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Pasture degradation modifies soil organic matter properties, biochemical functionality and microbial community composition of degraded Tibetan grasslands

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The Tibetan Plateau hosts the highest and largest pasture ecosystem worldwide, and stores 2.5% of the global soil organic carbon (SOC) stock. Kobresia pygmaea grasslands form the basis for local pasture economy, prevent soils from erosion, and retain large amounts of water for SE Asia. Intensive grassland degradation in recent decades destroyed mainly the upper root-mat/soil horizon of the alpine Kobresia pastures with dramatic consequences for soil organic carbon (SOC) storage, nutrient cycling and water balance of the affected regions.
To elucidate specific degradation processes, their interaction with SOC pools and on microbial communities and functions, we selected a degradation sequence in the core area of the Kobresia ecosystem that included six degradation stages (S0-S5). We showed that the intensified cracking of the topsoil caused a dying of the above- and belowground plant compartments and initiated soil erosion, as well as a subsequent loss of finer particle sizes with intensified degradation stages. Furthermore, root mat degradation and altered soil properties induced a shift in microbial community structure, with most pronounced changes in S4 and S5, and going along with altered microbial functions. SOC degrading enzymes shifted from easy to complex degradable substrates (e.g. fungal phenol oxidases) with degradation. Lower δ13C values of SOC with increasing degradation stage confirmed this intensified decomposition by the relative enrichment of more complex and 13C depleted organic substances (i.e. lignin and suberin). SOC stocks strongly decreased along the degradation sequence from undisturbed (S0) to the highly disturbed sites (S5). The total SOC loss for the strongest degraded stage (S5) was 70%. SOC loss in the upper root-mat horizons was mainly caused by erosion, while in the underlying root-mat horizons decreasing SOC concentration were basically attributed to SOM decomposition and decreasing C-input from plants. We conclude that pasture degradation decreases not only the mechanical protection of soil surface by Kobresia root mats, but also changes their biochemical and microbial functions. Consequently, a complex interaction of abiotic and biotic process underlies the largely irreversible degradation of Kobresia ecosystems on the Tibetan Plateau.