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Thermal properties of degraded lowland peat-moorsh soils

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Soil thermal properties, i.e.: specific heat capacity (c), thermal conductivity (K), volumetric heat capacity (C) govern the thermal environment and heat transport through the soil. Hence the precise knowledge and accurate predictions of these properties for peaty soils with high amount of organic matter are especially important for the proper forecasting of soil temperature and thus it may lead to a better assessment of the greenhouse gas emissions created by microbiological activity of the peatlands.

The objective of the study was to develop the predictive models of the selected thermal parameters of peat-moorsh soils in terms of their potential applicability for forecasting changes of soil temperature in degraded ecosystems of the Middle Biebrza River Valley area. Evaluation of the soil thermal properties was conducted for the parameters: specific heat capacity (c), volumetric heat capacities of the dry and saturated soil (Cdry, Csat) and thermal conductivities of the dry and saturated soil (Kdry, Ksat). The thermal parameters were measured using the dual-needle probe (KD2-Pro) on soil samples collected from seven peaty soils, representing total 24 horizons. The surface layers were characterized by different degrees of advancement of soil degradation dependent on intensiveness of the cultivation practises (peaty and humic moorsh). The underlying soil layers contain peat deposits of different botanical composition (peat-moss, sedge-reed, reed and alder) and varying degrees of decomposition of the organic matter, from H1 to H7 (von Post scale).

Based on the research results it has been shown that the specific heat capacity of the soils differs depending on the type of soil (type of moorsh and type of peat). The range of changes varied from 1276 $J \cdot kg^{-1} \cdot K^{-1}$ in the humic moorsh soil to 1944 $J \cdot kg^{-1} \cdot K^{-1}$ in the low decomposed sedge-moss peat. It has also been stated that in degraded peat soils with the increasing of the ash content in the soil the value of specific heat has decreased in a non-linear manner.

Thermal parameters of the dry mass of the studied soils (Kdry, Cdry) were characterised by the mean value of approximately 0.11 ± 0.028 $W \cdot m^{-1} \cdot K^{-1}$ and 0.781 ± 0.220 $MJ \cdot m^{-3} \cdot K^{-1}$. The application of the correlation analysis showed that the most significant predictor of these properties of soils is the soil bulk density which, respectively explains: 54.6% and 67.1% of their variation. The increase of the accuracy in determining Kdry and Cdry was obtained by developing regression models, which apart from the bulk density also include the chemical properties of the peat soils.

In the fully saturated soil the Ksat value ranged from 0.47 to 0.63 $W \cdot m^{-1} \cdot K^{-1}$, and the Csat varied from 3.200 to 3.995 $MJ \cdot m^{-3} \cdot K^{-1}$. The variation coefficients of these soil thermal features are at the level of approx. 5%. The obtained results allowed to conclude that the significant diversity of studied soils doesn't cause the significant differences in thermal soil parameters in fully saturated soils. The developed statistical relationships indicate that parameters Ksat and Csat were poorly correlated with saturated moisture content.