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Macropore induced soil saturated water conductivity – modelling based on X-ray CT scans of soil cores

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Saturated soil water conductivity (SSWC) is one of most important soil hydrological characteristics which strongly influences soil water transport phenomena. It is a macroscopic soil characteristics indispensable to modelling soil water transport processes. On its own, SSWC is determined by the soil pore transport processes occurring at the microscale. Consequently soil pore-space determines SSWC of pore media which may be modelled based on 3D pore-space information obtained from X-ray computational tomography. Such approach to modelling the SSWC of geological pore media is a well-established approach. Soil as a pore medium is not an exemption here, and in principle similar approach may be used for estimation of the SSWC of soil material. But soil naturally is a strongly nonhomogeneous pore medium and much bigger than usually sample sizes have to be used for SSWC estimation to obtain meaningful results. Typical size of soil cores used in soil survey studies has about 5 cm in diameter and volume100 cm^3. In contrast, typical dimensions of other geological pore media used in this type of studies is about few millimetres, which influences achievable resolution of X-ray CT scans. In presented study the saturated water conductivity is modelled based on X-ray CT scans of the soil cores. Soil material (10 soil cores) was sampled by two cores from topsoil of 5 different locations. Soil cores were scanned using X-ray micro-CT scanner and SSWC of samples together with other typically determined soil characteristics was determined. Voxel size achieved for X-ray CT scans was 20 μm which is about an order of magnitude bigger than voxel size used typically for such studies of other geological porous materials. As a result, only macropores were observed in CT scans, and for some samples there was no pore network percolation at all. In this situation typically used approaches for SSWC modelling couldn't be used. A new method of modelling the SSWC was proposed in this case, which uses information about macropore network only and treats macrpores as voids. Other soil sample area, which is below achievable CT scan resolution, is treated as a pore medium (soil matrix) with some intrinsic permeability. Based on CT scans 3D representation of pore media was obtained. Based on this information numerical mesh was generated used than for numerical simulations. There were two regions generated in the numerical mesh: one representing voids (macropores) and the remaining part representing the soil matrix. Elaborated model allowed for estimation of SSWC of soil samples and for analysis of relation between macroporosity of soil cores and its SSWC. A good estimation of SSWC was obtained using proposed model (R^2=0.73, RMSE=5.95*10^{-4}). The ratio of SSWC of soil core to SSWC of soil matrix has been found to be highly correlated with soil core macrporosity (R^2=0.88).