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Carbon and Nitrogen Use Efficiency in Microbial Communities in Antarctic Soils

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Terrestrial ecosystems in the Antarctic experience harsh environmental conditions including very low temperatures and a low carbon input leading to poorly developed ecosystems with low diversity and a low soil organic matter content, which may be vulnerable to perturbations in a future climate. Microbial transformation and decomposition of soil organic matter under the extreme climatic conditions in the Antarctic has received little attention so far. Specifically, little is known about microbial process rates and how they might be affected by climate warming.

We here report on C and N transformation rates and their corresponding microbial use efficiencies in two soil horizons of two sites on King George Island, the maritime Antarctica. We used novel isotope techniques to estimate microbial carbon use efficiency (CUE; based on incorporation of 18O from water into DNA) and nitrogen use efficiency (NUE; based on a 15N isotope pool dilution assays). The investigated two contrasting sites at marine terraces on basaltic rocks that were characterized by a stable surface. While both sites were similar in exposition, distance from sea and elevation, they differed in their vegetation cover and several biogeochemical parameters, such as soil pH and soil organic carbon and nitrogen content.

Surprisingly, we found low soil C:N ratios at both sites and for both horizons, i.e. below 12 in the organic crust and below 8 in the first mineral horizon. This indicates a low carbon availability relative to nitrogen and would thus imply a high microbial CUE. However, our results showed also a low CUE at both sites and in both horizons (CUE of 24% and 9% in the organic crust and mineral layer, respectively). In contrast, NUE was very high in organic layers (98%), pointing towards a strong nitrogen limitation, while in the mineral horizons, NUE was lower (between 84% and 72%), as expected for soil horizons with a C:N ratio below 8.

Thus, the NUE pattern followed stoichiometric theory (i.e. NUE was higher at higher soil C:N ratios). This was not the case, however, for microbial community CUE. Especially in the mineral soil, low NUE coincided with very low CUE. This indicates that the CUE of Antarctic microbial communities is not solely stoichiometrically controlled. The harsh environment, short growing season, and low carbon input may constitute an extremely stressful environment for soil microorganisms making it necessary for them to invest more carbon in maintenance (respiration) then into growth. This may ultimately lead to a very low CUE with repercussion on soil carbon storage in this environment.