Evaluation of Phosphorus Uptake within Aquatic Plants for the use of Nutrient Removal

Grace Wilbanks - Department of Biological Sciences - Missouri University of Science and Technology

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Introduction

Stormwater runoff from urban areas can lead to excess nutrients, such as phosphorus or nitrogen, in our waterways. These waste nutrients can lead to overgrowth of algae and plants, deoxygenation of ponds and streams, and death of the aquatic life in these important ecosystems. Currently, floating treatment wetlands are being used to combat these excess nutrients, combining a floating element with an absorptive media, either man-made or natural aquatic plants, into a model to float on an impacted lake.

Abstract

In this research project, multiple small-scale microcosm level experiments were run with different native aquatic plants to test their uptake ability for future use in a full-scale floating treatment wetland. Nutrient uptake was measured through soluble reactive phosphorus (SRP) tests, total phosphorus (TP) tests, and ash digestion of plant and algal samples. Algae and pondweed proved the most efficient in the trials for removing phosphorus from water. Coontail was also very effective, while duckweed and watercress were the least effective in their phosphorus removal.

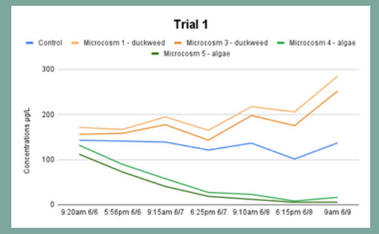
Results

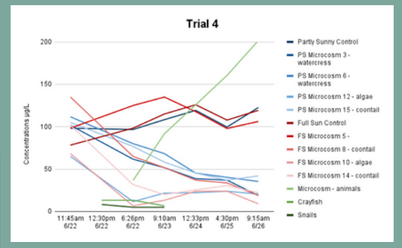
Chart 2

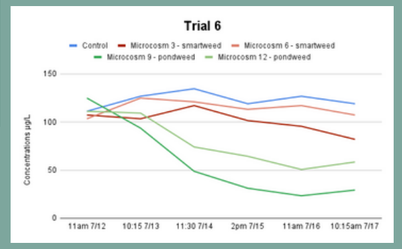
	Sub Sample #	Concentration (µg/L)
PS Microcosm 6 - Watercress	303	154.8
FS Microcosm 10 - algae	20	142.1
PS Microcosm 12 - algae	24	127.6
FS Microcosm 5 - Watercress	301	458.8
PS Microcosm 3 - Watercress	302	314
FS Microcosm 14 - Coontail	55	232.6
PS Microcosm 15 - Coontail	42	113.1
FS Microcosm 8 - Coontail	412	143.9

Fig. 2: TP concentration of trial 4 plants (including orthophosphate and soluble phosphorus concentration from ash

Fig. 1- Microcosm Data Graphs from Trials 1, 4, and 6







Discussion

Data suggests from all microcosm trials that algae and pondweed perform the best, shown in trials 1, 5, and 6. Duckweed seemed to die off and add nutrients rather than remove, shown in trial 1. Coontail seemed to fluctuate in concentrations no matter the condition it was started in, shown in trials 2 and 3. Further microcosm trials show similar results, except in trial 4, where coontail outcompeted algae in both full sun and partial sun. Trial 4 included an animal microcosm, tested without nutrient addition, which showed a positive trendline similar to the duckweed as the aquatic creatures died off and added carbon to the system.

The results of the SRP testing on the sub samples run from Trial 4 treated for TP testing show that the SRP of the microcosm samples do not include a large portion of the nutrients trapped within organic bonds. These TP tests are important within a larger scope of nutrient remediation, as they reveal the phosphorus outside of the organic phosphorus most commonly tested for.

As shown in the general fluctuation of the concentrations within the microcosms, a larger scale mesocosm would be more accurate as the simple aeration of the white tubs was not enough to sufficiently mix the nutrient spikes into the dechlorinated water. The white tubs were also reused after thorough scrubbing, meaning insufficient scrubbing could have contaminated the tubs with algal growth and altered the results. The plants that seemed to have little uptake and little phosphorus release would likely benefit from the larger scale mesocosms and a longer testing period.

Methodology

- Stormwater and lake samples were collected from the shoreline of local sites or from inlet and outlets and treated for future TP and SRP testing. Plants were collected from local lake sites such as Ber Juan lake and Frisco Lake.
- The plants were weighed and placed in 1 liter microcosms for trials. Water samples were taken before addition of 10 g/L Nitrogen and 1 g/L Phosphorus, afterwards, and at least daily for the duration of the trial After trial conclusion, the plants were weighed, dehydrated in an oven, and re-weighed.
- Smaller subsamples of the dried plant matter were collected and weighed, and later reduced to ash in a furnace, digested and reconstituted to 50 mL for future SRP testing
- TP tests were conducted with the local site unfiltered water collections to assess all forms of phosphorus present. The samples were digested and oxidized with sulfuric acid and potassium persulfate, then autoclaved and allowed to cool for future SRP testing.
- SRP tests were conducted by mixing 10 mL of each sample with 1 mL SRP reagent. The chemical reaction that took place turned the samples varying shades of blue, with darker blues having higher phosphorus concentrations. The samples were run against two blanks and two standards using a spectrophotometer set at 885 nm/sec to quantify their absorbance. Microsoft Excel was then used to calculate the concentration in µg/L.

Conclusion

The study explores nutrient uptake ability in various native aquatic plants with different conditions. When observing the results, it is evident that in a full scale treatment, algae and pondweed would prove the best.

References

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