Lead removal from aqueous solution using biochars derived from brown seaweed, grapefruit peel, and avocado residue

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Introduction

Biochar is a high in carbon charcoal formed with organic material heated in an oxygen depleted system (pyrolysis). Biochar is a potential method for carbon sequestration and is typically used as a soil amendment. However, biochar's highly porous structure can allow for it to be used as an effective filter media for removing contaminants from water, while being produced from organic waste.

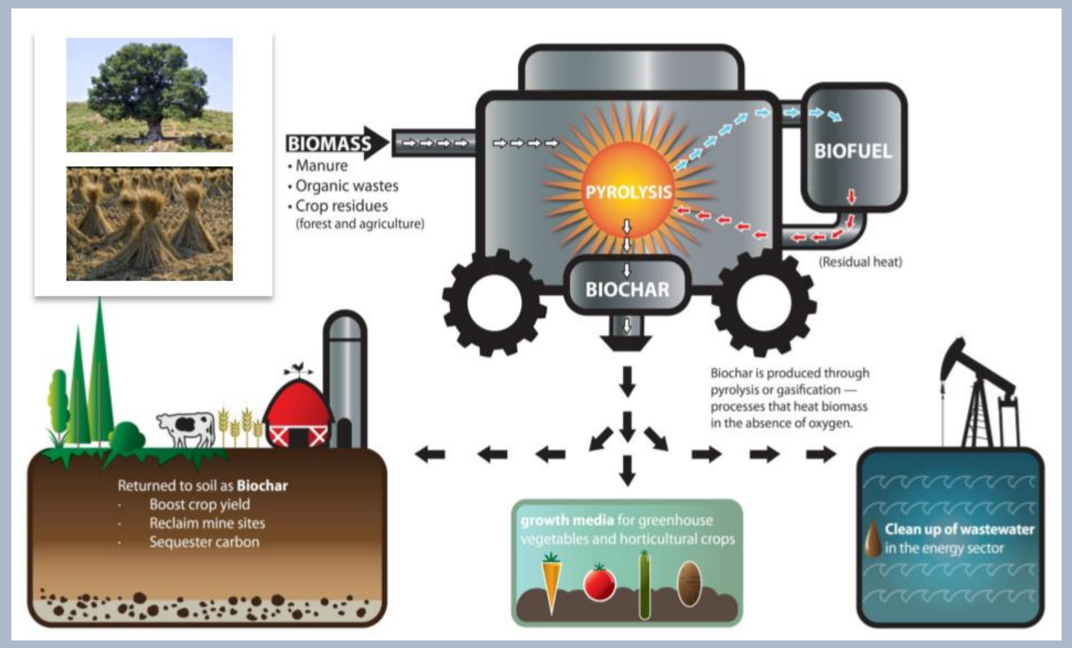

Figure 1. How biochar is made and its potential applications

Purpose

This study aims to compare biochars produced from various locally sourced, organic materials, and determine the biochars' adsorptive characteristics for aqueous lead. Two methods of production were used: "Conventional Pyrolysis" in which pyrolysis temperature was controlled, and "Unconventional Pyrolysis", in which pyrolysis temperature was not controlled. To assess their water filtration potential, batch adsorption tests for lead were performed.

Materials and Methods

Methods of Production

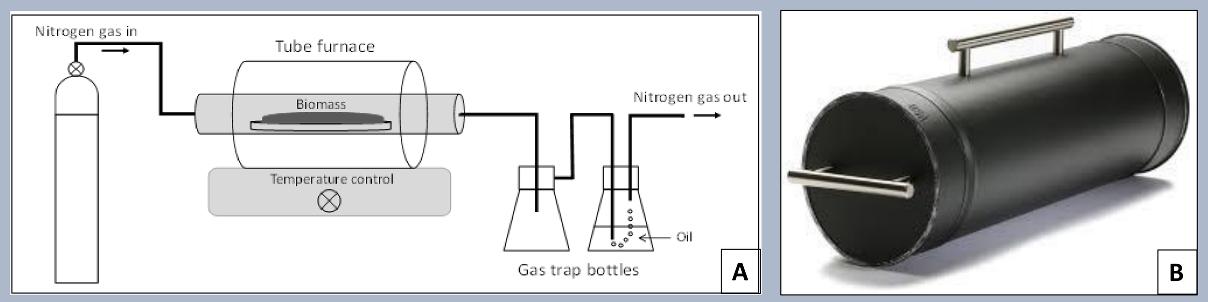

Figure 2. A) Tube Furnace Set-Up for pyrolysis B) Biocharlie

Biochars were produced through two methods: "Conventional Pyrolysis", using a tube furnace at controlled temperature of 300°C with nitrogen gas flowing through and "Unconventional Pyrolysis" using commercially available Biocharlie.

