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From soil calorimetry to climate change modelling: Temperature response of microbial resource-use efficiency

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Microbial soil respiration is a major flux in global greenhouse gas emissions. Its size is determined by the resource-use efficiency of the decomposer community and the availability of soil organic carbon for microbial decomposition. Experimental evidence suggests that the former is temperature sensitive¹ and varies among land-use management systems². Most Earth system models, however, consider resource-use efficiency as a constant property. We tested the temperature sensitivity of resource-use efficiency across land-uses applying a calorimetric approach. The results were then incorporated into an Earth system model to assess the consequences for projected soil respiration and thus potential impacts on our future climate.

Soils were sampled from arable, grassland, ley-farming, and forest research sites exposed to a boreal climate (64°07'N, 19°27'E). The samples were amended with two carbon substrates and incubated at a set of temperatures ranging from 5 to 20 °C. Resource-use efficiencies were calculated from heat production and residual substrate² when 15 % of the added substrate was utilized. Land-use specific temperature sensitivity curves were fitted to the data and incorporated into the Q model³ using Sweden as a case study.

Our results show that the temperature response of microbial resource-use efficiency is varying across land use management systems, a hitherto unknown phenomenon. Resource-use efficiencies in arable soils were not temperature sensitive and microbes residing in forest soils were most temperature sensitive. Comparing projections of soil respiration assuming (i) constant or (ii) temperature sensitive resource-use efficiency revealed differences in projected CO₂ emissions. Our findings emphasize the need to understand temperature responses of microbial resource-use efficiency. Further studies should establish reliable proxies for resource-use efficiency which can be exploited in model approaches.

Keywords: soil organic carbon, resource-use efficiency, temperature sensitivity, land use, isothermal calorimetry, soil carbon model

References

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