Utilizing Biochar to Restore Damaged Ecosystems

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Introduction

Urban and rural wetlands have been impacted heavily by nutrient loading and high salinity due to conventional agricultural practices and road salt runoff. Recent research in terrestrial ecosystems indicates that biochar application has the potential to adsorb nutrients, heavy metals, and salts present in the soil solution to benefit plant growth and reduce runoff pollution.[1,2] Biochar is created by pyrolyzing organic material via incomplete combustion under low oxygen conditions that lead to beneficial chemical properties (i.e. cation exchange capacity) as a soil amendment.[3] To date, minimal research exists on the potential of biochar adsorption capabilities to mitigate common pollutants in aquatic systems.

To address the gaps in knowledge, our research was developed to understand the ionic adsorption of common aquatic pollutants in the water column within a controlled stream simulation experiment. Specifically, we tested biochar's ability to act as a removable filter from aquatic ecosystems to improve downstream water quality over time. A time series experiment is crucial to better understand rates of ionic adsorption in stream systems in reference to biochar's surface saturation loads. The results of this preliminary research were designed to be scalable and practical for land management application in the field.

Methods

In Fall 2022, our team utilized flowing water stream simulators in Loyola University Chicago's Aquatic Simulation Lab (Fig. 3).

Stream simulator filled with DI water followed by respective salt (0 mg L^{-1}, 500 mg L^{-1}), phosphorus (0.1 mg L^{-1}, 3.5 mg L^{-1}) and nitrogen (2.0 mg L^{-1}, 20 mg L^{-1}) treatment rates. Our fully factorial research (replication = 6) submerged six (6) jute bags each with 40 grams of Wakefield Biochar derived from paper mill wood waste in each stream run (Fig. 2).

Over a six (6) week period, one randomly selected jute bag was removed from each simulator per week. Biochar samples were dried, ground, digested, and chemically analyzed via ion chromatography for cation (Na^+, NH_4^+, Ca^{2+}) and anion (Cl^-, NO_2^-, NO_3^-, PO_4^{3-}) concentrations.

Linear mixed effect models in R were used to analyzed repeated measure time series data for each ionic composition.

Figure 1. Jute bag containing BioChar, secured with zip tie, pre-treatment.

Figure 2. Wakefield BioChar, pre-treatment.

Research Question

Can biochar act as a practical removable filter in an aquatic system overloaded with fertilizer and/or road salts?

