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Three-dimensional numerical analysis of air entrapment effects during recurrent ponded infiltration experiment

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The use of nuclear magnetic resonance (MR) and X-ray computed tomography (CT) scanning is now well established in soil science and subsurface hydrology. Recurrent ponded infiltration test was performed on small undisturbed soil sample and further complemented with the MR and CT scanning techniques. The experiment reveals complex water regime accompanied with air entrapment effects. The decrease of the steady state flow rate during the second infiltration run, hypothesized to be caused by entrapped air with subsequent blockage of the large pores, was observed. In this study, distribution of entrapped air and its impact on water flow was studied through a novel combination of MR imaging and numerical modeling. CT-derived hydraulic properties was implemented via scaling factors of hydraulic conductivity and water content into the three-dimensional (3D) water flow model based on Richards' equation. MR relaxometry data were used to derive 3D maps of entrapped air. Simulation results were compared with measured outflow rates, pressure heads and 3D heterogeneous fields of water content visualized by MR imaging. The numerical analyses aimed at evaluating the impact of air entrapment (considering different entrapped volumes and spatial distributions) on outflow from the sample.

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