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Transport versus imbibition in a cylindric macropore

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A challenging problem of water transfer in unsaturated soils is the hydraulic function of the macroporosity as opened cracks, earthworm burrows, and channels left by roots. In macropores, free surface flow can be a dominant process especially for unsaturated soils. In this context, the fluid transfer reveals to be complex [1] and conceptual approaches of film flow (see for instance [2]) are not able to explain the associated flow regimes. Recently, using the Stokes equation and taking into account the macropore surface wettability, a rich range of flow shapes has been identified: droplets, thin films or rivulets and notably, there is a regime of complete wetting for an impervious macropore surface [3]. In the present work, the macropore surface is porous and fluid transfer may appear through the interface between the macropore and the soil matrix. We aim at studying the competition between imbibition and the transport in the macropore.
The model is based on the long-wave approximation with a free surface. The soil matrix wettability is taking into account using disjoining and conjoining pressures. Such an approach allows to model contact angle hysteresis if the wettability is not homogeneous [4]. The originality of this contribution is relative to the model of the fluid transfer at the matrix/macropore interface. Indeed, the linear classical flux condition on the liquid/porous interface as used in [5] does not yield if a hydrophobic coating is present: the flux depends on the matrix moisture too [6]. We propose a model taking into account wettability at the surface and also in the porous matrix.
We analyse the perturbation via imbibition using continuation techniques and tools of dynamical systems. This analysis displays a rich behaviour and highlights the crucial role of wettability in the fluid transfer.

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