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Microbial nitrogen use efficiency and soil inorganic N processes along a latitudinal transect in Europe

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In terrestrial ecosystems, soil organic N with high molecular weight becomes available for microorganisms after depolymerization by extracellular enzymes. The low-molecular weight organic N thereby released (i.e. oligopeptides, amino acids and amino sugars) is rapidly taken up by microorganisms for metabolism and growth, with surplus N which exceeds microbial N demand being released as ammonium (N mineralization). Microbial nitrogen use efficiency (NUE) is a proxy reflecting the partitioning of organic N taken up by soil microbes between incorporation into microbial biomass (growth) and N mineralization, which influences the availability of ammonium through gross N mineralization and subsequent nitrification. Microbial NUE indicates the microbial N demand relative to N supply and therefore is expected to sensitively respond to microbial N limitation. However, empirical evidence, as well as studies on possible controls on microbial NUE is scarce, including the implications of changes in microbial NUE on soil inorganic N cycling.

Mineral and organic soils were collected in 2017 at 96 sites along a latitudinal transect from south Spain (36.4° N, -6.0° E) to north Scandinavia (71.0° N, 25.8° E) to study the environmental controls on microbial NUE and inorganic N transformation processes on a continental scale. The sampling transect covered eight countries in Europe and three main land-uses (cropland, pastures and forests) in close vicinity at each site where available. Gross rates of N mineralization and nitrification, as well as microbial immobilization rates of amino acids, ammonium, and nitrate were measured with ^{15}N pool dilution assays. Microbial NUE was calculated based on the rates of microbial growth (in N equivalents), microbial amino acid immobilization and organic N mineralization.

Across the whole transect labile N was dominated by microbial biomass N, contributing between 60-95% to the sum of microbial N, dissolved organic N, ammonium and nitrate. In forests we observed a shift in dominance of total dissolved N from ammonium in Mediterranean to nitrate in temperate and dissolved organic N in boreal to subarctic soils. Gross N mineralization was significantly affected by land-use (lowest in arable soils), though not gross nitrification. Gross N mineralization and nitrification increased with latitude and with decreasing mean annual temperature (MAT) in arable and pasture soils, counter our expectations. We expected increasing N limitation of soil microbes towards higher latitudes as reflected by increasing microbial NUE and decreasing gross N mineralization. In contrast, microbial NUE decreased towards higher latitudes and lower MAT. Mean annual precipitation (MAP) didn't show a significant effect on gross N mineralization and nitrification. Possible drivers of these continental patterns in microbial NUE and inorganic N process rates including soil type, vegetation, nutrient availability and stoichiometry and microbial community structure will be discussed.