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Characterization, monitoring and imaging of biochar by geoelectrical measurements

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Biochar is a pyrolysis product or a by-product of fuel production from biological materials, mostly from energy plants, plant remains, or manure. Its addition to soil is discussed as a means of carbon sequestration and enhanced soil fertility, among several other beneficial effects. However, detrimental effects of biochar in soil are also discussed. The content of harmful substances, the influence of the material on microorganisms, and the modification of various soil properties may be critical. Although biochar has been intensively investigated in recent years, there is still a lack of knowledge due to the variability of soil and biochar properties, and the wide variety of experimental conditions used in these investigations. The properties of biochar strongly vary depending on the feed material and the production process. Therefore, it is of great interest to have methods which allow the characterization and long-term in-situ monitoring of biochar properties at different scales ranging from small laboratory columns to field sites. In this study, measurements on the complex electrical conductivity have been performed by spectral induced polarization (SIP). The method has been found to be a valuable tool for distinguishing different types of biochar and for monitoring the release of ions from biochar. SIP uses sinusoidal alternative current in the frequency range between 1 mHz and 45 kHz and provides information on the ohmic conductivity and on the electrical polarization of soil materials with added biochars. Whereas the release of ions leads to an increase of the ohmic conductivity, information on the chemical structure of biochars can be obtained from the polarization. Five types of biochar have been investigated in this study. The magnitude and the frequency dependence of the polarization can be used to distinguish the different types of biochar. Biochars with a larger degree of carbonization showed higher electronic conductivity and yielded higher polarization. The frequency dependence of the polarization further depended on the amount and the size of the biochar particles. The measurements also confirmed that the release of ions from biochar can be monitored using the ohmic conductivity. Whereas SIP is suitable for the characterization of biochar in the laboratory, electrical impedance tomography (EIT) can be used to obtain the spatial distribution of the complex electrical conductivity in laboratory columns and in the field. This method is an imaging technique based on the determination of SIP signals with a larger set of electrode positions. It opens up promising research avenues for in-situ monitoring of biochar in field soils.