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Hydraulic characterization of dual-permeability unsaturated soils using tension disc infiltration experiments: BEST-2K method

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Modelling and understanding water flow and solute transfer in the vadose zone require accounting for preferential flow and physical non-equilibrium transport. The dual permeability approach was developed to model preferential flow. This approach conceptualizes soils as having structural pores representing the fast flow region and the soil matrix with a much lower saturated hydraulic conductivity, with a first-order lateral exchange of water between the two regions. The use of such approach requires the knowledge of the hydraulic functions, i.e. the water retention and hydraulic conductivity functions, for both the matrix and fast flow regions. In this paper, we investigate the design of a new method, referred to as BEST-2K, to characterize the hydraulic functions of dual permeability media from water infiltration experiments. BEST-2K is based on the basics of the so-called BEST method. This method was previously developed to derive the hydraulic functions of single permeability media using single tension water infiltration (e.g., zero pressure head at surface for the Beerkan method). For BEST-2K, two successive water infiltrations are required: one at a constant water pressure head of -15 cm to activate the matrix porosity without macropores (i.e. pores more than 0.2mm in size) and the second with a zero pressure head at surface in order to activate the complementary fast flow porosity. From an experimental point of view, the two infiltrations can be successively conducted using a tension disc infiltrometer. The first cumulative infiltration is analysed with BEST method to derive the hydraulic functions of the matrix alone. The knowledge of the matrix hydraulic functions allows the calculation of cumulative infiltration component through the matrix during the second infiltration. The amount of water infiltrated into the fast flow region is then deduced by subtraction and is used to derive the hydraulic functions of the fast flow region. The proposed BEST-2K method is validated against analytical generated infiltration data to assess its precision and its robustness. At last, its use is detailed for specific sets of experimental data obtained with two coarse materials suspected to match dual-permeability behaviour. The results show that new BEST-2K algorithm is a promising tool for the hydraulic characterisation of heterogeneous soils.