Structural characterization and permeability estimation for soil regions at the interface between biopore coating and soil matrix

Luis Alfredo Pires Barbosa and Horst H. Gerke
Research Area 1 “Landscape Functioning”, Working Group “Hydropedology”, Leibniz Centre for Agricultural Landscape Research (ZALF), Eberswalder Str. 84, D-15374 Müncheberg, Germany (luis.pires@zalf.de)

During preferential flow events, soil macropores such as cracks and biopores (decayed root channels and earthworm burrows) may allow water and solutes to bypass the lower permeable soil matrix. The biopore walls are inherently compacted by the locomotion mechanism employed by earthworms and roots. In addition, there are the excretion of biopolymers and the hydrophobicity of mucilage excreted by the roots of plants or mucus by earthworms. This gives to the biopore a coating with physicochemical properties distinct from the soil matrix, such as wettability, sorption and cation exchange capacity. Consequently, changes in the mechanical properties of the material in that region are also expected, ensuring greater mechanical stability.

However, micro structural features (i.e. crack size distribution) are still poorly explored. The objective is to analyze such features in detail, in order to better understand the effects of the coating material on soil macro mechanical behaviour (i.e. tensile strength) to explain the flow exchange between biopore and the soil matrix.

Therefore, soil samples were collected from Bt horizons of two Haplic Luvisols located in northern Bohemia (Hneveces, near Hradec Kralove, Czech Republic; 50°18′47″ N, 15°43′03″ E). From these air dried samples, three earthworm burrows were identified and carefully separated from soil matrix.

The samples were scanned with X-ray microtomography (X-TEk XCT 225, Nikon Metrology), using 100 keV, 120μA and no filter. The reconstruction of three-dimensional images was done with the CT Pro 3D software package (version 3.1) at a spatial resolution of 10μm and 8-bit gray scale resolution. The permeability in each region was calculated along the biopore and perpendicularly to the biopore from matrix to coating using stokes solver.

The calculated hydraulic permeability for coating and matrix was 55 and 0.4 μm$^2$ along biopore direction and 11 and 3 μm$^2$ perpendicularly to the biopore. The results from image analysis show no differences in crack size distribution between the materials, but the number of cracks and connections were superior for the coating material, suggesting that the differences in the pore structure can strongly affect the macropore-matrix mass exchange.