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How do microorganisms from permafrost soils respond to short-term warming?

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Arctic ecosystems outpace the global rate of temperature increases and are exceptionally susceptible to global warming. Concerns are raising that CO₂ and CH₄ released from thawing permafrost upon warming may induce a positive feedback to climate change. This is based on the assumption, that microbial activity increases with warming and does not acclimate over time. However, we lack a mechanistic understanding of carbon and nutrient fluxes including their spatial control in the very heterogeneous Arctic landscape. The objective of this study therefore was to elucidate the microbial controls over soil organic matter decomposition in different horizons of the active layer and upper permafrost. We investigated different landscape units (high-centre polygons, low-centre polygons and flat polygon tundra) in two small catchments that differ in glacial history, at the Yukon coast, Northwestern Canada.

In total, 81 soil samples were subjected to short-term (eight weeks) incubation experiments at controlled temperature (4 °C and 14 °C) and moisture conditions. Heterotrophic respiration was assessed weekly, whereas physiological parameters of soil microbes and their temperature response (Q_{10}) were determined at the end of the incubation period. Microbial growth was estimated by measuring the incorporation of ¹⁸O from labelled water into DNA and used to calculate microbial carbon use efficiencies (CUE). Microbial biomass was determined via chloroform fumigation extraction. Potential activities of extracellular enzymes involved in C, N, P and S cycling were measured using microplate fluorimetric assays.

Cumulative heterotrophic respiration of investigated soil layers followed the pattern organic layers > upper frozen permafrost > cryoturbated material > mineral layers in both catchments. Microbial respiration responded strongly in all soils to warming in all soils, but the observed response was highest for organic layers and cryoturbated material at the beginning and end of the experiment. Average Q_{10} values at the beginning of the experiment varied between 1.7 to 4.3 with differences between horizons but converged towards Q_{10} values between 2.0_{min} to 2.9_{max} after eight weeks of

incubation. Even though microbial biomass C did not change with warming, microbial mass specific growth was enhanced in organic, cryoturbated and permafrost soils. Overall, warming resulted in a 65% reduced CUE in organic horizons.

Our results show no indication for physiological acclimatization of permafrost soil microbes when subjected to 8-weeks of experimental warming. Given that the duration of the season in which most horizons are unfrozen is rarely longer than 2 months, our results do not support an acclimation of microbial activity under natural conditions. Instead, our data supports the current view of a high potential for prolonged carbon losses from tundra soils with warming by enhanced microbial activity.

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