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Elevated Nitrogen Deposition Resulted in Enhanced Peat Decomposition Across Europe During the 20th Century

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Peatlands cover large areas of the Earth and represent one of the largest terrestrial carbon (C) storages. Although different studies investigated peat chemical properties in dependency of climatic factors and nitrogen (N) deposition, experiments were mostly restricted to small spatial scales or short time periods and did not study in detail peak bulk chemical properties. Therefore, this study addresses the impact of climate and N deposition on peat chemical properties across Europe during the 20th century.

We assessed peat chemical properties, using FTIR spectroscopic data of bulk peat, in 24 peatlands across Europe on a longitudinal gradient from Ireland to Finland and a latitudinal gradient from northern Sweden to Slovenia. We sampled peat at a resolution of 5 cm until a depth of 50 cm. We linked FTIR data to estimated peat ages and modelled time series data for annual temperature, precipitation and N deposition. We computed average random intercept regression models for FTIR bands representative for polysaccharides, aromatics and hydrogen bonds in polyphenols in order to relate peat chemical properties to the selected environmental factors including N deposition.

The models indicate that polysaccharides in peat decrease with increasing age, annual N deposition, temperature and precipitation. For hydrogen bonds in polyphenols and aromatics, the climate related patterns were weaker. Amplitudes of aromatics increased with increasing peat age and annual N deposition whereas amplitudes for hydrogen bonds in polyphenols decreased along the same gradient. We found a significant and strong interaction between annual N deposition during peat formation and peat age for all studied chemical groups leading on average to a two-fold higher decrease in amplitudes for polysaccharides and polyphenols and increase in amplitudes of aromatics for the most extreme N deposition level ($\sim$13 kg ha^{1} a^{1}) over a time range of 75 years in comparison to the lowest N deposition level ($\sim$1 kg ha^{1} a^{1}). Extrapolation indicates that this effect may be higher in the future. We did not find differences in peat chemistry due to N deposition for peat layers younger than approximately 30 years. Overall the results indicate that N deposition increases peat recalcitrance, but only in older peat layers.

Elevated N deposition most probably accelerates peat decomposition and leads to residual enrichment of recalcitrant material. This process probably already well affected peat chemistry across Europe during the 20th century at times of partly high N deposition. Our results are in accordance with other studies suggesting higher decomposition rates under elevated N deposition. Other authors found accelerated peat accumulation under elevated N deposition based on similar temporal and spatial scales. Hence, it remains unclear if and under which conditions N deposition leads to a C loss from peatlands or facilitates peat accumulation. More data may enhance the predictive possibilities of the developed model. Our models coupled to FTIR data provide a unique possibility to link results from different experiments. Therefore, we aim at collecting more data from other researchers willing to contribute to the model or couple the data to other experiments.