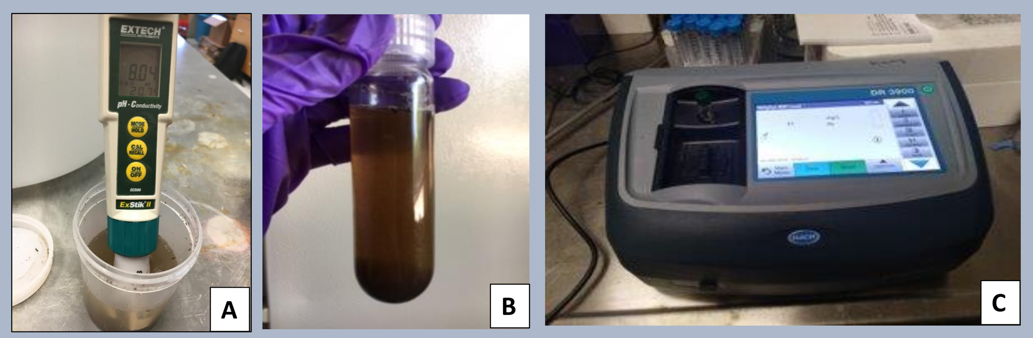

Figure 3.
A) pH conductivity probe measuring biochar's pH B) Lead solution and biochar after shaking for one hour C) HACH DR3900 Spectrophotometer used to measure lead concentrations

Biochar Characterization

Biochars were characterized for pH and Electrical Conductivity on a 1:10 ratio of biochar and deionized (DI) water using a pH-conductivity probe. Percent Carbon and Percent Nitrogen were obtained using an Elemental Analyzer.

Batch Lead Adsorption Tests

A 10 ppm Lead (Pb) Solution was made. 0.8 g of biochar/mass were added to 32mL of Pb solution (1:40 ratio) and shaken for 1 hour. HACH DR3900 Spectrophotometer was used to determine final lead concentration in solution. To determine adsorption, the equation used was:

$$Adsorbed\ amount\ (q) = \frac{(C_i - C_f)V_{solution}}{m_{sorbent}}$$

Biochar Characterization

Table 1. Properties of Biochars Produced

Source	Material	pH	Electrical Conductivity (us/cm)	Percent C (wt.)	Percent N (wt.)
Brown Seaweed	Biomass	8.13	310	25.05	1.36
	BioCharlie Biochar	6.88	2057	---	---
	Tube Furnace Biochar	7.94	1534	27.87	1.6
Avocado Seed	Biomass	7.11	983	42.94	0.77
	BioCharlie Biochar	8.85	4466	---	---
	Tube Furnace Biochar	7.66	125	60.33	1.38
Avocado Peel	Biomass	7.16	1158	48.06	1.1
	BioCharlie Biochar	---	---	---	---
	Tube Furnace Biochar	9.4	272	54.21	1.02
Grapefruit Peel	Biomass	6.26	1094	41.15	0.89
	BioCharlie Biochar	---	----	---	---
	Tube Furnace Biochar	9.04	855	53.5	1.59

Lead Adsorption

Batch Adsorption Tests were used to compare lead adsorption at 10 ppm between different methods of production and different source materials.

