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## A review of the importance of mineral nitrogen cycling in the plant-soil-microbe system of permafrost-affected soils – changing the paradigm

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The paradigm that permafrost-affected soils show restricted mineral nitrogen (N) cycling in favor of organic N compounds is based on the observation that net N mineralization rates in these cold climates are negligible. However, we find here that this perception is wrong. By synthesizing published data on N cycling in the plant-soil-microbe system of permafrost ecosystems we show that gross ammonification and nitrification rates in active layers were of similar magnitude and showed a similar dependence on soil organic carbon (C) and total N concentrations as observed in temperate and tropical systems. Moreover, high protein depolymerization rates and only marginal effects of C:N stoichiometry on gross N turnover provided little evidence for N limitation. Instead, the rather short period when soils are not frozen is the single main factor limiting N turnover. High gross rates of mineral N cycling are thus facilitated by released protection of organic matter in active layers with nitrification gaining particular importance in N-rich soils, such as organic soils without vegetation. Our finding that permafrost-affected soils show vigorous N cycling activity is confirmed by the rich functional microbial community which can be found both in active and permafrost layers. The high rates of N cycling and soil N availability are supported by biological N fixation, while atmospheric N deposition in the Arctic still is marginal except for fire-affected areas. In line with high soil mineral N production, recent plant physiological research indicates a higher importance of mineral plant N nutrition than previously thought.

Our synthesis shows that mineral N production and turnover rates in active layers of permafrost-affected soils do not generally differ from those observed in temperate or tropical soils. We therefore suggest to adjust the permafrost N cycle paradigm, assigning a generally important role to mineral N cycling. This new paradigm suggests larger permafrost N climate feedbacks than assumed previously.