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Storage and turnover of organic matter fractions along a Siberian Arctic soil transect

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Recent observation and climate models demonstrate that arctic ecosystems are already affected by climate warming, as revealed by continuous permafrost degradation and increase of active layer depths. Variations of organic matter (OM) storage in different soil horizons and the OM quality are likely the major drivers of trace gas emissions to the atmosphere. A better understanding of the biogeochemical cycling of OM in permafrost environments is the key to predict future climate changes and the role of terrestrial arctic regions. This study investigates the storage and turnover patterns of OM in functionally different pools, i.e., in particulate plant debris, extractable-water-soluble OM, and mineral-associated OM in permafrost soils along a West-East Siberian transect in the Russian Arctic. We quantified the stocks of total soil organic C (OC) and the respective OM fractions for the first soil meter. Furthermore, we estimated their apparent ^{14}C ages by accelerator mass spectrometry, and determined the mineralization rates and bioavailability of particulate, mineral-bound, and bulk OM in a 90-day incubation experiment. Particulate OM was separated from the mineral-associated OM fraction by density fractionation with sodium polytungstate (density cut-off 1.6 g cm^{-3}) and the OM liberated by this treatment was quantified. Considerable differences in OM storage existed from the West- to the East Siberian Arctic. Cryosols of the Central- and East Siberian sampling sites stored on average 56% more OC than those in West Siberia (25 $\pm$ 7 kg m^{-2}versus 11 $\pm$ 4 kg m^{-2} to 1 m soil depth). However, the proportion of the three OM fractions to total OM was similar among the sites. In mineral soil horizons, on average, 17 $\pm$ 5% of the total OM was particulate OM, 61 $\pm$ 10% was associated with minerals, and 21 $\pm$ 3% could be mobilized in dissolved forms during density fractionation. Except for West Siberian soils, $\sim$30% of the OM of the first soil meter was stored in permafrost while another 13-30% was located in cryoturbated horizons. In contrast to temperate soils, where particulate OM turns over much faster than the mineral-associated OM, the differences in apparent ^{14}C ages of the fractions in comparable soil horizons from our study sites were minor. Moreover, the incubation experiment showed only slight differences in total mineralization rates among the fractions and the bulk soil. In the cryoturbated horizons the total respiration rates of the mineral-associated OM fraction exceeded even those of particulate OM. Therefore, we hypothesize that in arctic environments, stabilization of OM by mineral surfaces or metal ions is of minor relevance compared to temperate soils. External constraints such as high moisture, low soil temperature, and the annual or perennial frozen stage are probably more important in controlling the persistence of OM in permafrost-affected soils.