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Microbial respiration per unit microbial biomass increases with carbon-to-nutrient ratios in soils

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The ratio of carbon-to-nutrient in forest floors is usually much higher than the ratio of carbon-to-nutrient that soil microorganisms require for their nutrition. In order to understand how this mismatch affects carbon cycling, the respiration rate per unit soil microbial biomass carbon – the metabolic quotient (qCO_2) – was studied. This was done in a field study (Spohn and Chodak, 2015) and in a meta-analysis of published data (Spohn, 2014).

Cores of beech, spruce, and mixed spruce-beech forest soils were cut into slices of 1 cm from the top of the litter layer down to 5 cm in the mineral soil, and the relationship between the qCO_2 and the soil carbon-to-nitrogen (C:N) and the soil carbon-to-phosphorus (C:P) ratio was analyzed. We found that the qCO_2 was positively correlated with soil C:N ratio in spruce soils (R = 0.72), and with the soil C:P ratio in beech (R = 0.93), spruce (R = 0.80) and mixed forest soils (R = 0.96). We also observed a close correlation between the qCO_2 and the soil C concentration in all three forest types. Yet, the qCO_2 decreased less with depth than the C concentration in all three forest types, suggesting that the change in qCO_2 is not only controlled by the soil C concentration. We conclude that microorganisms increase their respiration rate per unit biomass with increasing soil C:P ratio and C concentration, which adjusts the substrate to their nutritional demands in terms of stoichiometry.

In an analysis of literature data, I tested the effect of the C:N ratio of soil litter layers on microbial respiration in absolute terms and per unit microbial biomass C. For this purpose, a global dataset on the microbial respiration rate per unit microbial biomass C - termed the metabolic quotient (qCO_2) - was compiled form literature data. It was found that the qCO_2 in the soil litter layers was positively correlated with the litter C:N ratio and negatively related with the litter nitrogen (N) concentration. The positive relation between the qCO_2 and the litter C:N ratio resulted from an increase in respiration with the C:N ratio in combination with no significant effect of the litter C:N ratio on the soil microbial biomass C concentration. The results suggest that soil microorganisms respire more C both in absolute terms and per unit microbial biomass C when decomposing N-poor substrate. Thus, the findings indicate that atmospheric N deposition, leading to decreased litter C:N ratios, might decrease microbial respiration in soils.

Together, the two studies show that the respiration rate per unit microbial biomass C is not constant but increases with the soil carbon-to-nutrient ratio.

References

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