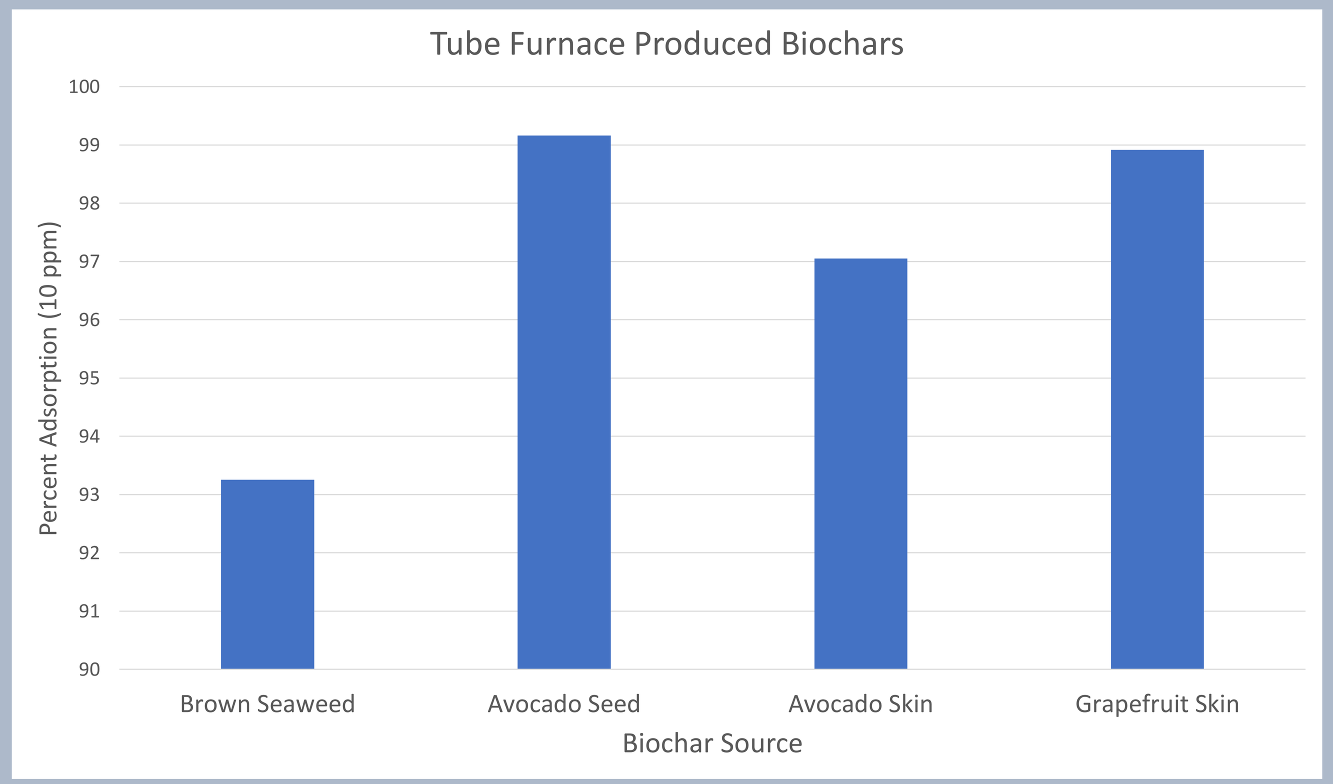

Figure 4. Percent Adsorption by Biochars produced using Laboratory Tube Furnace in Batch Adsorption Tests

