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Visualization of physico-chemical properties and microbial distribution in soil and root microenvironments

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Plant root development is influenced by soil properties and environmental factors. In turn plant roots can also change the physico-chemical conditions in soil resulting in gradients between roots and the root-free bulk soil. By releasing a variety of substances roots facilitate microbial activities in their direct vicinity, the rhizosphere. The related microorganisms are relevant for various ecosystem functions in the root-soil interface such as nutrient cycling. It is therefore important to study the impact and dynamics of microorganisms associated to different compartments in root-soil interfaces on a biologically meaningful micro-scale.
The analysis of microorganisms in their habitats requires microscopic observations of the respective microenvironment. This can be obtained by preserving the complex soil structure including the root system by resin impregnation resulting in high quality thin sections. The observation of such sections via fluorescence microscopy, SEM-EDS, and Nano-SIMS will be highlighted in this presentation. In addition, we will discuss the combination of this methodological approach with other imaging techniques such as planar optodes or non-invasive 3D X-ray CT to reveal the entire spatial structure and arrangement of soil particles and roots.
When combining the preservation of soil structure via resin impregnation with 16S rRNA targeted fluorescence in situ hybridization (FISH) single microbial cells can be visualized, localized, and quantified in the undisturbed soil matrix including the root-soil interfaces. The simultaneous use of multiple oligonucleotide probes thereby provides information on the spatial distribution of microorganisms belonging to different phylogenetic groups. Results will be shown for paddy soils, where management induced physico-chemical dynamics (flooding and drying) as well as resulting microbial dynamics were visualized via correlative microscopy in resin impregnated samples.