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Drivers of microbial nitrogen use efficiency and soil inorganic N processes at the continental scale

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Microbial nitrogen use efficiency (NUE) depicts the partitioning of organic N taken up by soil microbes between incorporation into microbial biomass (N growth) and N mineralization, which is important in mediating microbial organic and inorganic N processes in soils. Previous studies found microbial NUE was regulated by microbial-to-resource C:N imbalances and further it was affected by soil temperature and soil moisture at the regional scale. However, the controls of microbial NUE at the continental scale are yet unclear and underlying mechanisms need to be investigated at larger scales to advance our understanding of this key parameter of the terrestrial soil N cycle.

In this study, we determined the rates of microbial N growth, gross N mineralization and gross nitrification in 95 mineral top-soils along a latitudinal transect in Europe, and calculated microbial NUE as the ratio of microbial N growth over microbial organic N uptake (sum of growth and N mineralization). We aimed to examine the contributions of climate, land use, soil organic matter, soil C:N ratio, dissolved organic matter, soil pH, soil texture as well as microbial community size and composition to microbial NUE and consecutive N mineralization and nitrification processes at the continental scale.

Our results show that microbial NUE decreased with increasing latitude in croplands and grasslands, and varied largely in forest soils. Microbial NUE was positively affected by mean annual temperature (MAT), soil pH and dissolved organic matter in cropland and grassland soils, while it was less affected by climatic factors and soil properties in forest soils. Different from the regional scale, soil C/N and soil texture did not exert a major control on microbial NUE. With increasing microbial NUE gross N mineralization decreased markedly. The amount of soil organic matter and of microbial biomass were main predictors of microbial N growth while N mineralization was more constrained by the availability of soil organic matter, highlighting the importance of soil organic matter quality and stabilization for ammonium release.

Overall this large-scale study demonstrates that microbial NUE controls soil organic N mineralization through factors affecting the organic N investment of soil microbes in growth relative to N mineralization (overflow metabolism), though important drivers of this partitioning are still unknown.