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Rapid transformation of peptide-like organic nitrogen upon permafrost thaw

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Significant organic nitrogen stocks have accumulated in permafrost peatlands over millennia. Climate change is expected to increase peatland thaw, making this organic nitrogen more susceptible to biogeochemical degradation. However, the fate of this accumulated nitrogen after thaw remains poorly understood and could contribute to potent greenhouse gas (N_2O) formation. To elucidate organic nitrogen transformations across a thaw transition (palsa to thaw front to bog), we employed 21 tesla electrospray ionization Fourier transform ion cyclotron resonance mass spectrometry, nuclear magnetic resonance spectroscopy, and metatranscriptomic sequencing to analyze dissolved organic nitrogen (DON) composition, dissolved organic matter (DOM) molecular structure, and metatranscriptomic gene expression. We observed a roughly tenfold increase in DON concentration and a significant increase in ammonium concentration between the palsa and thaw front, accompanied by preferential degradation of peptide-like DON molecules. DON concentrations decreased sharply (73%) between the thaw front and bog, while expression of ammonium-producing genes was significantly higher in the bog compared to the palsa. Our findings highlight the release and rapid biotransformation of nitrogen across a thaw transition, emphasizing the need for improved characterization of nitrogen fate and comprehensive models incorporating nitrogen cycling for more accurate predictions of future Arctic greenhouse gas emissions.