Characterization of Grapefruit Peel Biochar for future immobilization of Cu2+ and Pb2+ ions in soil

Michael Alfredo Navarro, Paola Granados, and James Jihoon Kang
School of Earth, Environmental, and Marine Sciences, University of Texas Rio Grande Valley

Introduction

- Biochar is a potential sorbent that can enhance immobilization of heavy metals in soil and aqueous solutions. It can act as a soil amendment that improves soil fertility.
- Reduces the need for synthetic chemical fertilizers and pesticides. It has the ability to remain stable and functional for long durations of time.
- The objective of this study was to 1) produce biochar using grapefruit peel (GP) that are commonly available in Lower Rio Grande Valley
- 2) characterize the GP biochar materials for selected physicochemical properties
- 3) evaluate their efficacy in removing lead (Pb) and copper (Cu) from aqueous solution as well as in the soil as a soil amendment.

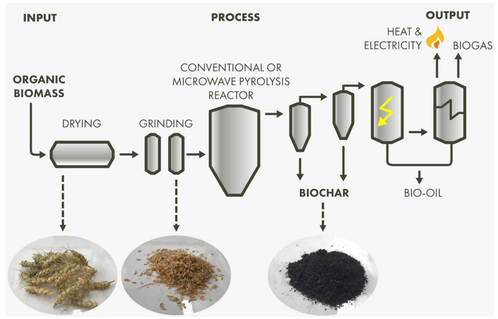

Fig. 1. Depicts the biochar making process and its various uses as a soil amendment and energy alternative

Biochar

- The GP was pyrolyzed 450°C and 800°C, respectively, using a laboratory furnace under limited oxygen condition. The biochar process was initiated by first gathering grapefruit peel feedstock, then rinsing the peels 3 times with water to ensure that any foreign debris was removed.
- Once the peels were cleaned thoroughly, they were then placed in the oven for 24 hours at 110°C to remove any moisture.
- After the 24 hours had elapsed the peels were placed into the oven for two hours and samples were created at two temperatures, 450°C and 800°C.
- The samples were then filtered out with deionized water and placed in the oven to dry again overnight to complete the biochar making process.

Fig. 2. Grapefruit biomass feedstock and its respective biochar products after pyrolosis at 450°C and 800°C.

Cation Exchange Capacity

- The cation exchange capacity refers to the total capacity of the biochar sample to hold and exchange positive ions, measured in cmolc/kg of biochar, it is pivotal in understanding the potential of adsorption.
- Both GP 450° and 800° were tested to measure the capacity of their ability to exchange cations, GP 800° and resulted in an average of 383cmolc/kg of biochar, while GP 450° was discovered to have an average of 445cmolc/kg of biochar.
- The significance of the results display that the samples will have a high affinity to adsorb heavy metals from a liquid solution and soil, the presence of active sites increases with lower pyrolysis temperatures, potentially making GP 450°C more efficient at immobilizing positively charged toxic metals than GP 800°C.

Point of Zero Charge

- The point of zero charge is a procedure to help find the pH of the solution where the cations and anions are the same amount on the surface of the adsorbate. In this case, the target of the method is to adsorb positively charged ions from a solution, the pH of the solution would have to be greater than the pH pzc to have a negatively charged sorbate surface.
- The results for the point of zero charge on the biochar samples were at a pH of 9.2 for GP 450°C, and pH 9.5 for GP 800°C. The significance of the resultant data infers that if the goal is to remove positively charged ions from a solution, the pH of the solution would have to be above a pH of 9.2.
- Understanding the surface charge of the adsorbent material is extremely useful when wanting to target a specifically charged particle, in the case of this researchCu2+ & Pb2+.

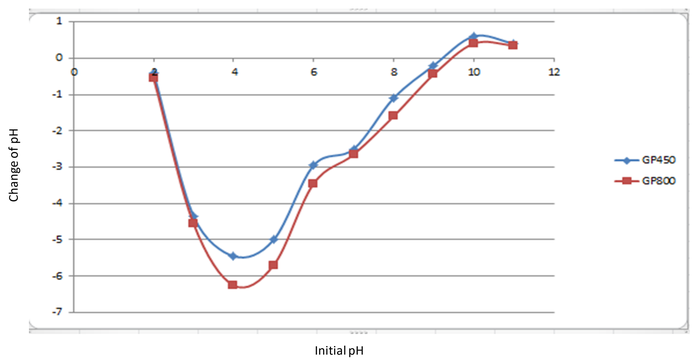

Fig. 3. Point of Zero Charge for GP 450 was reached at pH 9.2 , and pH 9.5 for GP 800

References:
• He, L., Zhong, H., Liu, G., Dai, Z., Brookes, P. C., & Xu, J. (2019). Remediation of heavy metal contaminated soils by biochar: Mechanisms, potential risks and applications in China. Environmental Pollution, 252, 846–855
Zhang, C., Zeng, G., Huang, D., Lai, C., Chen, M., Cheng, M., Tang. W., Tang. L., Dong. H., & Huang. B. (2019). Biochar for environmental management: Mitigating greenhouse gas emissions, contaminant treatment, and potential negative impacts. Chemical Engineering Journal, 373, 902–922.

Proximate Analysis of GP biochar

- The proximate analysis is a procedure that examines the moisture content, ash content, mobile matter, and resident matter of the GP biochar all of which are crucial in determining how stable the biochar will be when placed into action.
- The results from the data displayed that the resident matter of the samples ranged between 50-54%, with GP 450° at 54%.
- This suggests the potential for the grapefruit peel biochar to act as an efficient adsorbent is high, and the probability of microbial degradation is low.
- Resident Matter% (fixed matter)refers to “recalcitrant matter”, a stable portion in the biochar sample
- Ash% is the fraction of the moisture free biochar that is not organic; Ash% inorganic portion after burning at 700°C
- Volatile Matter (mobile matter)% is the portion of organic matter that becomes gaseous or mobile, leaving the ash and resident matter constituents in the biochar sample

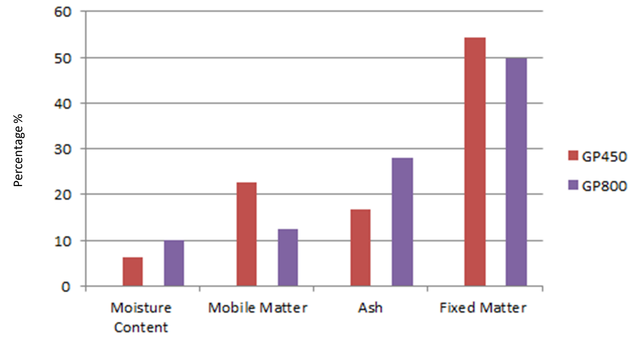

Fig. 4 The comparison between Grapefruit biochar at 450°C and 800°C for mositure content, mbile matter, ash content, and fixed matter represented in percentages

Summary / Future Work

- Predictions on the success of grapefruit biochar as a sorbent for heavy metal ions are promising based on the characterization analysis, which have proven to display that grapefruit biochar can be stable in the environment as well as immobilize heavy metals physically and chemically.
- Future works include adsorption isotherm of Pb and Cu using the GP biochars and soil column experiment to test the efficacy of the GP biochar as a soil amendment in immobilizing heavy metals. The study results will provide recommendations in beneficially recycling GP as a sorbent for heavy metals in soils.

Acknowledgments

The authors like to acknowledge financial support from USDA National Needs Graduate and Postgraduate Fellowship Grants Program and the US EPA P3, USDA-NIFA Hispanic Serving Institutions Education Grants Program, and University of Texas Rio Grande Valley.