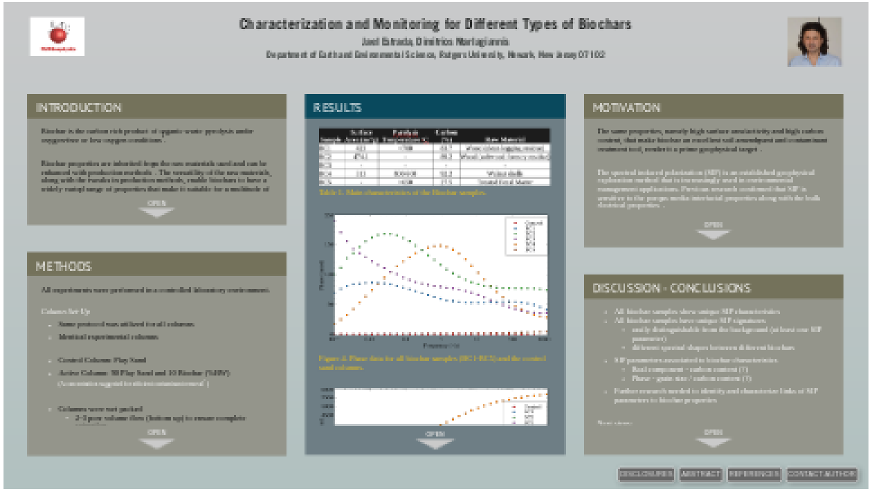
Characterization and Monitoring for Different Types of Biochars



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PRESENTED AT:

INTRODUCTION

Biochar is the carbon rich product of organic waste pyrolysis under oxygen-free or low oxygen conditions[1].

Biochar properties are inherited from the raw materials used and can be enhanced with production methods[2]. The versatility of the raw materials, along with the tweaks in production methods, enable biochars to have a widely varied range of properties that make it suitable for a multitude of applications[1].

In recent years, biochar has generated research interest because of its potential value in environmental and agricultural purposes.

Advantages of Biochar:

- Multi-purpose material for passive applications[1].
  - Soil amendment[1]
  - Environmental management[1]
    - Contaminant treatment[1]
    - Carbon sequestration[3]
- Unique surface properties
  - High sorption capacity
- Long term stability
- Versatility[1]
- Adaptable for different environments[1].

Limitations of Biochar:

- Versatility
- Uniform application
- Large scale characterization[1]

METHODS

All experiments were performed in a controlled laboratory environment.

Column Set-Up

- Same protocol was utilized for all columns
- Identical experimental columns

- Control Column: Play Sand
- Active Column: 90 Play Sand and 10 Biochar (%BW)

(A concentration suggested for efficient contaminant removal[1])

- Columns were wet packed
  - 2-3 pore volume flow (bottom up) to ensure complete saturation.
- Homogenized biochar-sand porous media

Figure 1. An image of the homogenized biochar-sand porous media.

- Saturating solution: 300 uS/cm (NaCl in DIW)

Figure 2. An image of the column after being wet packed and saturated.

SIP Set-Up

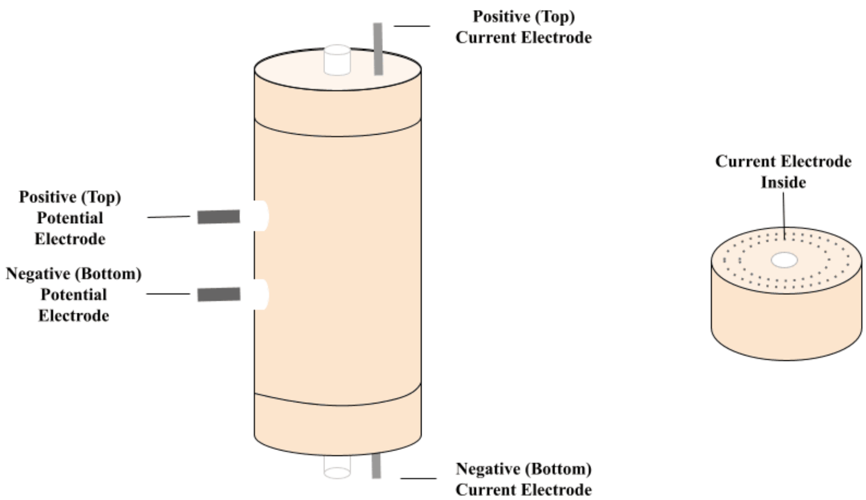

Figure 3. A schematic of the column showing the basic elements for SIP measurements.

SIP measurements

- Instrument: PSIP (by Ontahs & Ermac)
- Duplicate measurement
  - Frequency range: 10^{-3} to 10^{3} Hz.

RESULTS

Sample	Surface Area (m^2/g)	Pyrolysis Temperature °C	Carbon (%)	Raw Material
BC1	423	<700	83.7	Wood (clean logging residue)
BC2	474.1	-	89.2	Wood (softwood forestry residue)
BC3	-	-	-	-
BC4	313	800-900	92.2	Walnut shells
BC5	-	>650	27.5	Treated Fecal Matter

Table 1. Main characteristics of the Biochar samples.

