Geophysical Research Abstracts
Vol. 16, EGU2014-5870, 2014
EGU General Assembly 2014

Cycling of organic and mineral nitrogen along a latitudinal transect in Western Siberia

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The availability of nitrogen in soils is constrained by the breakdown of N-rich organic polymers, in particular proteins. Oligo-peptides and amino acids derived from protein depolymerization are subsequently taken up by soil microorganisms, and, if nitrogen availability exceeds nitrogen demand, excess nitrogen will be released as ammonium ("nitrogen mineralization"), which then can be used as a substrate for nitrification.
We here report on the dynamics of organic and mineral nitrogen along a latitudinal transect in Western Siberia (67°-54°N), from the tundra (tree growth restricted by low temperature), over three sites of coniferous forest (taiga) and two sites of forest steppe (deciduous forest and meadow), to steppe (tree growth restricted by low precipitation). For each of the seven sites, we sampled three soil horizons, and applied 15N pool dilution assays to determine gross rates of protein depolymerization, nitrogen mineralization, and nitrification.
All nitrogen transformation rates were significantly correlated with carbon and nitrogen content, as well as microbial biomass, and decreased with depth from organic topsoil over mineral topsoil to mineral subsoil. The decrease with depth was stronger for protein depolymerization than for nitrogen mineralization and nitrification, i.e. ratios of mineralization or nitrification over protein depolymerization increased with depth. As both mineralization and nitrification depend on the degree of microbial nitrogen limitation, our findings suggest that microbial nitrogen limitation decreased with soil depth, possibly due to increasing energy limitation of microorganisms.
Within the organic topsoil, protein depolymerization rates showed large variability between ecosystems, reaching the highest values in middle (60°N) and southern taiga (58°N), representing the most productive forests along the transect. We discuss these results with respect to differences of the biomes in climatic conditions, vegetation, quantity and quality of soil organic matter, microbial biomass and community composition, as well as in the association of trees with different types of mycorrhiza. Especially in boreal forests (such as middle and southern taiga), plant nitrogen acquisition largely relies on association with ectomycorrhizal fungi that are actively involved in the decomposition of organic polymers.