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Isotope evidence for N2-fixation in Sphagnum peat bogs

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Waterlogged organic soils store as much as 30 % of the world's soil carbon (C), and 15 % of the world's soil nitrogen (N). In the era of climate change, wetlands are vulnerable to increasing temperatures and prolonged periods of low rainfall. Higher rates of microbial processes and/or changing availability of oxygen may lead to peat thinning and elevated emissions of greenhouse gases (mostly CO_2, but also CH4 and N2O). Biogeochemical cycling of C and N in peat bogs is coupled. Under low levels of pollution by reactive nitrogen (NO_3-, NH4+), increasing N inputs may positively affect C storage in peat. Recent studies in North America and Scandinavia have suggested that pristine bogs are characterized by significant rates of microbial N2 fixation that augments C storage in the peat substrate. We present a nitrogen isotope study aimed at corroborating these findings. We conducted an isotope inventory of N fluxes and pools at two Sphagnum-dominated ombrotrophic peat bogs in the Czech Republic (Central Europe). For the first time, we present a time-series of del15N values of atmospheric input at the same locations as del15N values of living Sphagnum and peat. The mean del15N values systematically increased in the order: input NH4+ (-10.0 ‰ < input NO_3- (-7.9 ‰ < peat porewater (-5.6 ‰ < Sphagnum (-5.0 ‰ < shallow peat (-4.2 ‰ < deep peat (-2.2 ‰ < runoff (-1.4 ‰ < porewater N2O (1.4 ‰. Importantly, N of Sphagnum was isotopically heavier than N of the atmospheric input ($p < 0.001$). If partial incorporation of reactive N from the atmosphere into Sphagnum was isotopically selective, the residual N would have to be isotopically extremely light. Such N, however, was not identified anywhere in the ecosystem. Alternatively, Sphagnum may have contained an admixture of isotopically heavier N from atmospheric N2 (del15N N2 = 0 ‰. We conlude that the N isotope systematics at the two Czech sites is consistent with the concept of significant N2 fixation rates in ombrotrophic peat bogs. We note that high energy is required to break the triple bond of the N2 molecule, and hence, microrganisms will tend to fix N2 only at relatively low inputs of reactive nitrogen.