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Hydraulic Functions of Peat Across Types and Climate Zones

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Abstract

The hydro-physical properties of peat play a pivotal role in regulating the water, nutrient, and carbon cycles of peatland ecosystems. Despite their importance and complexity, our understanding of peat hydraulic properties remains limited. In this study, we compiled a comprehensive global database of the peat physical, hydraulic, and chemical properties, including bulk density (BD), porosity, macroporosity, saturated hydraulic conductivity (K_s), carbon content, and carbon density, encompassing tropical peatlands, northern fens, northern bogs, and permafrost regions. Our primary objective was to examine how these properties vary along a BD gradient across different climate zones. The results revealed a robust linear relationship between carbon density and BD for peat types with carbon content exceeding 35% (R^2> 0.92, p < 0.001), suggesting that these functions can serve as reliable tools for estimating the carbon stock of peatlands. However, the specific functions differed between peat types and climate zones. Total porosity was found to decrease linearly as BD increased, while macroporosity followed a power-law relationship with BD. These trends were consistent across all peat types, underscoring a strong and reliable association between BD and both total porosity and macroporosity. Additionally, K_s exhibited a general decline with increasing BD, with the relationship characterized by log-log functions that varied among peat types and climate zones. This indicates that K_s is significantly influenced by the peat-forming vegetation such as wood, *sphagnum*, sedge, and the prevailing climatic conditions of the peatland. This study demonstrated that the key peat hydro-physical-chemical parameters—including carbon density, porosity, macroporosity, and K_s can be reliably estimated using the BD, with relatively high coefficients of determination (R^{2}>0.4), highlighting the critical importance of determining BD as a proxy for estimating other hydro-physical properties of peat when direct measurements are unavailable.

Keywords: peat; physical and hydraulic properties; bulk density; carbon density; saturated hydraulic conductivity, permafrost peatlands

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