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Carbon storage capacity of semi-arid grassland soils and sequestration potentials in Northern China

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Organic carbon (OC) sequestration in degraded semi-arid environments by improved soil management is assumed to contribute substantially to climate change mitigation. However, information about the potential saturation of soil organic carbon (SOC) and derived sequestration potentials in steppe soils is missing. In this study, we estimated the OC storage capacity of semi-arid grassland soils on the basis of remote, natural steppe locations in Inner Mongolia, Northern China. Based on the maximum OC saturation of the fine mineral fraction (silt and clay particles <20 μm) of natural grassland soils, OC sequestration potentials of degraded steppe soils (grazing land, arable land, eroded areas) were estimated. The analysis of natural grassland soils revealed a strong linear regression between the proportion of the fine fraction and its OC content, confirming the importance of silt and clay particles for OC stabilization in steppe soils. This relationship was similar to derived regressions in temperate and tropical soils but on a lower level, probably due to a lower C input and different clay mineralogy. In relation to the derived OC storage capacity, degraded steppe soils showed a high OC saturation of 84 to 89% despite massive SOC losses. As a result, the OC sequestration potential of degraded grassland soils was generally low. This can be related to a relatively high contribution of labile SOC, which is preferentially lost in the course of soil degradation. Moreover, wind erosion leads to substantial loss of silt and clay particles and thus to a direct loss of the ability to stabilize additional OC amounts. Our findings indicate that the SOC loss in semi-arid environments induced by intensive land use is largely irreversible. Observed SOC increases after improved land management mainly result in an accumulation of labile SOC prone to land use/climate changes and can thus not be regarded as contribution to long-term OC sequestration.