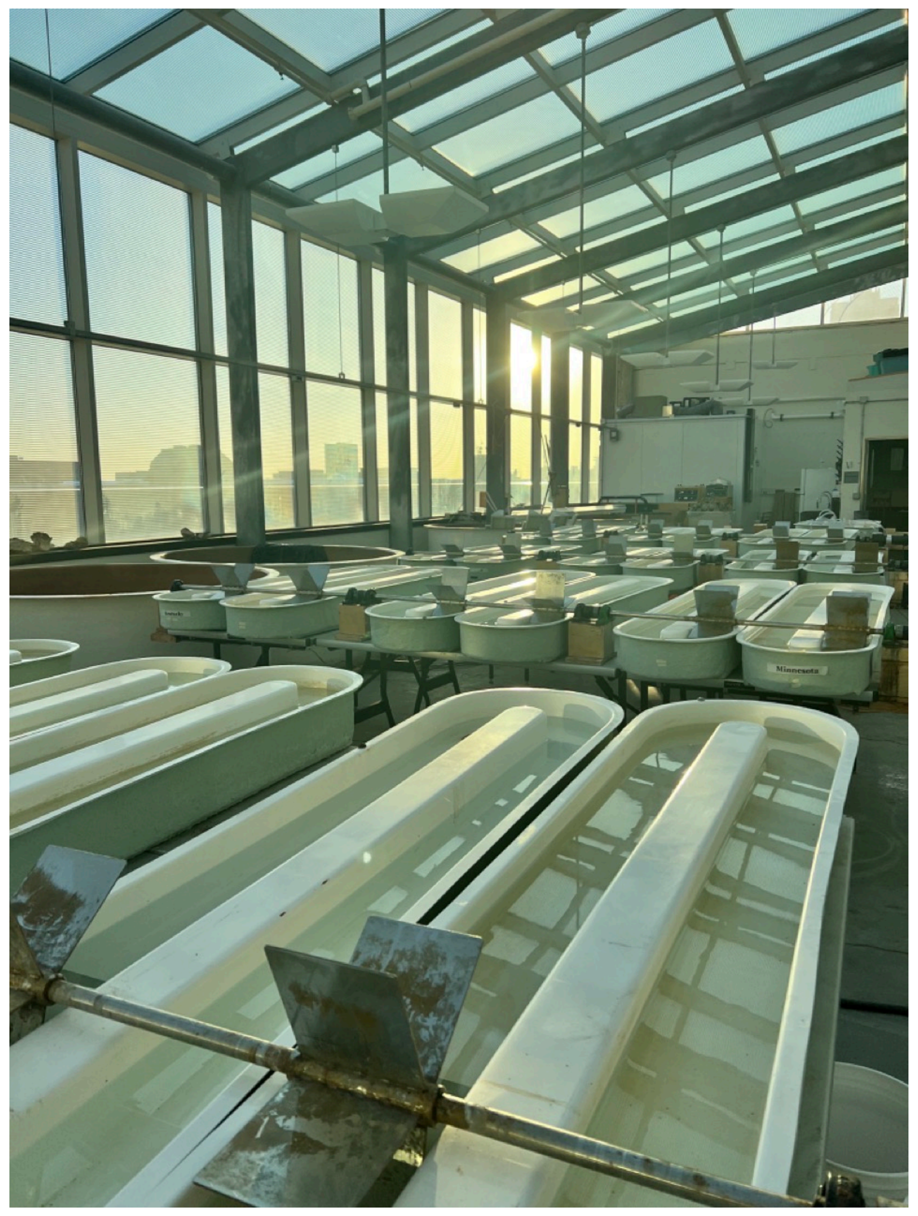

Figure 3. Experimental set-up in Loyola's Aquatic Simulation Lab.

Figure 4. Experimental set-up in Loyola's Aquatic Simulation Lab .

Figure 5. Stream D4 with no salt and low nutrient treatments in Week 4. BioChar bags were submerged and held under bricks to prevent movement.

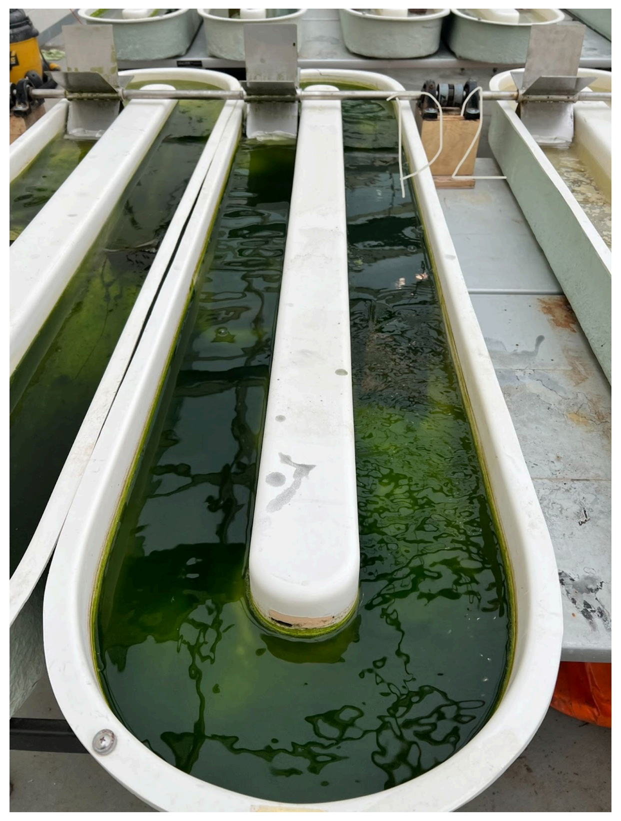

Figure 6. Stream D2 with no salt and high nutrient treatments in Week 4. BioChar bags were submerged and held under bricks to prevent movement.

Figure 7. Stream D3 with salt present and no nutrient treatments in Week 4. BioChar bags were submerged and held under bricks to prevent movement.

Results

Chemical and statistical results are forthcoming on the printed poster.

Looking Forward

These preliminary results are anticipated to suggest that biochar can sequester harmful ions and has the potential to be applied as a removable filter to damaged wetlands. Land management techniques can apply biochar as a soil amendment to curb the impacts of fertilizer and road salt inputs from agricultural and urban runoff. Sequestering these harmful pollutants can support native vegetation in the face of exotic species invasion to help restore wetland function, hydrology, and biodiversity.

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References

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