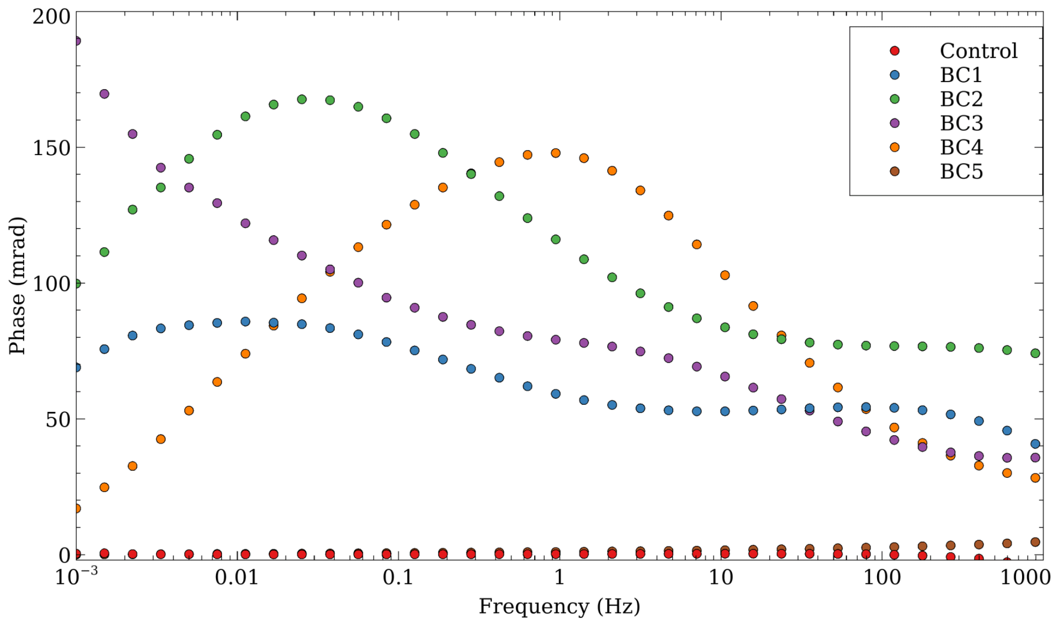

Figure 4. Phase data for all biochar samples (BC1-BC5) and the control sand columns.

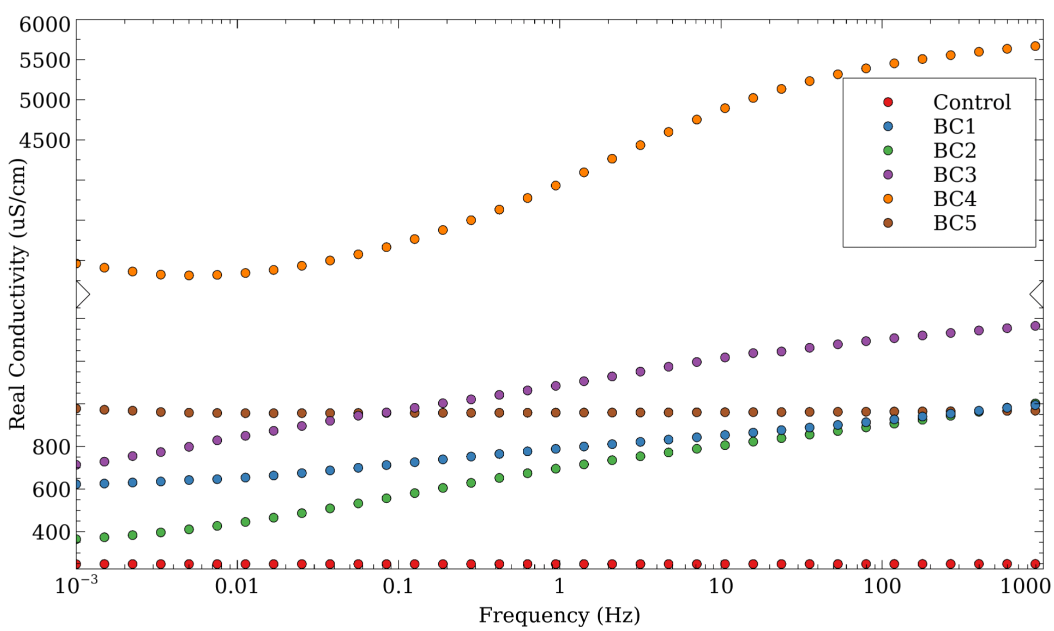

Figure 5. Real conductivity data for all biochar samples (BC1-BC5) and the control sand columns.

