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Slow Redistribution of Capillary Trapped Gas in Heterogeneous Porous Medium

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Infiltration is the key hydrological process that affects a formation of runoff, floods generation, water erosion, and leaching of contaminants through soil. These processes are often most intensive in nearly saturated soils. An example of frequently highly saturated and intensively leached soils are the filter layers of the storm water infiltration swales, bioretention cells, and rain gardens. It was shown that soils rarely reach full water saturation, thus clusters of residual air reside in pores [1]. The consequences of partial water saturation are the increased gas storage and reduced hydraulic conductivity [2]. The extent of the impact of trapped air on soil water processes depends on the amount of entrapped air, and even more, on its spatial distribution [3] within the pore space. Recent experiments showed that neutron tomography has sufficient sensitivity to quantitatively detect small changes of water content, and thus the changes of trapped air content in dual-porosity material [4]. The aim of this study was to assess quantitatively the air trapping and subsequent slow redistribution in the dual-permeability material during water flow as well as during situation at which water in the nearly saturated soil does not flow.
Redistribution of trapped gas was quantitatively studied by three-dimensional (3D) neutron imaging in series of experiments conducted on a sample composed of fine porous ceramic and coarse sand. The redistribution of water was studied under both no-flow and steady state flow conditions. A series of ponded infiltration experiments was conducted on a sample by delivering heavy water with a peristaltic pump to the top of the sample while maintaining a constant water level. The water was allowed to flow freely by gravity through the perforated disc at the bottom of the sample. Four continuous and three intermittent infiltration runs were conducted on the sample with different initial water contents. The neutron imaging was conducted at Neutron Radiography (NEUTRA) beam line of the Swiss Neutron Spallation Source (SINQ) at the Paul Scherrer Institute (PSI) in Villigen, Switzerland [5]. A total number of 69 tomography images were taken for this study. Images that represented the three-dimensional spatiotemporal distribution of air and water in the sample were calculated with use of images of fully saturated and dry sample [6].
Based on the robust experience of visualization of the flow within heterogeneous samples, it seems that due to the huge local (microscopic) pressure gradients between contrasting pore radii the portion of faster flowing water becomes attracted into small pores of high capillary pressure. The process depends on the initial distribution of entrapped air which has to be considered as random in dependence on the history and circumstances of wetting/drying. The rate of the redistribution was significantly higher in the case of steady state flow condition in comparison to no-flow conditions. Imaging also demonstrates that residual air accumulated preferentially on the interfaces between coarse sand and fine ceramics. The transfer from fine to large pores leads to the reduced hydraulic conductivity of the sample.

References

[1] Faybishenko, B. A. (1995), Hydraulic behavior of quasi-saturated soils in the presence of entrapped air - Laboratory experiments, Water Resources Research, 31(10), 2421-2435.
[2] Votrubova, J., M. Cislerova, M. H. G. Amin, and L. D. Hall (2003), Recurrent ponded infiltration into structured soil: A magnetic resonance imaging study, Water Resources Research, 39(12).
[3] Dohnal, M., V. Jelinkova, M. Snehota, J. Dusek, and J. Brezina (2013), Tree-Dimensional Numerical Analy-

sis of Water Flow Affected by Entrapped Air: Application of Noninvasive Imaging Techniques, Vadose Zone Journal, 12(1).
[4] Snehota, M., V. Jelinkova, M. Sobotkova, J. Sacha, P. Vontobel, and J. Hovind (2015), Water and entrapped air redistribution in heterogeneous sand sample: Quantitative neutron imaging of the process, Water Resources Research, 51(2), 1359-1371, doi: 10.1002/2014wr015432
[5] Lehmann, E. H., P. Vontobel, and L. Wiezel (2001), Properties of the radiography facility NEUTRA at SINQ and its potential for use as European reference facility, Nondestructive Test. Eval.,
[6] Sacha, J., Snehota M., Hovind, J., (2016), A quantitative evaluation of the water distribution in a soil sample using neutron imaging [online]. Acta Polytechnica. 2016, 56s. 388-394. doi: https://doi.org/10.14311/AP.2016.56.0388

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