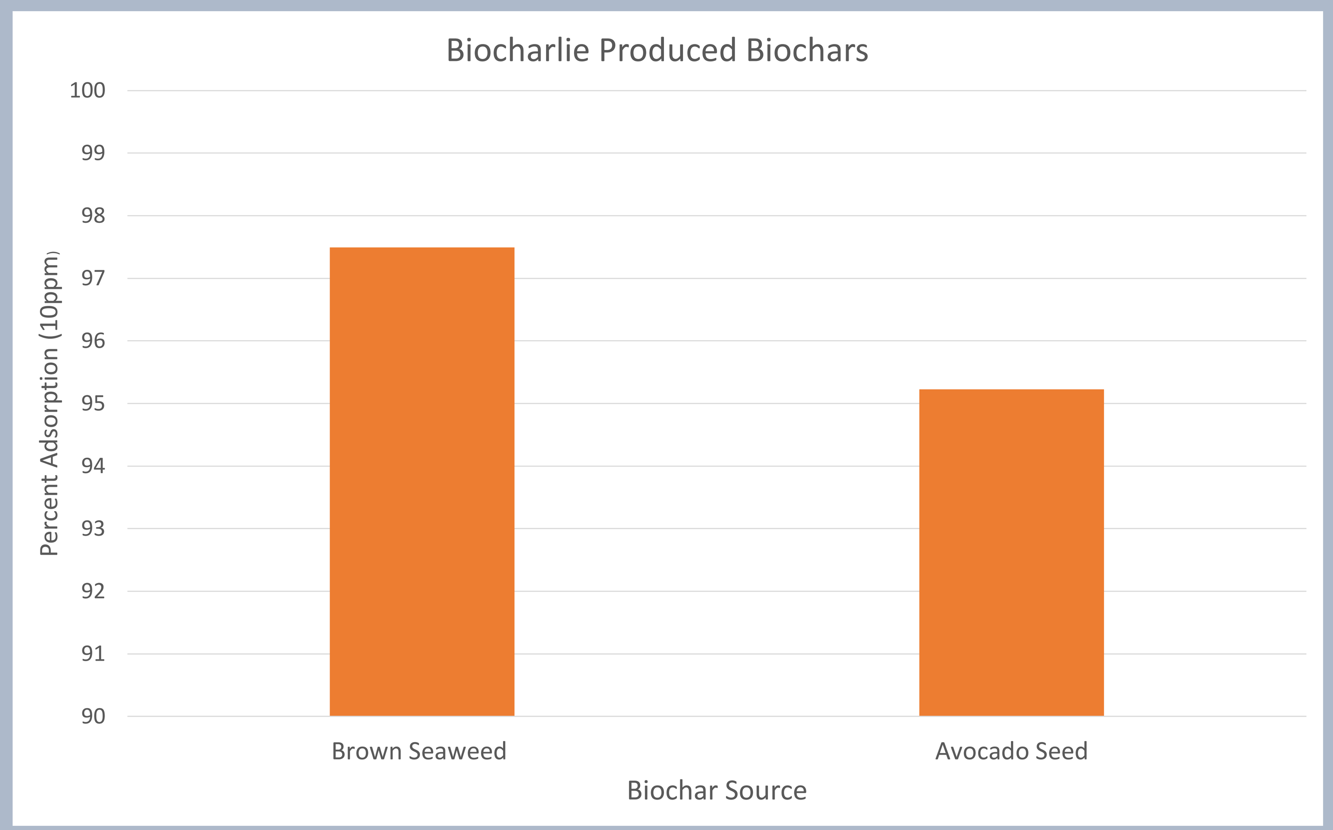

Figure 5. Percent Adsorption by Biochars produced using Biocharlie in Batch Adsorption Tests

FTIR Analysis

FTIR analysis was performed on tube furnace produced biochars to gain insight into which functional groups could be attributed to a greater adsorption. (Keiluweit, 2010)

