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Untangle soil-water-mucilage interactions: 1H NMR Relaxometry is lifting the veil

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Mucilage is mainly produced at the root tips and has a high water holding capacity derived from highly hydrophilic gel-forming substances. The objective of the MUCILAGE project is to understand the mechanistic role of mucilage for the regulation of water supply for plants. Our subproject investigates the chemical and physical properties of mucilage as pure gel and mixed with soil.

1H-NMR Relaxometry and PFG NMR represent non-intrusive powerful methods for soil scientific research by allowing quantification of the water distribution as well as monitoring of the water mobility in soil pores and gel phases.Relaxation of gel water differs from the one of pure water due to additional interactions with the gel matrix. Mucilage in soil leads to a hierarchical pore structure, consisting of the polymeric biohydrogel network surrounded by the surface of soil particles. The two types of relaxation rates 1/T1 and 1/T2 measured with 1H-NMR relaxometry refer to different relaxation mechanisms of water, while PFG-NMR measures the water self-diffusion coefficient. The objective of our study is to distinguish in situ water in gel from pore water in a simplified soil system, and to determine how the “gel effect” affects both relaxation rates and the water self-diffusion coefficient in porous systems. We demonstrate how the mucilage concentration and the soil solution alter the properties of water in the respective gel phases and pore systems in model soils.

To distinguish gel-inherent processes from classical processes, we investigated the variations of the water mobility in pure chia mucilage under different conditions by using 1H-NMR relaxometry and PFG NMR. Using model soils, the signals coming from pore water and gel water were differentiated. We combined the equations describing 1H-NMR relaxation in porous systems and our experimental results, to explain how the presence of gel in soil affects 1H-NMR relaxation. Out of this knowledge we propose a method, which determines in situ the presence of mucilage in soil and characterizes several gel-specific parameters of the mucilage.

Based on these findings, we discussed the potential and limitations of 1H-NMR relaxometry for following natural swelling and shrinking processes of a natural biopolymer in soil.