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Böden als deformierbare poröse Medien: Ursachen und Bedeutung für physikalische Bodenfunktionen, Erfassung, Modellierung

Autoren

C. Buchmann[1], S. Kamutzki[1], M. Horvat[2], S. Peth[2], G. E. Schaumann[1]
[1]University Koblenz-Landau, Institute for Environmental Sciences, Group of Environmental and Soil Chemistry, Landau; [2] University of Kassel, Department of Soil Science, Witzenhausen

Titel

How does particulate organic matter (POM) swelling affect soil –water interactions and soil structural stability on different scales?

Abstract

Particulate organic matter (POM), root mucilage and synthetic polymers are swellable polymeric substances ("hydrogels") which form a three-dimensional polymer network between soil particles. On the one hand, hydrogels can alter soil hydrological properties via their strong influence on water holding capacity and soil wettability. On the other hand, it has been recently shown that the presence of swollen hydrogel structures between soil particles can significantly contribute to soil structural stability. However, until now, only model polymer hydrogels have been used, and the findings still need to be transferred to soils which contain natural swellable organic substances. In this study, we investigated how the swelling of different POM fractions in soil contributes to soil-water-hydrogel interactions and to soil structural stability on different scales. We assumed that the swelling of easily available inter-aggregate POM (frPOM) and occluded intra-aggregate POM (iPOM) differ in their contribution to soil structural stability. For this purpose, we investigated the structural stability and soil-water interactions of a silty sand soil in a 2x2 nested design comprising tilled and non-tilled as well as compost-fertilized and non-fertilized sub-treatments. POM fractions were isolated by soil density fractionation and subsequently characterized for their swelling and water binding properties. Soil-water interactions in terms of water distribution and water mobility were assessed by one- and two-dimensional ^{1}H-NMR relaxometry and pulsed-field-gradient (PFG) NMR. Results from ^{1}H?NMR measurements were linked with soil structural stability measurements conducted on the micro- and macroscale using soil rheology, wet sieving and crushing tests. On the micro- and macroscale, soil structural stability was higher for compost-fertilized samples than for non-fertilized with different effects of tillage. This was especially related to the presence of frPOM- and iPOM-associated water which revealed a significantly higher viscosity than mineral pore water. On the microscale, frPOM showed the highest contribution to soil structural stability, whereas iPOM predominantly stabilized the soil structure on the macroscale. The relationships suggest that the spatial location and hence the swellability of organic structures in soil could explain the nature of hydrogel-induced soil structural stability.