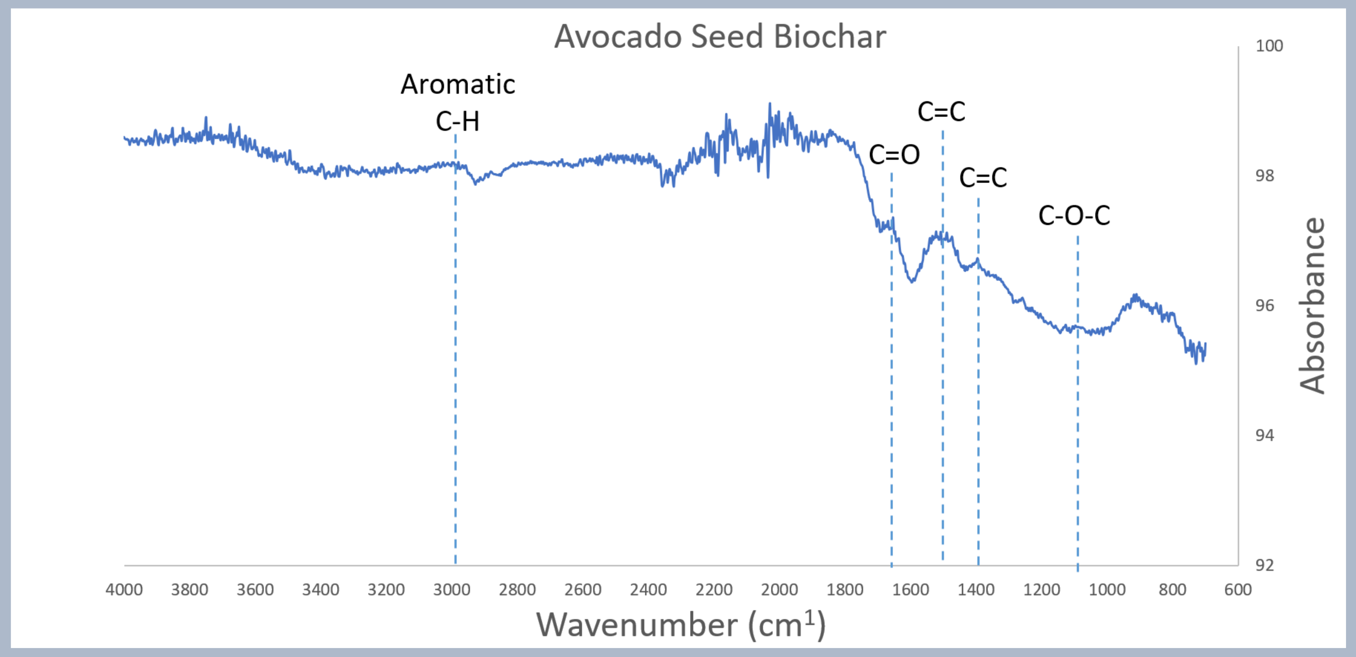

Figure 6. FTIR Analysis for surface functional groups of Avocado Seed Biochar

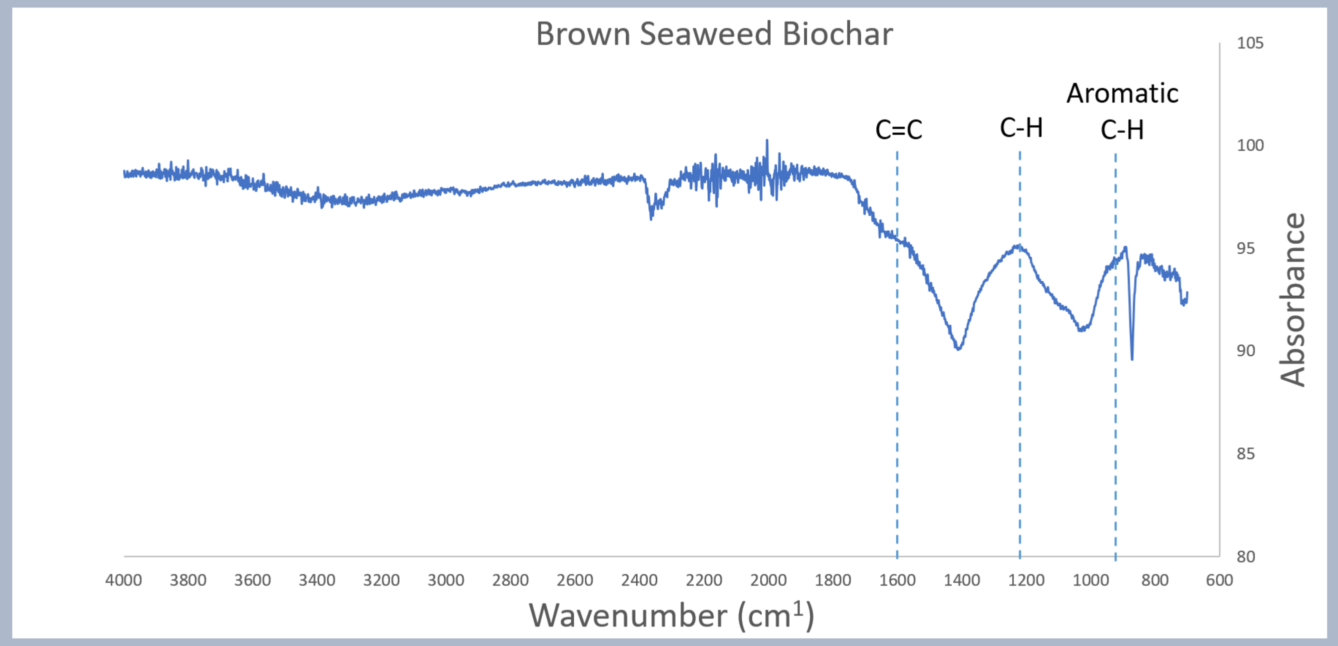

Figure 7. FTIR Analysis for surface functional groups of Brown Seaweed Biochar

Conclusions

- Batch adsorption tests showed all biochars produced, regardless of method of production or source material, showed greater than 90% lead adsorption.
- Percent Yield during pyrolysis was around 50% for most biochars produced.
- Biochars produced using biocharlie showed an increased electrical conductivity compared to tube furnace produced biochars.
- The avocado seed biochar produced by the tube furnace showed the greatest percent lead adsorption
- FTIR Analysis of tube furnace produced biochars support previous literature indicating that the presence of oxygen accounts for a greater adsorption.

References

Alberta Biochar Initiative, 2015. How biochar is made, and its potential applications. Available at http://albertabiochar.ca/wp-content/uploads/2014/04/ABI-Pamphlet.pdf. Accessed on November 1, 2019.

Keiluweit, Marco, Peter S. Nico, Mark G. Johnson, and Markus Kleber. "Dynamic Molecular Structure of Plant Biomass-Derived Black Carbon (Biochar)." *Environmental Science & Technology* 44, no. 4 (February 15, 2010): 1247–53. https://doi.org/10.1021/es9031419.

Mireles, S., J. Parsons, T. Trad, C.-L. Cheng, and J. Kang. "Lead Removal from Aqueous Solutions Using Biochars Derived from Corn Stover, Orange Peel, and Pistachio Shell." *International Journal of Environmental Science and Technology* 16, no. 10 (October 1, 2019): 5817–26. https://doi.org/10.1007/s13762-018-02191-5.

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