

Degradation of Tibetan grasslands: Consequences for soil organic carbon and nutrients losses

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The Kobresia pastures, commonly known as “alpine meadow”, cover the southeastern quarter of the Tibetan Highlands (~450, 000 km²). They host important grazing ground for livestock (i.e. yaks, sheep and goats) and thus ensure the livelihood of the Tibetan herders. The Kobresia pastures also store huge amount of soil organic carbon (SOC) and nutrients (e.g. nitrogen (N) and phosphorus (P)), which are required for sufficient forage production. In recent decades, the Kobresia pastures have experienced severe degradation due to anthropogenic activities and climate change, which has initiated high losses of SOC and nutrients and threatened the functioning of this ecosystem. Plenty studies have been implemented showing the response of degradation on SOC and nutrients levels on local scale. They classify these alpine pastures into various degradation stages that are mainly based on vegetation characteristics (e.g. vegetation coverage, proportion of edible plants). Within this study we synthesized their results in a review for a better understanding of SOC and nutrients losses following pasture degradation across the whole ecosystem. We aggregated the degraded Kobresia pastures into five degradation stages: Non-degraded, Light degradation, Moderate degradation, Heavy degradation and Extreme degradation. Results show that degradation from light to extreme stages has lost on average 42 ± 2 % SOC, 33 ± 6 % N and 17 ± 4 % P as compared to the non-degraded pastures. This implies strong reduction of soil fertility and an exacerbation prevailing N and P limitations. Concurrently, degradation has decreased aboveground and belowground biomass by $\sim 42 \pm 3$ % and $\sim 45 \pm 6$ %, which reflects (a) decreasing photosynthetic C input and (b) less available forage for livestock. Besides, the declining vegetation promotes wind and water erosion. In conclusion, our results provide an overview and a quantification of degradation impacts on plant characteristics and soil properties that improve estimations regarding SOC and nutrients losses across the whole ecosystem. This highly matters because large amounts of SOC have been lost due to erosion and mineralization. Most likely this has polluted the Tibetan headwaters and contributed to climate change, respectively. Further, the decreasing N and P losses have reduced soil fertility lowering forage production. Therefore, it endangers the livelihood of the Tibetan herders, which highly rely on forage to feed their livestock. Despite plenty of ameliorations (e.g. fertilization, grazing enclosure, reseeding) have been proposed and implemented at many locations, their impacts on pasture ecosystems (especially on soil fertility) are still subtle and thus require further investigations.

Keywords: Kobresia pastures, Tibetan Plateau, Grassland degradation, Soil organic carbon, Soil nutrients