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Residual gas saturation effects on hydraulic conductivity of coarse sand

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The aim of the first part of this study was to experimentally determine the relationship between gas residual saturation (Sgr) and actual hydraulic conductivity (K) of coarse sand. Sgr indicates the ratio of entrapped air volume to pore volume of the sample. The value of residual gas saturation value determined in experiments exhibits temporal variability (due to history of wetting and drying, due to redistribution, air dissolution etc.), but many two-phase models assume value of Sgr to be constant.

The K(Sgr) relationship was determined in series of constant head infiltration-outflow experiments. The first runs was performed on fully saturated sample. After the first infiltration run and then after each subsequent infiltration run, sample was drained under tension on a sand tank. Sgr was determined gravimetrically before each infiltration run. The value of K was determined using a Darcy's law from measured steady state flux and each measurement then provided one value of K(Sgr). Several relative hydraulic conductivity models were tested to fit the measured points.

In the second part of this study the aim was to compare hydraulic conductivities predicted from the retention curves by Mualem – van Genuchten model and measured K(Sgr). The performance of both concepts was tested in numerical simulation of the complex infiltration-outflow experiment using TOUGH2 multiphase model (Pruess et al., 2012). TOUGH2 model considers Sgr as a point, below which gas phase becomes immobile, but its content still can be reduced by dissolution into water. The simulated infiltration-outflow experiment was previously conducted on a compacted sample composed of fine, medium coarse and coarse sand (Sněhota et al., 2015). The data of water content distribution during various stages of the experiment were determined by means of neutron tomography. The Levenberg-Marquardt algorithm was used for parameter optimization. Four parameters (permeability and residual gas saturation of fine and medium coarse sand) were optimized to obtain the best agreement between simulation and experiment, dependent on the amount of water in sub-regions of the sample. Comparison between results obtained using hydraulic conductivity predicted by Mualem – van Genuchten model and actually determined K(Sgr) relationship was done.

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