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Experimental investigation of infiltration in soil with occurrence of preferential flow and air trapping

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Recently, a number of infiltration experiments have not proved the validity of standard Richards' theory of the flow in soils with wide pore size distribution. Water flow in such soils under near-saturated conditions often exhibits preferential flow and temporal instability of the saturated hydraulic conductivity.
An intact sample of coarse sandy loam from Cambisol series containing naturally developed vertically connected macropore was investigated during recurrent ponding infiltration (RPI) experiments conducted during period of 30 hours. RPI experiment consisted of two ponded infiltration runs, each followed by free gravitational draining of the sample. Three-dimensional neutron tomography (NT) image of the dry sample was acquired before the infiltration begun. The dynamics of the wetting front advancement was investigated by a sequence of neutron radiography (NR) images. Analysis of NR showed that water front moved preferentially through the macropore at the approximate speed of 2 mm/sec, which was significantly faster pace than the 0.3 mm/sec wetting advancement in the surrounding soil matrix. After the water started to flow out of the sample, changes in the local water content distribution were evaluated quantitatively by subtracting the NT image of the dry sample from subsequent tomography images. As a next stage, the experiment was repeated on a composed sample packed of ceramic and coarse sand. Series of infiltration runs was conducted in the sample with different initial water contents.
The neutron tomography data quantitatively showed that both in natural soil sample containing the macropore and in the composed sample air was gradually transported from the region of fine soil matrix to the macropores or to the coarser material. The accumulation of the air bubbles in the large pores affected the hydraulic conductivity of the sample reducing it up to 50% of the initial value. This supports the hypothesis on strong influence of entrapped air amount and spatial distribution on infiltration into heterogeneous soils.
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