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Human induced impacts on soil organic carbon in southwest Iceland

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The Icelandic environment has been strongly influenced by natural processes during the Holocene. Since settlement in AD 874, the introduction of grazing animals and other land use has drastically affected the natural environment. This includes the diminishing of vegetative cover, which has led to soil exposure and accelerated erosion over large areas, especially when in conjunction with harsh climate. This has specifically impacted processes and properties of volcanic soils (Andosols), which are subject to accelerated erosion by wind and water. While approximately 46% of the land surface in Iceland has sustained continuous vegetation cover, large areas have lost some or all of their soil cover formed during the postglacial era. Elsewhere, remaining soils have sparse or no vegetation cover, thus impairing soil carbon (C) sequestration. Among their multifunctional roles, soils support plant growth, increase soil biotic activity, enhance nutrient storage and strengthen the cycling of water and nutrients. In contrast, soil degradation by accelerated erosion and other processes impairs soil quality, reduces soil structure and depletes the soil organic matter (SOM) pool. Depletion of the SOM pool has also global implications because the terrestrial C pool is the third largest pool and strongly impacts the global C cycle.

Erosional–depositional processes may deplete soil organic C (SOC) by erosion and increase by deposition. Some SOC-enriched sediments are redistributed over the landscape, while others are deposited in depression sites and transported into aquatic ecosystems. SOC decomposition processes are severely constrained in some environmental settings and any SOC buried under anaerobic conditions is protected against decomposition. Yet, the impact of the SOC transported by erosional processes and redistributed over the landscape is not fully understood because the variability in its turnover characteristics has not been widely studied. Thus, the fate of C transported by erosional processes remains a debatable issue.

The study presents the effect of soil erosion on vegetation, soil accumulation (SA), SA rate (SAR), soil quality, soil mass, and the soil organic carbon (SOC) pool in Brown Andosols and Histosols in a 24 km2 area in southwest Iceland. Undisturbed prehistoric soils were distinguished from disturbed historic soils using tephrochronology. Soil erosion has been severe during historic time (last 1135 yr), resulting in the increase of the soil mass deposited in soils covered by vegetation by a factor of 7.3–9.2 and net loss of soil in un-vegetated areas. The SAR correlated positively with SOC sequestration. SOC is easily transported and, given the extensive accumulation of soil, the net effect of burial and subsequent reduction in decomposition is to increase SOC storage. Nevertheless, the increased accumulation and soil depletion has decreased soil quality, including the SOC, and reduced soil resistance to erosion with the depleted SOC contributing to enrichment of atmospheric CO_2. The initial terrestrial disturbance was triggered by anthropogenic land use during the Medieval Warm Period, followed by volcanic activity approximately three centuries later. The combination of harsh climate during the Little Ice Age and drastic anthropogenic perturbations has led to land degradation at a catastrophic scale.