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Estimation of water saturated permeability of soils, using 3D soil tomographic images and pore-level transport phenomena modelling

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There are some important macroscopic properties of the soil porous media such as: saturated permeability and water retention characteristics. These soil characteristics are very important as they determine soil transport processes and are commonly used as a parameters of general models of soil transport processes used extensively for scientific developments and engineering practise. These characteristics are usually measured or estimated using some statistical or phenomenological modelling, i.e. pedotransfer functions.

On the physical basis, saturated soil permeability arises from physical transport processes occurring at the pore level. Current progress in modelling techniques, computational methods and X-ray micro-tomographic technology gives opportunity to use direct methods of physical modelling for pore level transport processes. Physically valid description of transport processes at micro-scale based on Navier-Stokes type modelling approach gives chance to recover macroscopic porous medium characteristics from micro-flow modelling.

Water microflow transport processes occurring at the pore level are dependent on the microstructure of porous body and interactions between the fluid and the medium. In case of soils, i.e. the medium there exist relatively big pores in which water can move easily but also finer pores are present in which water transport processes are dominated by strong interactions between the medium and the fluid – full physical description of these phenomena is a challenge.

Ten samples of different soils were scanned using X-ray computational microtomograph. The diameter of samples was 5 mm. The voxel resolution of CT scan was 2.5 μm. Resulting 3D soil samples images were used for reconstruction of the pore space for further modelling. 3D image threshholding was made to determine the soil grain surface. This surface was triangulated and used for computational mesh construction for the pore space. Numerical modelling of water flow through the sample was performed. Steady-state Navier-Stokes equations for incompressible laminar flows were used for that purpose.

Resulting from modelling values of the soil saturated permeabilities were compared with results from measurements, made using constant head permeameter. Differences in this results were discussed.

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