Localization of organic carbon pools in the soil matrix with X-ray computed tomography

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A better understanding of the mechanisms involved in the protection of SOM will be important in predicting the evolution of soil quality and the impact of SOM on global change. Few studies focused on the role of the soil pore system in SOM decomposition (Strong et al., 2004; De Gryze et al., 2005). The relationship between soil structure and SOM dynamics is indirect, as soil water and air distribution influence the biological activity in different pore classes (Strong et al., 2004). Soil water distribution is mainly influenced by pore necks, which determine at given water potential if a pore will be water-filled or air-filled. It is thus necessary to quantify this pore neck size distribution if a relationship between soil structure and SOM dynamics is to be studied. X-ray computed tomography (X-ray CT), a non-destructive imaging technique, can provide us images of soil samples in three dimensions. When processing these images, it is possible to gain spatial information about the soil pore system, the pore neck size distribution and its water distribution and relate this spatial information directly to SOM dynamics.

In this research, we used X-ray CT to identify pore size classes relevant for SOM decomposition during an incubation experiment. Because of the trade-off between sample size and resolution in X-ray CT, the dimensions of the undisturbed soil columns were chosen to be small (D: = 1 cm, h = 1 cm) to attain a voxel resolution of 9.44µm (voxel = pixel in 3D). Thirty six undisturbed soil columns (sandy loam) were incubated for 35 days at 20°C and C mineralization was measured with gas chromatography (at days 2-4-6-8-13-20-27-35). All soil columns had similar carbon content (ranging between 4.34 - 4.45%), but were divided in three groups of different bulk densities (1.41, 1.67 & 1.79 g cm^{-3}), each incubated at two moisture contents (50% and 75% WFPS) in 6 replicates. After incubation, 3 soil columns per treatment were immediately scanned with X-ray CT to minimize possible moisture loss. The high-resolution grey scale X-ray CT images in three dimensions were processed with Morpho+ (Cnudde et al., 2010) and 3-D information about water distribution in soil was combined with C mineralization data to identify the locations of SOM decomposition in the soil matrix.

First results show negative correlations between CO_2 respiration and bulk density and volume of small (<180 µm equivalent diameter) pores. X-ray CT data indicated the majority of fine pores to be completely filled with water and hence a limited contribution of the finer pore space may be expected. Positive correlations with macro porosity (>1200 µm eq. diam.), which was not water-filled may suggest an indirect effect on SOM decomposition by improved aeration in finer surrounding pores that do contain water. Intermediately sized pore space (180-1200 µm equivalent diameter) constituted the majority of the pore space (±75%) and showed a weaker correlation with C mineralization. A further in depth subdivision of intermediately sized pore space according to shape parameters such as maximum opening, pore neck distribution, etc. is ongoing.

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