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Pasture degradation modifies soil organic matter properties and biochemical functioning in Tibetan grasslands

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Kobresia pastures of the Tibetan Plateau represent the world's largest alpine ecosystem. Moderate husbandry on Kobresia pastures is beneficial for the storage of soil organic carbon (OC), nitrogen (N) and other nutrients and prevents erosion by establishment of sedge-turf root mats with high OC allocation rates below ground. However, undisturbed root mats are affected by freezing and thawing processes, which cause initial ice cracks. As a consequence decomposition of root mat layers will be accelerated and current sedentarization programs with concomitant increased grazing intensity may additionally enhance root mat degradation. Finally, cracks are enlarged by water and wind erosion as well as pika activities until bare soil surface areas without root mat horizons occur. The aim of this study was to understand the impact of the root mat layer on soil organic carbon stabilization and microbial functioning depending on soil depths and to predict future changes (OC, N and nutrient losses, soil microbial functioning in SOM transformation) by overgrazing and climate change.

We investigated the mineral soil below Kobresia root mats along a false time degradation sequence ranging from stage 1 (intact root mat) to stage 4 (mats with large cracks and bare soil patches). Vertical gradients of δ13C values, neutral sugar, cutin and suberin contents as well as microbial biomass estimated by total phospholipid fatty acid (PLFA), microbial community composition (PLFA profiles) and activities of six extracellular enzymes involved in the C, N, and P cycle were assessed.

Soil OC and N contents as well as C/N ratios indicate an increasing illuviation of topsoil material into the subsoil with advancing root mat degradation. This was confirmed by more negative δ13C values as well as significantly ($p \leq 0.05$) increasing contributions of cutin derived hydroxy fatty acids to OC in the subsoils from degradation stages 1 to 4. PLFA profiles were surprisingly similar in the subsoils of degradation stages 1, 2 and 3 although OC contents and composition in the subsoil changed progressively from stage 1 to 4. Only the PLFA profiles of stage 4 differed from those of the other subsoils, suggesting that microbial communities were mainly controlled by other factors than C and N contents and SOM composition. These findings were also confirmed by the activities of β-glucosidase, xylanase, amino-peptidases and proteases. Those enzyme activities were highest in the subsoil of degradation stage 4, whereas degradation stages 2 and 3 showed low enzyme activities in the subsoil if related to soil OC amount and composition. We conclude that pasture degradation decreases not only mechanical protection of soil surface by Kobresia root mats, but also changes their biochemical and microbial functions.