Biochar is a rich topic for research due to its numerous potential advantages. Biochar is a carbon-rich material made by carbonizing organic materials (e.g., manure, agricultural residues, woody biomass, etc.) in a zero or limited oxygen environment. Biochar is often presented as a panacea to cure many different limitations of soil. However, biochar is not all the same. Materials and processes used to create biochar have great effects on the resulting biochar’s characteristics. The results of this study show a strong relationship between both feedstocks and temperature with properties of biochar. Higher pyrolysis temperature reduces the amount of biochar produced, increases its surface area, and reduces its cation exchange capacity (CEC). Different feedstock materials also produce highly different CEC. Studying properties of different biochar types at a specific production temperature is important to know its usable quantity and quality, in order to develop biochar that may improve specific limitations of different soils.

Methods and Instruments

Four biomass feedstocks:
- Tamarixaphyllawood with bark
- Perennial ryestraw
- Arundo biomass

were air-dried and milled. Large particles were removed by sieving to <1 mm. Feedstocks were pyrolyzed at four temperatures (300, 400, 500, 600°C) using a pyrolysis reactor in Biosystems Engineering Dept. at WSU.

Biochar yield: measured mathematically as described by Novak et al. (2009)

Surface Area: measured by carbon dioxide sorption at 273K using multipoint Brunauer, Emmett and Teller (BET) analysis on microtritom Tristar II PUSI Surface Area and Porosity Analyzer (N sorcross, GA, USA). Prior to analysis, samples vacuum degassed at 150°C for 12 hours. Then, adsorption isotherms of carbon dioxide were determined at pressure p/p0=0.5 to p/p0=0.03 with 75 set equilibrium points. Then Dubin-Radushkevich (DR) equation used to estimate surface area and micropore volume.

Cation Exchange Capacity (CEC): determined by method of Munera et al. (2018). Biochar samples were washed with diluted solution of HCl three to five times to remove ash, then washed in distilled water until pH became 7 and EC less 0.2 ms cm⁻¹. Samples were saturated with NaCl and then washed with alcohol. Ammonium measured in the final extract is equal to the total CEC.

Scanning Electron Microscopy (SEM):

The samples pyrolyzed at 300°C were placed on carbon tabs and SEM stubs before gold platting. Samples were then examined using the Hitachi SEM.

Results

The results of linear regression analysis show a significant effect for both pyrolysis temperature and feedstock on biochar characteristics. Pyrolysis temperature affected biochar yield, surface area, and cation exchange capacity of biochar from every feedstock (p < 0.01, R² 0.78-97), except surface area of perennial ryestraw. Likewise, feedstocks had a significant effect on biochar yield, surface area, and cation exchange capacity at every temperature (p < 0.05 with R² 0.13-0.81).

Conclusions

Feedstock properties and biochar production methods affect the resulting biochar CEC and surface area. The examined types of biochar could be used in agricultural applications to increase cation exchange capacity (CEC) and surface area in poor or sandy soils. Further research is needed to investigate the impact of pyrolysis temperature on other important characteristics such as aliphatic functional groups which determine hydrophobicity (Novak et al., 2009).

References