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Influence of Soil Structure on Microbial Protein Degradation

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Evidence suggests that micro-scale biogeochemical interactions could play a highly significant role in the persistence of organic matter in soils, thus, soil physical structure might play a decisive role in preventing nutrient consumption by microorganisms.

To study effects of spatial microstructure on soil nutrient cycles, we have constructed artificial habitats ("soil chips") for microbes that simulate soil structures. Microfluidic, so called Lab-on-a-chip technologies, are one of the tools we used to simulate various stages of soil aggregation at a microscale. To test the ability of microorganisms to degrade organic matter under different conditions we used casein as a proxy for organic matter. This protein was labeled with a fluorophore that emits fluorescence when the protein is cleaved. The fluorescence changes in every structure inside the "soil chip" was followed throughout the experiment using fluorescence microscopy, and quantified using Image J as a software for image analysis.

The organisms used for this study were lab cultures of Psilocybe subviscida, a saprotrophic soil fungi, a strain of model soil bacteria, and an extract of natural soil bacteria. Each experiment was performed under aseptic conditions to be sure that the protein degradation was done by the studied species.

To control that the fluorescence produced was not an effect of auto fluorescence, we subjected the studied species to an equivalent amount of a non-fluorescent casein. Also, since the conditions inside the soil-chip are submersed in liquid, we tested the effect of diffusion of the fluorophore. Moreover, the stability of the fluorophore over time was also tested by introducing it into the growing medium and following the changes in fluorescence over time. A positive control was also done using Trypsin as a model enzyme for the protein degradation. Finally, to compare the protein degradation with the microbial biomass, the fluorescence intensity of the protein was compared with the auto fluorescence of the fungal hyphae and with the fluorescence intensity of the GFP labeled bacteria.

By comparing the total fluorescence intensity in the different structures and the fluorescence profiles along different channels it could be tested how the different structures inside the soil-chip influenced the ability of microorganisms to degrade protein.

Understanding small-scale processes in soils is crucial to predict carbon and nutrient cycling, and to enable us to give recommendations for soil management in agriculture, horticulture and nature conservation. If parameterization of soil structure as a central determinant for carbon sequestration is possible, it will allow strong argumentation for management practices that conserve and foster soil structure, such as low-tillage, support of mycorrhizal fungi, and reduction of heavy machinery usage.