Geophysical Research Abstracts
Vol. 17, EGU2015-1834-1, 2015
EGU General Assembly 2015

Synchrotron Microtomographic Quantification of Geometrical Soil Pore Characteristics Affected by Compaction

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Soil compaction degrades soil structure and affects water, heat, and gas exchange as well as root penetration and crop production. The objective of this study was to use X-ray computed microtomography (CMT) techniques to compare differences in geometrical soil pore parameters as influenced by compaction of two different aggregate size classes. Sieved (diam. < 2mm and < 0.5mm) and repacked (1.51 and 1.72 Mg m-3) Hamra soil cores of 5- by 5-mm (average porosities were 0.44 and 0.35) were imaged at 9.6-micrometer resolution at the Argonne Advanced Photon Source (synchrotron facility) using X-ray computed microtomography. Images of 58.9 mm3 volume were analyzed using 3-Dimensional Medial Axis (3DMA) software. Geometrical characteristics of the spatial distributions of pore structures (pore radii, volume, connectivity, path length, and tortuosity) were numerically investigated. Results show that the coordination number (CN) distribution and path length (PL) measured from the medial axis were reasonably fit by exponential relationships P(CN)=10-CN/Co and P(PL)=10-PL/PLo, respectively, where Co and PLo are the corresponding characteristic constants. Compaction reduced porosity, average pore size, number of pores, and characteristic constants. The average pore radii (64 and 61 μm; p<0.04), largest pore volume (1.6 and 0.6 mm3; p=0.06), number of pores (55 and 50; p=0.09), characteristic coordination number (6.3 and 6.0; p=0.09), and characteristic path length number (116 and 105; p=0.001) were significantly greater in the low density than the high density treatment. Aggregate size also influenced measured geometrical pore parameters. This analytical technique provides a tool for assessing changes in soil pores that affect hydraulic properties and thereby provides information to assist in assessment of soil management systems.