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The temperature and moisture regime of charcoal-enriched land use legacy soils

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The stratigraphy and properties of soils can be significantly altered by past land use, even in areas that have been continuously used for forestry. Soils on relict charcoal hearths (RCHs) are a widespread example of such a pedological legacy of past forest use. RCH soils occur in many forest areas and receive increasing attention as model sites to study long-term effects of soil amendment with biochars, however, their physical properties have hardly been studied. The objective of our study was to characterize the soil temperature and moisture regime of RCH soils through comparison to reference forest soils on sandy substrates in woodlands in Brandenburg, Germany. We combined laboratory analyses of bulk density, pore size distribution, thermal conductivity and saturated hydraulic conductivity with sensor-based monitoring of soil temperature, moisture contents and matric potentials.

The results of laboratory analysis reveal high soil organic matter (SOM) contents, a low bulk density and high porosity of the RCH substrates. Associated with this RCH specific soil structure, RCHs exhibit clearly lower thermal conductivity. However, the higher total porosity of RCH substrates does not necessarily imply higher water retention and plant-available water contents in the RCH soils than in the topsoil horizons of undisturbed forest soils. The monitoring results reveal distinct differences between the temperature regimes of the RCH and reference profiles, with the RCH soil exhibiting higher daily and seasonal temperature variations within the topmost horizon, but lower variations in deeper parts of the profiles. Soil moisture monitoring shows higher water contents in RCH soils under relatively wet conditions and lower water contents under dry conditions, and increased spatial variation in soil moisture in RCH soils. Overall, the results show increased spatial and temporal variability of soil temperature and moisture on RCHs, which implies an increased variability in ecological site conditions in historic charcoal production areas.