between time points. **B)** Sample containers, syringes, and filters ready for the next time point.

Lab Methods

- Filtered samples were analyzed for dissolved NO_3-N, NH_4-N, and PO_4-P concentrations using flow-injected colorimetry (QuickChem 8000, Lachat Instruments, Loveland, CO, USA). NO_3 -N and PO_4-P were analyzed simultaneously by the cadmium reduction method (QuikChem Method 10-107-04-1-B 1996) and the ascorbic acid method (QuikChem Method 10-115-01-1-B 1996), respectively. NH_4-N was analyzed using the salicylate method (QuikChem Method 10-107-06-2-B).
- Total nitrogen (TN) and total phosphorus (TP) were measured on unfiltered samples by first digesting the unfiltered sample in an autoclave with potassium persulfate, followed by colorimetric analysis methods for NO_3-N and PO_4-P (APHA 1998, QuikChem Method 10-107-04-1-B 1996, QuikChem Method 10-115-01-1-B 1996).

Data Analysis

Linear regressions were performed on the data from the nutrient uptake assays (Fig 5). The reverse sign of the slopes were then used as the nutrient uptake rate. Data was statistically analyzed using R (v.4.1.2). T-tests were used to examine inter-site comparisons. An ANOVA was used to look at intra-site nutrient comparisons.

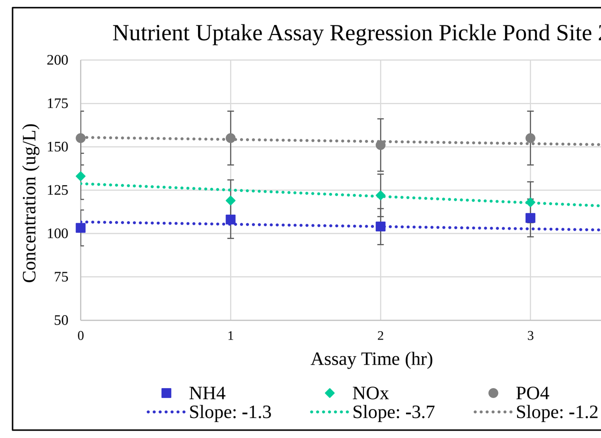

Fig 5. Example from Pickle Pond site 2 of a nutrient uptake assay's linear regression. Shows the change in nutrient concentration over the assay.

Results

Examination of the data from the nutrient uptake assays found no significant difference in the initial nutrient concentrations between sites. Additionally, neither the differences in uptake rates between sites nor within each site were found to be significant. The regression slopes calculated for each nutrient at each sample location were also found not to be statistically significant.

Discussion

The study site, Pickle Pond, was chosen due to its contamination and isolation from the greater SLRE. Loon's Foot Landing is open to the SLRE and has no such history of contamination. This, along with location proximity and similar habitats, makes for a good control site.

The results tell us that the contamination present at the sample site is not likely inhibiting the nutrient uptake rate when compared to the control site. It is important to note that this assay is on the water column, so the algae and bacteria in the water may not be directly impacted by the contamination at Pickle Pond like those in the sediment would be.

The four-hour nutrient uptake assay has a limited sample size due to time restraints for completing the assay; which may contribute to the lack of significance in the uptake regressions. Although there are not significant differences, we can still examine trends between and within sites.

As displayed in Figure 6, Loon's Foot appears to utilize all 3 forms of nutrients across the sites, whereas Pickle Pond favors the uptake of NO_x and PO_4. This reflects that N sourced from NO_x and PO_4 are considered limiting nutrients at Pickle Pond.

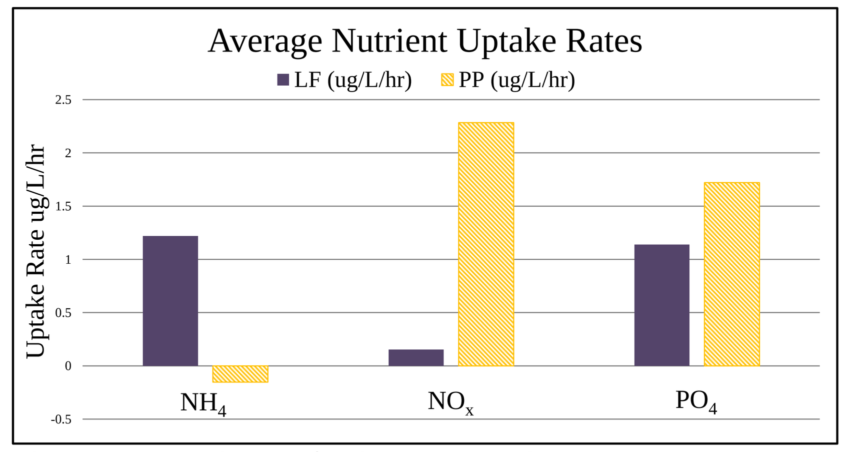

Fig 6. Average uptake rate of each nutrient at each site.

