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The Thesis Submitted for the Degree of PHD (in the field of Water Engineering)

Effect of biochar particles size and amount and water content on thermal properties of loam and sandy loam soils

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Abstract

Thermal properties are one of the important properties of soil, which affect many processes such as plant growth and development, decomposition of organic matter, development of soil-building processes, and material transfer. The thermal properties of soil include conductivity, diffusivity, thermal capacity and resistance depending on moisture content, bulk density, soil particle size and amount and size of organic matter particles. In the last decade, the use of biochar as an organic amendment has been noticed due to its effect on the physical properties and fertility of the soil and plant growth. However, research on the effect of biochar on soil thermal properties has not been completed yet. The aim of this study is to investigate the effect of particle size and amount of grape biochar and soil moisture on thermal properties of two soils with sandy loam and loam texture in Sistan plain. Experiments in experimental columns with four treatments including the amount of biochar (1 and 5%), the size of biochar particles (1-2, 0.1-15 and less than 0.15 mm), soil moisture (0.07, 2. 0 and 0.78) and soil texture (loam and sandy loam) were done in three replicates. Thermal properties of soil were measured using KD2 device and KD2 Pro Utility software in each sample in the laboratory and the average comparison of test factors was done at a significance level of 5% with the help of SPSS program. In this research, the mathematical models of Campbell, modified Campbell, Zhao and de-Vries were evaluated to estimate the conductivity, diffusivity and heat capacity of the soil. The results showed that biochar decreases the apparent density, true density and quartz percentage of the soil and increases the porosity, organic carbon, electrical conductivity, pH of the soil. These changes directly or indirectly cause changes in thermal properties. In this research, two positive and negative mechanisms for thermal properties were revealed: humidity increases thermal properties and biochar decreases thermal properties. The size of biochar particles also had a significant effect on soil thermal properties. Addition of 5% biochar with particle size >0.15, 1-0.15, 1-2 mm decreased the thermal conductivity of soil to 21, 26 and 32% respectively at Sw=0.07, which indicates less reduction of conductivity. Thermal in the use of biochar with smaller particles. The results of mathematical modeling showed that Campbell's model for predicting thermal conductivity with R^2=0.98 provided better results than Zhao et al.'s model with R^2=0.87. For predicting the heat capacity, de Vries mathematical model with R2=0.96 provided better results than Zhao et al.'s model with R2=0.94.

Keywords: soil thermal conductivity, heat capacity, regression models, Campbell model, bulk density