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0.1 Physics of non-equilibrium flow

P. Germann

Soil Science Section, Department of Geography, University of Berne, Switzerland
(germann@giub.unibe.ch / Fax: +41 31 631 85 11)

It was demonstrated that the wetting front moved with a constant velocity vertically over a layer of 2 m during infiltration into a homogeneously filled sand. The degree of water saturation in the sand was always distinctly less than unity. Constant velocity indicates that the moving water was neither accelerated nor decelerated. No acceleration also means that no net force was acting on the moving water. Thus, the forces were continuously balanced at a very local scale. We propose that gravity was the only driving force and momentum dissipation due to the water's viscosity was the only force that opposed gravity. The proposition represents a case of Darcy's law that is restricted to unit hydraulic gradient and extended to also operate in the vadose zone.

If flow within fissures is assumed i.e., plane-Poiseuille flow, than thickness, F (m), of the film of the moving water and its contact length, L (m m^{-2}), per cross-sectional area of the medium are the two important geometrical parameters. They suffice to relate mobile water content, w (m^3 m^{-3}), with the volume flux density, q (m s^{-1}), with the velocity of flow, v (m s^{-1}), and with specific momentum dissipation, M(Pa s), that is necessary to equilibrate gravity. Other flow geometries, like Hagen-Poiseuille flow in a cylindrical pipe or Cuette-flow along a solid surface with the other water surface contacting the gas phase, scale linearly with plane-Poiseuille flow. In principle, the concept also explains fingering if it is applied to a system with a finer porous medium overlaying a coarser one. The concept may thus provide for a theoretical base for experimental investigations on gravity-driven viscous flow in porous and fissured media.