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Estimating microbial growth and carbon use efficiencies in soil: links to fungal-bacterial dominance, SOC-quality and stoichiometry

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Microbial decomposers process a great majority of net primary production in the biosphere and therefore regulate carbon (C) and nutrient cycling and energy flow. Microbial decomposers are responsible for six times more carbon dioxide (CO_2) emissions than human activities so it is crucial to understand their contribution to C cycling. During decomposition microbial metabolism controls the partitioning of conversion of plant biomass-C resources into microbial biomass or CO_2. While an important part of mineralized C is respired back to the atmosphere as CO_2, another fraction is incorporated and stored in microbial biomass. Therefore, the interplay between microbial catabolism and anabolism regulates C stocks and emissions from terrestrial environments. The efficiency with which microorganisms use C substrates is often termed Carbon Use efficiency (CUE), or the ratio of growth to assimilation.

In the present study we established a comparison between aquatic and terrestrial microbial growth by assuming similarities in terms of resource use, microbial growth and CUE. We measured microbial respiration and estimated fungal and bacterial growth in C units in submerged plant litter in aquatic microcosms. We calculated conversion factors between bacterial and fungal growth to biomass and this allowed for estimates of CUE and fungal to bacterial ratios in a dataset of agriculture, subarctic, beech and spruce forest soils with pH 4-7, C:N ratio of 8.7 - 32 and soil organic matter (SOM) content ranging from 6-63%.

Fungal growth ranged from 0.15-0.45 μg C h-1 g-1 SOM with the highest rates measured in agriculture soils, while bacterial growth rates ranged from 0.2- 2-5 μg C h-1 g-1 SOM and were the highest in subarctic soils. We reported that fungal growth rates were positively correlated with C- quality and pH in our soil data set, but not bacterial growth. CUE values clustered according to land use, and ranged from 0.03 to 0.3. In our soil data set, subarctic soils had the highest CUE, followed by agriculture and spruce and beech forest soils. Soils with higher bacterial dominance over fungi had higher CUE than fungal dominated soils. This was the case of subarctic soils, while beech and spruce forest soils had the lowest CUE and higher fungal dominance. Our study represents a snapshot of microbial activity occurring in freshly sampled soils and therefore offers a new insight on the efficiency of C-substrate use in environmental samples.