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Carbon use efficiency of 13C-glucose under oxic and anoxic conditions in forest soils

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Carbon use efficiency (CUE), the proportion of assimilated C allocated into the soil organic matter (biomass, extracellular compounds) and released as gaseous respiration (or fermentation) products, has become an important attribute in soil and ecosystem studies during last decades because CUE variability and the reactivity of resulting organic pools have significant implications for C sequestration in soils. Higher proportions of assimilated C that is released from soil or assimilated into easily decomposable organic compounds translate into heightened sensitivity of the soils to organic matter losses. Variation in CUE has been linked to substrate quality, stoichiometry, temperature, microbial community structure, and physiology, but the effect of redox state on CUE and C partitioning remains unresolved.
We used a stable isotope labelling approach (13C-glucose) to follow the fate of added C in two organic forest soils under oxic and anoxic conditions. To test the effect of different anaerobic pathways on CUE and C partitioning, the chosen soil matrices were naturally similar in C quality and stoichiometry but differed in the concentration of ferrous electron acceptors. Following preincubation under oxic or anoxic conditions, the soils were amended with 13C glucose (ca. 3 at.% enrichment) and incubated in airtight vials under oxic or anoxic conditions for 72 and 216 h, respectively. During the incubation, glucose consumption, CO_2 evolution, and the partitioning of 13C into bulk microbial biomass, lipid biomarkers, extracellular compounds, and gases were measured.
Under oxic conditions, glucose was completely consumed within 48 h, as microbial biomass increased exponentially and then plateaued. Both CUE and the amount of C assimilated into organic pools decreased during exponential growth and then stabilized until the end of incubation. Under anoxic conditions, glucose consumption was slow and only 40-60% was consumed during the entire incubation period, with faster mineralisation of glucose in the high-Fe compared to low-Fe soil. Although net microbial growth was slow (low Fe soil) or even negative (high Fe soil) under anoxic conditions, both CUE and the proportion of assimilated C remaining in organic pools was similar to that observed under oxic conditions. However, water-soluble C increased at the expense of microbial growth under anoxic conditions.
Our study implies that redox state affects mainly quality but not CUE or the relative proportion of C substrate that is over days to weekly timescales sequestered into soils.