

7. The contribution of black carbon to the carbon storage in a permafrost ecosystem

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Abstract

In boreal forests, fire is a frequent disturbance and converts soil organic carbon to black carbon. On the one hand, this may act as a long-term carbon sink, because black carbon is believed to belong to the refractory carbon pool. On the other hand, fire disturbance may lead to permafrost degradation and thus to carbon losses. Here, we studied the total carbon and the black carbon storage in a small catchment characterized by a varying permafrost pattern in order to assess controlling factors of carbon storage in such ecosystems. The catchment Grawijka Creek was located in the forest tundra ecotone at the lower Yenissej north of Igarka, Siberia. It contains various landscape units with southern exposed permafrost-free mineral soils, north faced permafrost mineral soils, and permafrost-affected raised bogs in plateau positions showing in part thermokarst erosion. There were indications of forest fires at all landscape units.

Total carbon storage in soil down to a depth of 90 cm ranged between 5 and 95 kg m⁻² and declined in the order intact raised bogs > northern exposed soils ≥ thermokarst degraded bogs > south faced soils. Black carbon is ubiquitous in the soils of the catchment and contributed to about 1 - 12 % of soil organic carbon as identified by the BPCA method. This calculates a black carbon storage from about 0.1 kg m⁻² to 10 kg m⁻², which is much more than in permafrost free taiga ecosystems further south. The relative contribution of black carbon to soil organic carbon as well as the absolute stock of black carbon is highest in the intact bogs with shallow active layer followed by mineral soils of the northern aspects having also a high permafrost table. A large proportion of black carbon is stored within the permafrost. In contrast, soils with deep active layer or lacking permafrost had only little black carbon. Significant concentrations of black carbon in the creek draining the catchment indicates that black carbon decomposition to smaller and more polar units takes place and that black carbon is exported in part from soils to the hydrosphere.

From these results it can be concluded that forest fire does not necessarily lead to permafrost degradation and that black carbon is an important constituent in the organic carbon storage of the catchment's soils. Black carbon is in particular preserved in permafrost-affected soils. However, it appears not to be stable in soils lacking permafrost or having a deep active layer. Black carbon thus cannot be considered as a refractory carbon pool in the investigated forest tundra ecotone. Thawing of permafrost may lead to the mobilization also of this carbon pool.