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Pasture management controls soil organic matter stocks, properties, and biochemical functioning in Tibetan grasslands

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The Tibetan Plateau hosts the highest and largest pasture ecosystem worldwide, and provides tremendous sinks for carbon. Due to the sheer size of the of the Tibetan Plateau, feedback effects of soil organic carbon (OC) losses from inadequate grassland management are of undisputed relevance for ecosystem stability and future global change scenarios.
Given the vital importance of the Tibetan steppes as global OC sinks, we combined data on OC stocks from own studies with an extensive literature review on soils developed under montane and alpine Kobresia pygmaea and Stipa grandis pastures. We calculated soil OC stocks at the Tibetan Plateau within the first 30 cm of the soil profile depending on pasture management and climate. Vertical gradients of δ13C values, neutral sugar, cutin and suberin contents, lignin phenol contents as well as microbial community composition (t-RFLP analysis, 16S rDNA und IST sequencing) and activities of six extracellular enzymes involved in the C, N, and P cycle were assessed. The depth gradients of these parameters reflected degradation processes from intact Kobresia pastures (stage 0) to pronounced degradation (bare soil; stage 5).
Moderate husbandry is beneficial for the storage of OC, nitrogen (N) and other nutrients (e.g. phosphorus) for the majority of the montane grasslands of the Tibetan Plateau (i.e. Kobresia pygmaea pastures). However, Kobresia root mats originated from grazing are affected by desiccations and frost, which cause polygonal cracking and initiates soil erosion. This process is accelerated under high grazing pressure (overgrazing) that enhances root mat degradation. Increasing degradation caused by large herbivore densities resulted in an increased OC decomposition demonstrated by decreasing δ13C values. The δ13C shift towards more negative values reflects the relative enrichment of 13C depleted lignin components during OC decomposition in the strongly disturbed soil. Translocation of topsoil material into the subsoil with advancing degradation (from stages 1 to 5) was indicated by increasing contributions of cutin to OC in the subsoils. Microbial community composition in the subsoil changed progressively from stage 1 to 5 with most pronounced changes of the fungal community. These findings were confirmed by the enzyme activities involved in the degradation of more complex OC compounds (e.g. fungal phenoloxidases) that were highest in the subsoil of degradation stage 4. In contrast, degradation stages 2 and 3 showed low enzyme activities in the subsoil if related to soil OC amount. 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. Moderate grazing improves the pastures, increases OC sequestration and may stop the degradation of soils on Tibetan plateau.