Assessing Biochar's Potential to Curb Salt Pollution in Freshwater Systems

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Introduction

Road salt pollution in the Great Lakes region has been steadily increasing in aquatic systems due to urban sprawl and road safety concerns. Excessive road salt (measured as Cl^- mg/L) impacts water quality adjacent to roadside ecosystems by increasing electro- conductivity and altering soil solution osmotic gradients, thus rendering habitats inhospitable for native plants and animals. To date, few mitigation strategies exist to manage salinity in freshwater streams, lakes, and wetlands.

Biochar, the by-product of heating organic waste in low oxygen environments, has gained attention as a soil amendment that improves terrestrial systems with degraded agricultural and saline soils. Biochar research indicates highly porous surfaces with high cation exchange capacity that can effectively buffer pH and improve nutrient retention. In aquatic systems with highly saline water infiltration, biochar's role as a salt adsorption filter has not been assessed.

The ISGS General Water Quality Standard for surface waters is 500mg Cl^-/L. During spring run-off, roadside ditches in IL have measure peak chloride values at 6,000mg Cl^-/liter. *In this exploratory study, I investigated biochar's capacity to filter Na^+ & Cl^- ions from a saline solution at peak run-off collected over 12L.*

Research Hypothesis:
Treatment buckets with 50% Sand / 50% biochar will significantly adsorb more Na+ and Cl- ions compared to 100% sand buckets only.

Methods

In this fully factorial experiment, I developed a flow-through bucket system to collect 9.89g/L H_2O road salt in DI water passing through **100% Sand** or **50% Chip Energy Wood-derived biochar + 50% Sand** mix (based on weight) (replication = 3).

Twelve (12) liters of saline water was passed through the filtration media and collected from the installed taps at four (4) time intervals (Figure 1). Water subsamples were collected from the flow-through port three (3) minutes after adding 6L, 8L, 10L, and 12 L to the 50% Sand + 50% Biochar treatments. Water subsamples were collected from the flow-through port at 2L, 4L, 6L, and 12L for the 100% Sand controls.

Chemical analyses were performed on water samples using ion chromatography. Linear mixed effects models were analyzed in R.

Methods

Photo 1. Experimental set-up of saline solution *(6,000mg Cl-/L)* flowing through matrix of 50% Biochar / 50% Sand or 100% sand.

Photo 2. Constructing a flow-through system with buckets and spigots.

