Geophysical Research Abstracts
Vol. 20, EGU2018-12896, 2018
EGU General Assembly 2018

Stokes approach to preferential flow at the Darcy scale

Christina Bogner (1) and Peter F. Germann (2)

(1) University of Bayreuth, Ecological Modelling, BayCEER, Bayreuth, Germany (christina.bogner@uni-bayreuth.de), (2) Prof. em., University of Bern, Switzerland (pf.germann@bluewin.ch)

Preferential flow in soils is fast, limited to infiltration, and occupies but a small portion of porosity. However, how fast is it, how much water is involved, what is its flow rate, and how far is it carried? Supported with numerous measurements, a Stokes approach to preferential flow provides the answers at the operational Darcy scale. The approach to preferential flow in permeable soils is based on momentum dissipation during viscous laminar flow. Thus, dynamic water films percolate through soils that are determined by their thicknesses F and their specific contact areas L per unit soil volumes.

We determined the two parameters in a series of infiltration experiments by sprinkler-irrigating two disturbed and two undisturbed soil cores with diameters and heights of 15 and 30 cm, respectively. The three irrigation rates were 10, 32, and 64 mm h^{-1}. We also added Br^{-} and ^{18}O-tracers to the irrigation waters. We observed no behavioral differences between the two conservative tracers, however, both were substantially delayed with respect to the arrivals of the wetting fronts. Linear regressions of the 12 tracer delays against various combinations of the F- and L-parameters produced significant coefficients of determination of up to $r^2 = 0.79$. This renders the Stokes approach to infiltration a valid explanation for the observed delays of tracer breakthrough. We thus consider the flow geometry with the thicknesses in the range of $6.4 \leq F \leq 12$ μm, the wide specific contact areas in the range of $2140 \leq L \leq 4270$ m^2 m^{-3}, and the small mobile water contents in the range of $0.015 \leq w \leq 0.045$ m^3 m^{-3} as the major causes for the retardation of the tracers. Conversely, this kind of tracer delay interpretation provides a hydro-mechanical explanation for the still somewhat obscure hydrological phenomenon of ‘pushing out old water’.