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Irreversible changes in Phosphorus cycling driven by permafrost thaw in subarctic palsa mires

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Phosphorus (P) is an essential element for life and limits productivity in many terrestrial and aquatic ecosystems. Histosols contain a large amount of P because of their high content of organic matter and effective adsorption processes. Climate warming promotes the degradation of permafrost and increases decomposition leading to unprecedented geochemical changes in Carbon (C) and Nitrogen (N) cycles. To assess the effect of permafrost thaw on P cycling, we determined available P, Hedley P fractions and phosphatase activity across a thawing gradient in a palsa mire complex at Stordalen (Abisko, 68ºN, Sweden). We analysed three site types in a space-for-time approach (palsa, transition zone and collapsed palsa) at four different depths (5-10, 40-45, 70-75 and 95-100 cm). Available or relatively labile P were higher in surface samples compared to deep peat in the palsa and collapsed sites. The main P fraction of these samples was organic P and P bound to Iron (Fe) and Aluminum (Al) (NaOH-Porg), which made up between 40 and 70% of total P. The collapsed palsa sites had a lower proportion of P in these fractions and higher organic and inorganic available P, as well as phosphatase activity -specially in surface samples- suggesting that increased temperature, microbial activity and redox changes contribute to transforming Fe-Al bound P into other forms. Total P (TP) in deep layers (>50 cm) is dramatically reduced (between 15 and 30%) after permafrost thaw. In contrast, in surface samples (5-10 cm) TP increased by 60% suggesting an important change in the depth profile of this nutrient related to permafrost disappearance. The described changes indicate a major increase in P availability for plant and microbes after permafrost thaw, and a lower storage capacity for P in deep peat layers. P mobilization in subarctic peatlands after permafrost thaw may thus result in lower surface N/P ratios, and changes in ecosystem productivity and C fixing capacity. Permafrost thaw and associated changes in hydrology and underground circulation in areas with discontinuous permafrost may play an important role in the release of P and its interaction with C, N, Al and Fe cycles.