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Temperature effects on protein depolymerization and amino acid immobilization rates in soils.

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Increasing N deposition, land use change, elevated atmospheric CO_2 concentrations and global warming have altered soil nitrogen (N) cycling during the last decades. Those changes affected ecosystem services, such as C and N sequestration in soils, which calls for a better understanding of soil N transformation processes. The cleavage of macromolecular organic N by extracellular enzymes maintains an ongoing flow of new bioavailable organic N into biotic systems and is considered to be the bottle neck of terrestrial N cycling in litter and soils. Recent studies showed that protein depolymerization is susceptible to changes in C and N availabilities. Based on general biological observations the temperature sensitivity of soil organic N processes is expected to depend on whether they are rather enzyme limited (i.e. Q_{10}=2) or diffusion limited (i.e. Q_{10}= 1.0 – 1.3). However, temperature sensitivities of protein depolymerization and amino acid immobilization are still unknown.

We therefore here report short-term temperature effects on organic N transformation rates in soils differing in physicochemical parameters but not in climate. Soil samples were collected from two geologically distinct sites close to the LFZ Raumberg-Gumpenstein, Styria, Austria, each from three different management types (arable land, grassland, forest). Four replicates of mineral soil were taken from every site and management type. The area provides a unique opportunity to study geological and management controls in soils without confounding effects of climate and elevation. The soils differ in several soil chemical parameters, such as soil pH, base saturation, soil C: N ratio and SOM content as well as in soil physical parameters, such as soil texture, bulk density and water holding capacity.

Soils were pre-incubated at 5, 15 and 25°C for one day. Protein depolymerization rates and amino acid immobilization rates were assessed by an isotope pool dilution assay with ^{15}N labeled amino acids at the three different temperatures. Amino acid concentrations and at% ^{15}N of amino acids were measured in soil extracts at two time points by a novel approach based on the conversion of α-amino groups to N_2O and purge-and-trap isotope ratio mass spectrometry. Protein availability was measured by extraction in solvents of increasing extraction efficiency (water, salt, metaphosphate, hydroxide), followed by acid hydrolysis to free amino acids and reaction with orthophthaldialdehyde. Peptidase activity was also measured at 5, 15 and 25°C using fluorescence probes.

We expect that soil texture (clay content) and pH will affect protein sorption and availability and thereby affect depolymerization rates. Soil C:N ratios may control the N demand of microorganisms and thus affect enzyme production and amino acid immobilization rates. Moreover, soil pH is a major control on microbial community structure and may thereby affect the production of extracellular enzymes involved in protein and peptide decomposition. Due to the differences in temperature sensitivity of diffusion and enzymatic processes we expect higher temperature sensitivities given that protein decomposition is enzyme- rather than substrate-limited. This study will therefore greatly advance our understanding of major controls of the soil N cycle and provide highly important data for refining soil N cycle models.