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Thermal properties of soils: effect of biochar application

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Thermal properties (thermal conductivity, heat capacity and thermal diffusivity) have a significant effect on the soil surface energy partitioning and resulting in the temperature distribution. Thermal properties of soil depend on water content, bulk density and organic matter content. An important source of organic matter is biochar. Biochar as a material is defined as: “charcoal for application as a soil conditioner”. Biochar is generally associated with co-produced end products of pyrolysis. Many different materials are used as biomass feedstock for biochar, including wood, crop residues and manures.
Additional predictions were done for terra preta soil (also known as "Amazonian dark earth"), high in charcoal content, due to adding a mixture of charcoal, bone, and manure for thousands of years i.e. approximately 10-1,000 times longer than residence times of most soil organic matter. The effect of biochar obtained from the wood biomass and other organic amendments (peat, compost) on soil thermal properties is presented in this paper. The results were compared with wetland soils of different organic matter content. The measurements of the thermal properties at various water contents were performed after incubation, under laboratory conditions using KD2Pro, Decagon Devices. The measured data were compared with predictions made using Usowicz statistical-physical model (Usowicz et al., 2006) for biochar, mineral soil and soil with addition of biochar at various water contents and bulk densities. The model operates statistically by probability of occurrence of contacts between particular fractional compounds. It combines physical properties, specific to particular compounds, into one apparent conductance specific to the mixture.
The results revealed that addition of the biochar and other organic amendments into the soil caused considerable reduction of the thermal conductivity and diffusivity. The mineral soil showed the highest thermal conductivity and diffusivity that decreased in soil with addition of biochar and pure biochar. The reduction of both properties was mostly due to decrease in both particle density and bulk density. Both biochar and the organic amendments addition resulted in a decrease of the heat capacity of the mixtures in dry state and considerable increase in wet state.
The lowest and highest reduction in the thermal conductivity with decreasing water content was obtained for pure biochar and mineral soil, respectively. The thermal diffusivity had a characteristic maximum at higher bulk densities and lower water contents.
The wetland soil higher in organic matter content exhibit smaller temporal variation of the thermal properties compared to soils lower in organic matter content in response to changes of water content. The statistical-physical model was found to be useful for satisfactory predicting thermal properties of the soil with addition of biochar and organic amendments.

Usowicz B. et al., 2006. Thermal conductivity modelling of terrestrial soil media - A comparative study. Planetary and Space Science 54, 1086-1095.