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Growth efficiency of aerobic and anaerobic bacteria and archaea in forest soil

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Microbial carbon use efficiency (CUE) has been studied for a variety of upland soils, as a tool for estimating the carbon sequestration potential. While most CUE studies assume that in such soils carbon is always utilised through aerobic respiration, it is well recognised that anaerobic microniches are always present in soil aggregates. Moreover, global climate change promotes shifts in soil activity by altering soil aeration status, because of intensified hydration-desiccation cycles. Therefore, CUE should be measured under more realistic assumptions regarding the soil aeration status.

This study focuses on the effect of oxygen on C mineralization in forest soil and quantifies C distribution between biomass and different metabolites. Forest soils were collected from two sites in the Bohemian Forest (Czechia) of low and high iron content and incubated under oxic and anoxic conditions. Solutions of 13C-labelled-glucose and D2O (1%) were added to the soils to promote microbial growth and subsequently track stable isotope incorporation into the biomass, the released gases, and extracellular metabolites over 72 hours. We use four independent approaches to estimate CUE, which are based on microbial respiration (CO_2; CH4 production was under detection limit), glucose consumption, biomass growth as well as label incorporation into lipid biomarkers, extra-cellular metabolites, and changes in the profile of active microbial communities.

As expected, the oxic incubation showed a rapid utilization of glucose and immediate production of biomass and CO_2. Under anoxic conditions, 90% of the added glucose was still present after 72 hours, and soils showed significantly lower microbial activity in terms of CO_2 production. The low-iron soil samples were more active under oxic conditions while the high-iron samples were more active under anoxic conditions. Samples are currently being processed for stable isotope probing in extracted microbial C (organic acids), lipids and RNA.

Our findings confirm that the establishment of anoxia in soil decreases C transformation rate and more C remains in soil. Iron-rich soils develop reducing conditions slower, since iron-oxides act as alternative electron acceptors. Effect of redox conditions on CUE is shown.