Looking Forward

The data presented here represents a small snapshot of how nutrients cycle through an aquatic ecosystem. Other data can be used in conjunction with the results from the nutrient uptake assays discussed.

Sediment samples were collected from each site along with the water. The data from the 2020 sediment is currently being analyzed and could offer insight into how nutrients are processed at each location. Of particular interest is the enzyme activity and the role it plays in the nutrient cycle.

The same suite of samples were collected from Pickle Pond and Loons Foot Landing in 2021. Upon completion of analysis, they will add another valuable year of pre-remediation data for a more robust comparison. The data collected pre-remediation will be used to compare to post-restoration values. This will allow us to determine if there were significant changes after the completion of the restoration at Pickle Pond.

In addition to the samples collected and ran in the previous years, a new focus will be given to identifying Cyanobacteria through phytoplankton taxonomy, and phycocyanin fluorescence. The presence of Cyanobacteria could be useful in explaining the nitrogen fixation seen at some sites.

Remediation is scheduled to begin in 2022 and sampling will continue. The proposed remediation (Fig 7) will feature the removal of contaminated sediment and invasive species, additional openings to the bay, as well as improving fish and wildlife habitat.

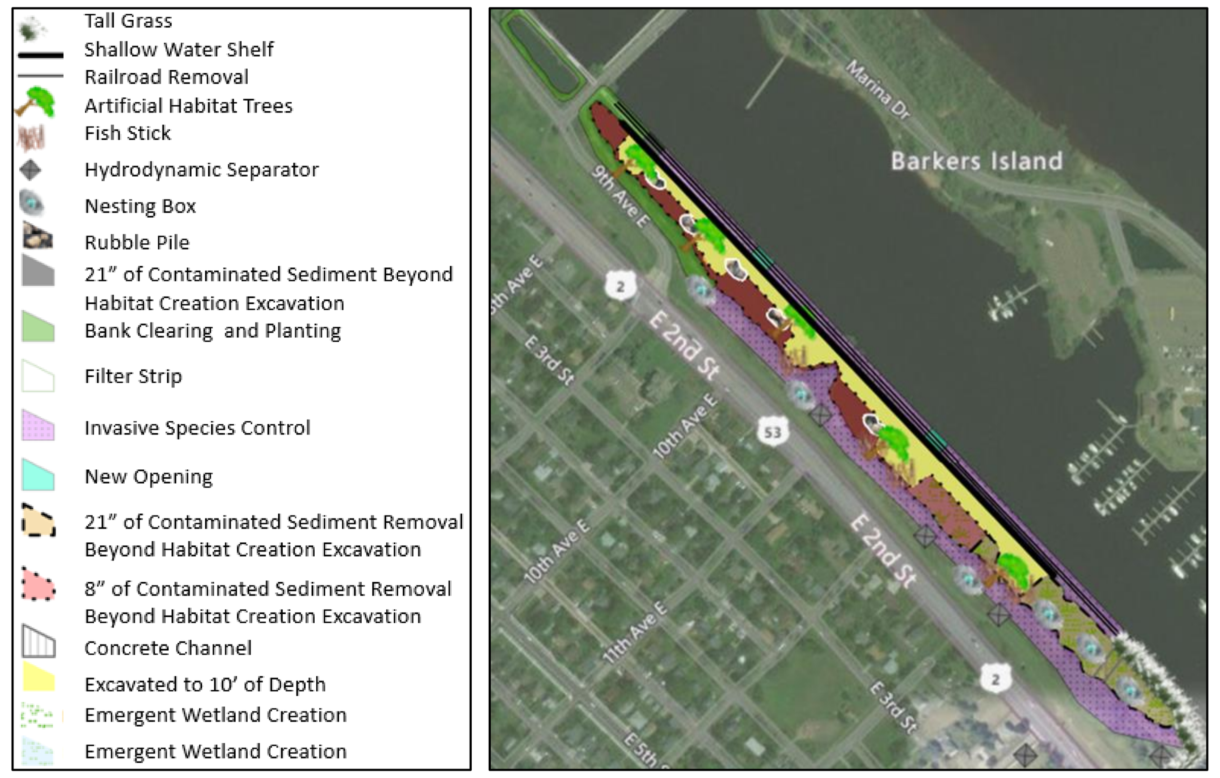

Fig 7. Planned remediation at Pickle Pond

References

US EPA. "Pickle Pond Restoration Site." 2021, storymaps.arcgis.com/stories/8f7897482ea34b05a67e6f9425cc8131. Accessed 22 Dec. 2021

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