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Scaling of preferential flow in biopores by parametric or non parametric transfer functions

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Rapid flow in connected macropores - often worm burrows or sometimes shrinkage cracks - is today accepted to play a key role for transport of agro chemicals in cohesive soils. Nevertheless, we still struggle to come up with reliable predictions at the field or even the catchment scale, also because crucial information on the spatial distribution of connected subsurface structures is most difficult to access. Assessing the environmental risk of pesticides transport in earthworm burrows requires the development of an integrated eco-hydrological model that allows predictions of a) the spatiotemporal distribution and population dynamics of anecic earthworms, b) the related pattern of connective preferential flow pathways (i.e., earthworm burrows), and c) the space-time pattern of infiltration and travel times distribution of solutes considering short and long term feedbacks. The suggested paper will present the first steps towards this long term goal of the so called BIOPORE project.

The first step is to assess statistical data on the spatial distribution of worm burrows in the study area. Deep digging earthworms create mainly vertical semi-permanent burrows of moderate tortuosity down to a depth of 3m (Shipitalo and Butt, 1999). Data on the spatial density of worm burrows and their depth is gathered by preparing horizontal soil profiles (Zehe and Fluehler, 2001). Hydraulic properties of worm burrows are straightforward to measure either by means of a special permeameter (Shipitalo and Butt, 1999) or by taking macroporous samples to the lab.

The next step is to establish a link between the distribution of travel depths of a tracer/pesticide that occurs during events and the depth distribution of connected flow paths that link the surface continuously to the subsoils. To this end we generate a population of macropores using a Poisson process for the number of macropores per model element, a normal process compared with an anisotropic random walk for pore lengths and finally assign the measured hydraulic capacities to these pores. By combining this population of macropores with observed data on soil hydraulic properties we obtain a virtual reality. Flow and transport is simulated for different rainfall forcings comparing two models, Hydrus 3d and Catflow. The simulated cumulative travel depths distributions for different forcings will be linked to the cumulative depth distribution of connected flow paths. The latter describes the fraction of connected paths - where flow resistance is always below a selected threshold that links the surface to a certain critical depth. Systematic variation of the average number of macropores and their depth distributions will show whether a clear link between the simulated travel depths distributions and the depth distribution of connected paths may be identified.

The third essential step is to derive a non parametric transfer function that predicts travel depth distributions of tracers and on the long term pesticides based on easy-to-assess subsurface characteristics (mainly density and depth distribution of worm burrows, soil matrix properties), initial conditions and rainfall forcing. Such a transfer function is independent of scale ? as long as we stay in the same ensemble i.e. worm population and soil properties stay the same.

Shipitalo, M.J. and Butt, K.R. (1999): Occupancy and geometrical properties of Lumbricus terrestris L. burrows affecting infiltration. Pedobiologia 43:782-794
Zehe E, and Fluehler H. (2001b): Slope scale distribution of flow patterns in soil profiles. J. Hydrol. 247: 116-132.