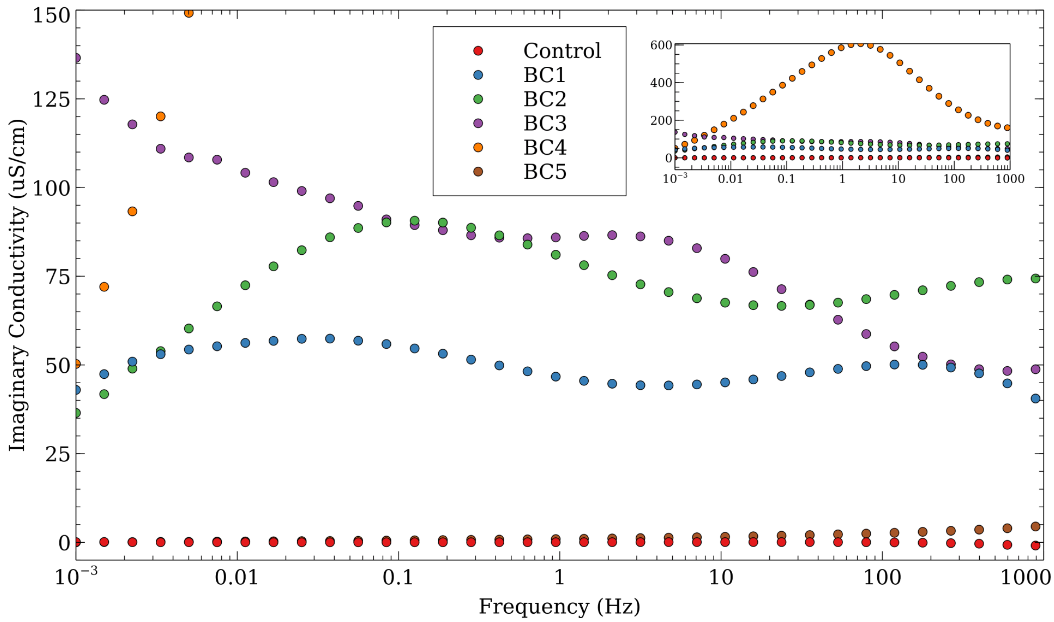

Figure 6. Imaginary conductivity data for all biochar samples (BC1-BC5) and the control sand columns.

The SIP data show some interesting characteristics.

- Phase data (Figure 4) show unique peaks for each biochar sample
  - BC1 - BC4 show high phase values (up to 200 mrad), with smooth peaks at different frequency ranges
  - BC3 high peak is not fully captured (out of frequency range used)
  - BC1 shows 2 smooth peaks
  - BC5 show no characteristic peak probably associated to the big size of the sample (>10mm)
- Real conductivity data (Figure 5) highlight the high conductivity of biochar in general
  - BC1-BC4 show strong frequency dependence
    - loosely follows carbon content of samples
  - BC5 conductivity is also elevated, but no frequency dependence
    - larger size and lowest carbon content
- Imaginary conductivity data (Figure 6) also show characteristic peaks
  - BC4 shows different behaviour
    - result of high real conductivity and real conductivity dependence (highest carbon content effect?)

MOTIVATION

The same properties, namely high surface area/activity and high carbon content, that make biochar an excellent soil amendment and contaminant treatment tool, render it a prime geophysical target[1].

The spectral induced polarization (SIP) is an established geophysical exploration method that is increasingly used in environmental management applications. Previous research confirmed that SIP is sensitive to the porous media interfacial properties along with the bulk electrical properties[2].

SIP monitoring can enable performance monitoring even at the field scale - all in real time and environmentally friendly. SIP is a rapid, cost effective and a non-invasive operation.

The objectives of this study are two-fold:

(a) develop quantitative links between SIP and the physical properties of biochar, and

(b) understand how the physicochemical properties of biochar influence the SIP response.

DISCUSSION - CONCLUSIONS

- All biochar samples show unique SIP characteristics
- All biochar samples have unique SIP signatures
  - easily distinguishable from the background (at least one SIP parameter)
  - different spectral shapes between different biochars
- SIP parameters associated to biochar characteristics
  - Real component - carbon content (?)
  - Phase - grain size / carbon content (?)
- Further research needed to identify and characterize links of SIP parameters to biochar properties

Next steps:

- SIP measurements on the same grain fraction of all biochars
- SIP measurements biochars with different carbon content
  - use 5%, 10%, 20% biochar B/W
- SIP measurements on biochars using same raw materials, but different pyrolysis conditions
- SIP measurements on biochars using different raw materials, but similar pyrolysis conditions

DISCLOSURES

We would like to thank Biorforcetech, Oregon Biochar Solutions, and other companies, for providing us with the biochar samples that made this research possible.

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ABSTRACT

Biochar is the carbon rich product of organic waste pyrolysis under oxygen-free conditions. Biochar properties are inherited from the raw materials used and can be enhanced with production methods. The versatility of the raw materials, along with the tweaks in production methods, enable biochars to have a widely varied range of properties, that make it suitable for a multitude of applications. This versatility, in turn, makes characterization, and performance monitoring challenging especially in large scale applications, typical of biochar use. Biochars have unique electrical properties that could be used to fill this gap. The complex electrical properties of biochar remain largely unstudied; this work explores them for different types and concentrations of biochar in porous media. Early measurements on the complex conductivity signatures of biochars, show promising results for both characterization and mass/volume estimation. Biochar surface properties appear have a profound effect on complex conductivity signals, suggesting the potential use of such methods as characterization and monitoring tools, even in large scale operations.

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