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Isotopic investigations of dissolved organic N in soils identifies N mineralization as a major sink process

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Dissolved organic nitrogen (DON) is a major component of transfer processes in the global nitrogen (N) cycle, contributing to atmospheric N deposition, terrestrial N losses and aquatic N inputs. In terrestrial ecosystems several sources and sinks contribute to belowground DON pools but yet are hard to quantify. In soils, DON is released by desorption of soil organic N and by microbial lysis. Major losses from the DON pool occur via sorption, hydrological losses and by soil N mineralization. Sorption/desorption, lysis and hydrological losses are expected to exhibit no 15N fractionation therefore allowing to trace different DON sources. Soil N mineralization of DON has been commonly assumed to have no or only a small isotope effect of between 0-4‰ however isotope fractionation by N mineralization has rarely been measured and might be larger than anticipated. Depending on the degree of 15N fractionation by soil N mineralization, we would expect DON to become 15N-enriched relative to bulk soil N, and dissolved inorganic N (DIN; ammonium and nitrate) to become 15N-depleted relative to both, bulk soil N and DON. Isotopic analyses of soil organic N, DON and DIN might therefore provide insights into the relative contributions of different sources and sink processes. This study therefore aimed at a better understanding of the isotopic signatures of DON and its controls in soils. We investigated the concentration and isotopic composition of bulk soil N, DON and DIN in a wide range of sites, covering arable, grassland and forest ecosystems in Austria across an altitudinal transect. Isotopic composition of ammonium, nitrate and DON were measured in soil extracts after chemical conversion to N2O by purge-and-trap isotope ratio mass spectrometry. We found that delta15N values of DON ranged between -0.4 and 7.6‰ closely tracking the delta15N values of bulk soils. However, DON was 15N-enriched relative to bulk soil N by 1.5±1.3‰ (1 SD), and inorganic N was 15N-depleted relative to DON by on average 3‰ (maximum 18‰. There were no ecosystem-specific or altitudinal differences in the 15N enrichment of DON i.e. between arable, grassland and forest ecosystems and at different altitudes in Austria, negating strong effects of climate, soils and management on the 15N-enrichment of DON. These results have strong implications on global isotope-based models of ecosystem N cycling, given that predominant soil DON losses will cause ecosystems to become 15N depleted (e.g. undisturbed, low N ecosystems), while inorganic N losses cause ecosystems to become 15N-enriched (e.g. managed or N saturated ecosystems with open N cycles).