Results

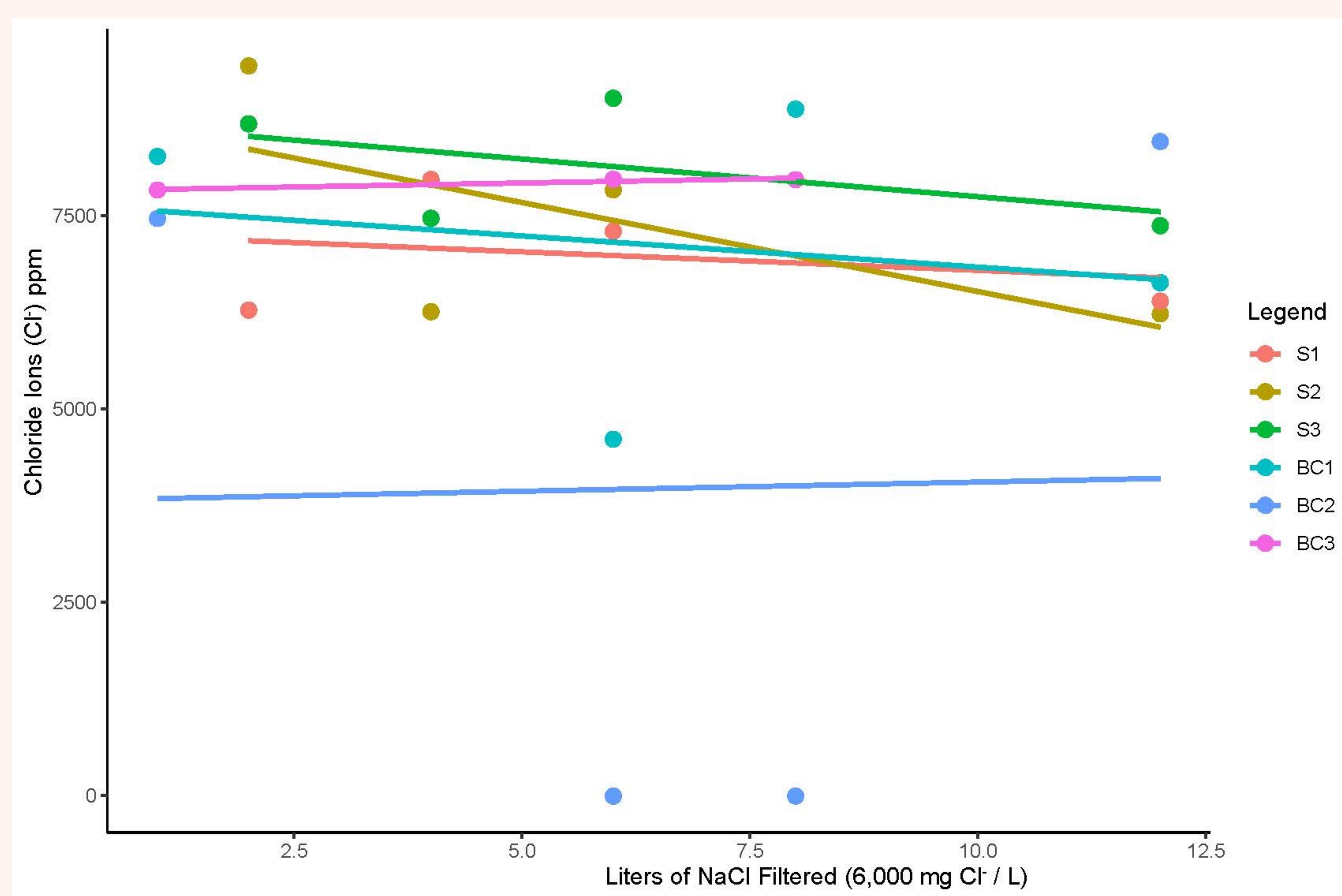

Figure 1. Chloride in ppm within filtered water samples as a function of repeated salt-treated water addition and treatment type (S= 100% Sand, BC=50% Sand and 50% Biochar)

Discussion

No significant difference in Cl^- ion concentration across multiple water sampling time points was detected between the water samples taken from the 100% Sand versus 50% Biochar and 50% Sand treatments ($p > 0.05$).

This preliminary study indicates that biochar + sand did not differ from sand in terms of chloride repulsion or adsorption. As biochar has been hypothesized to have a high cation exchange capacity, understanding of the fate of Cl^- ions in crucial if biochar is applied in saline polluted soils or water systems. Flow-through water samples had the potential to bind Cl^- via complexation with carbon side chains or repelled by biochar's hypothesized negative surface charge.

Based on this preliminary research, wood-derived biochar does not likely adsorb chloride OR repel additional Cl^- ions from the sand matrix. As a neutral soil amendment within an aquatic system, we may observe no change to Cl^- ions in a restored aquatic system or downstream of application.

Future Directions

While biochar application may not be a viable solution for chloride containment, biochar still has a variety ecosystem restoration benefits. For instance, biochar is observed to increase nutrient and heavy metal pollution retention in degraded soils. Biochar also supports plant growth as it sustains microbial activity.

Land practitioners and policy makers should contextualize biochar's repelling quality when considering the movement of chloride through aquatic systems.

I intend to analyze the water samples I collected for sodium content, which will direct my understanding of how biochar can be used to mitigate the effects of roadside salt pollution.

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