8. Conservation of soil organic matter through cryoturbation in arctic soils in Siberia

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Abstract

Cryoturbation plays a major role in the distribution of soil organic carbon in Arctic regions. Mixing of soil organic matter (SOM) into lower soil layers through cryoturbation can conserve C by withdrawing it from the regular C cycle, thereby delaying C return to the atmosphere. Thus, understanding the fate of cryoturbated organic C becomes increasingly important in evaluating the arctic C cycle within a changing climate.

The purpose of our studies was to detect the effect of cryoturbation and organic matter burial on microbial decomposition processes and to assess whether cryoturbation is able to effectively inhibit decomposition and preserve C pools in the soil.

Our study site was located at the Gydansky-Peninsula in Siberia (N 69° 43.0‘, E 74° 38.8‘; 74 m a.s.l.), in the typical tundra subzone. The soil was Epigleyi-Turbic Cryosol with an average active layer thickness of 60 cm. The site showed signs of strong cryoturbation, with highly contorted soil horizons and frequent organic intrusions within the soil profile. Most of the buried SOM was located between 30 and 60 cm depth and had a colour and structure similar to the thin A horizon (5 cm), but a much higher organic C content than the surrounding B horizon.

The amount of C stored in the whole active layer averaged 13.5 (±0.5) kg m^{-2}. O and A horizons only held a small part of the C (0.78 kg and 1.5 kg m^{-2}, respectively) whereas the buried layer accounted for more than one third of the total C stock (4.7 (±0.5) kg m^{-2}), more than double the amount of C in O and A horizons together. The C and N content of the buried horizon was relatively high (15.2% C; 0.35% N) and similar to the C and N content of the A horizon. The C/N ratios of A horizon and buried layer were also very similar, suggesting that the A horizons and the buried horizons may be roughly at the same stage of SOM decomposition. However, radiocarbon measurements indicated that C in humic acids of the buried horizon is on average three times older than in the A horizon. Our estimate of the minimum time period after subduction showed that the mixing of the humic layers into the deep soil must have occurred some 800 – 1400 years ago. In combination with the high amount of soil organic matter held by the buried layer this strongly suggests, that decomposition was substantially delayed by burying. The observed microbial properties supported this result: the buried layer showed significantly lower microbial biomass, N mineralization and microbial respiration rates compared to the chemically similar A horizon. The decrease of decomposition processes was most likely caused by changing abiotic conditions as a result of the subduction of the top soil layers, the most important of which may be temperature and soil moisture.

Increasing temperatures due to global warming is expected to increase cryoturbation. This could either lead to increased decomposition of buried layer, when buried layers are transported upwards in the soil profile, or to conservation of SOM, when modern A horizons are exposed to subduction processes.