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Do swelling and microbial activity affect pore size distribution in humous soil samples?

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Top soil layers are influenced by strong changes in moisture, which affect sorption and transport processes for e.g. pollutants. ^{1}H-NMR relaxometry may be used as a method to determine water uptake characteristics of soils, gaining information about water distribution and mobility as well as pore size distribution. The principle of this method is to observe changes of the longitudinal or transversal magnetization due to spin relaxation of protons back to equilibrium after excitation within an external static magnetic field. The changes of magnetization can be described using exponential functions with time constants T_1 and T_2 (longitudinal and transversal relaxation times, respectively). In porous media, one obtains a multitude of relaxation times, which are displayed as relaxation time distributions (RTD). The correlation between the measured relaxation time $T_{1,2}$ and the pore size can be described with $\frac{1}{T_{1,2}} = \frac{1}{T_{1,2B}} + \frac{\lambda}{T_{1,2S}} \frac{S_0}{V_0}$.....()()()(Hinedi et al., 1997). $T_{1,2}$ is the relaxation time of water confined within a pore, averaged from the bulk relaxation time ($T_{1,2B}$) and the surface relaxation time ($T_{1,2S}$). λ is the layer thickness, in which $T_{1,2S}$ takes place and $\lambda / T_{1,2S}$ the surface relaxivity ($\rho_{1,2}$), S_0 the water covered pore surface and V_0 the water filled pore volume. Recent studies.....(Schaumann et al., 2004; Todoruk et al., 2003) revealed relevance of swelling and wetting processes of soil organic matter (SOM), but also assumptions of microbial influences on ^{1}H-NMR relaxometry.

The goal of this investigation was to achieve first indications to which extent microbial activity and quantity of bacteria affect T_2 relaxation time distribution during rewetting of humous soil samples. We used a humous forest soil sample and added cellobiose to selected samples to enhance microbial activity (treated samples). Treated and untreated samples were moistened and investigated at several points of time during 3 weeks.

The RTD of all samples showed up to three peaks. During hydration, the number of peaks decreased, and the peaks revealed significant movement towards lower relaxation times. Microbial respiratory activities were highest after 1-3 days of hydration, with values 2 to 15 times higher in the treated as compared to the untreated samples. Total cell counts increased in all samples from 1 to 5 x 10^9 cells/g.

We assume changes in the pore size distribution as well as of the spin relaxation mechanisms are responsible for the shifts in the RTD of the untreated samples. This can be due to wetting and swelling of SOM and increasing numbers of paramagnetic centers. In addition, we found indications that soil microorganisms may have a further substantial effect on the RTD.

References

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