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An Assessment of Palaeoecological and Geochemical Indicators for the Re-establishment of Peat Formation in Ombrotrophic Bogs

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The restoration of peatlands is becoming an increasingly important topic for both policymakers and the scientific community. However, knowledge on the past succession of ombrotrophic bogs, the extent of disturbance, and their response to current human impacts and restoration efforts remains limited. An adequate understanding of what factors promote peat formation, as well as the environmental conditions that preserve peat quality, is essential for the establishment of effective and predictable restoration trajectories. To identify and evaluate biogeochemical conditions that promote carbon (C) accumulation, as well as those that maintain low C decomposition rates, peat cores were taken from two rewetted (KR1 and DM1) peatlands and one degraded (AV1) peatland. Each core was dated using radiocarbon and analysed in high resolution for (1) its geochemistry to infer about peat quality, (2) testate amoeba to reconstruct past water table levels, and (3) its C accumulation rates.

Apparent C accumulation rates were high in the young, upper layers for cores DM1 and KR1 (ranging up to 400 and 600 g C m^{-2} y^{-1}, respectively) relative to the lower pre-restoration layers, indicating a successful re-establishment of peat formation. At the degraded site AV1, apparent C accumulation rates were significantly lower (max. 40 g C m^{-2} y^{-1}), and current conditions indicate overall C losses, since restoration efforts have yet to be made here. The identified periods of strong C accumulation go hand in hand with low C/N ratios, indicative of a low degree of peat decomposition. This was confirmed by an FT-MIR spectroscopy derived humification index (HI). The HI and C/N ratio showed a roughly opposite pattern, as expected for little decomposed peat being relatively high in polysaccharides. Surprisingly, there was no significant correlation between a testate amoebae reconstructed water table depth (WTD) and C/N ratios for AV1 and KR1. In DM1, a positive relationship between WTD and C accumulation rates was observed, whereas an inverse relationship would be expected. Still, reconstructed WTD coincided mostly well with vegetation

succession. These findings suggest the importance of multiple parameters to assess re-establishment of peat formation by novel vegetation and the degree of historical degradation. Moreover, redox sensitive species, such as iron, sulphur and phosphorus, apparently served as suitable indicators for the current average water table depth. Second, they indicate at what depth the redox conditions in the peat are reducing, and thus where decomposition rates can drop significantly.

In summary, this study discusses various palaeoecological and geochemical parameters that can help assess re-establishment of C accumulation in peatlands under restoration. Individual parameters, such as a reconstructed WTD may not always correspond to C decomposition indices in such transient systems. The accumulation of redox sensitive species may potentially be a suitable indicator for successful rewetting, as it marks the depth of increasingly reducing conditions favourable for C storage.

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