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Swelling of peat soil samples as determined by 1H NMR relaxometry

F. Jaeger (1) and G.E. Schaumann (2)

(1) University Koblenz-Landau Institute of Sciences Department of Chemistry Section Organic and Environmental Chemistry Universitaetsstr. 1 56070 Koblenz , (2) Universität Koblenz-Landau Institute of Environmental Sciences Soil and Environmental Chemistry Fortstr. 7 76829 Landau

The swelling of soil organic matter (SOM) rich samples like peat soils may affect sorption and desorption of nutrients and contaminants. In the course of swelling the state of water may change and SOM may form a gel phase. Two peat soil samples in different degradation states from one location in Germany were saturated with water. Their swelling kinetics were studied at 5°C, 19°C and 30°C using 1H NMR relaxometry at 7.5 MHz. CPMG pulse sequence and the inversion recovery method were used to determine transverse (T2) and longitudinal (T1) relaxation time distributions, respectively. The gel phase and the state of water were both characterized with 1H NMR relaxometry, Cryo-NMR and differential scanning calorimetry (DSC). Three types of water were found in both peats: Non-freezing bound water and two types of freezable water which showed a splitting of the melting peak in the DSC thermogram. The stepwise water drainage of the peat samples by centrifugation revealed increasing T1/T2 ratios, which were not caused by proton relaxation, due to spin diffusion in internal field gradients. It can be assumed that both the splitting of the melting peak and the increasing T1/T2 ratios were caused by a phase separation of the “free” freezable water as found for conventional biopolymers like starch. Due to the organic surfaces one phase of the freezable water is structured which affects the rotational motion of water molecules, and thus caused different T1 and T2 values. From the swelling kinetics three processes (fast, medium, slow) of water dislocation from larger to smaller T2 values were distinguished. The time constants of the processes were found to be in the range of minutes (fast), hours (medium) and days/weeks (slow). The activation energies ranged between 15 - 50 KJ mol-1 suggesting that physical and physical/chemical processes are governing the swelling of SOM like a sterical re-orientation of SOM macromolecules, the water-structuring and hydration of SOM.