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Substrate use efficiency of microbial communities along a latitudinal transect through Western Siberia

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As stable soil organic matter is largely derived from microbial compounds, the partitioning of C uptake by microorganisms into growth and respiration determines the C storage potential in soils. The proportion of substrate carbon (C) which is invested into new microbial biomass (i.e., microbial growth), compared to the fraction of substrate carbon C which is respired as as CO_2,is often referred to as substrate use efficiency (SUE) or carbon use efficiency (CUE). According to stoichiometric theory, the CUE of microbes is strongly controlled by the availability of nutrients such as nitrogen (N), as microorganisms have to maintain their biomass stoichiometry within relatively narrow boundaries. Hence, when microorganisms are nitrogen limited, excess C is respired (low SUE), while conversely excess N is mineralized when C is limiting (high SUE).

In this study we took advantage of the high variability in biotic and abiotic factors, such as C:N ratio and litter input quality, between samples taken from the top three soil horizons (organic topsoil, upper and lower mineral horizon) from six different ecosystems along a 1,500 km linear-distance latitudinal transect through Western Siberia. We hypothesized that SUE would increase with soil depth, as organic matter becomes successively enriched with N relative to C, and decrease with latitude, as ecosystem N availability decreases. To determine SUE we measured uptake and respiration of a mixture of ^{13}C labeled substrate (consisting of monosaccharides, organic acids, amino acids and amino sugars), as well as C and N pools and extracellular enzyme activities.

In contrast to our expectations, we found that microbial SUE in lower mineral horizons was significantly lower than in upper mineral horizons, while there was no significant difference to the organic horizons. This is contradictory to the theory of ecological stoichiometry, since microbial SUE did not increase with decreasing soil C:N. Potential oxidative enzyme activities increased with soil depth, while the ratio of cellobiosidase:phenoloxidase decreased, indicating reduced substrate quality and/or accessibility in lower horizons. Within horizons, SUE was always negatively related to oxidative enzyme activity, while a negative correlation with the C:N ratio was only observed in the upper mineral horizon. Since higher activities of oxidative enzymes in deeper horizons are likely the result of higher substrate complexity, we conclude that organic matter quality exerts a stronger control on SUE than organic matter stoichiometry.