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Using simple model approaches to predict leaching in heterogeneous flow fields

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It is generally accepted that water flow and solute transport in soils are heterogeneous. This heterogeneity leads to an increase of the dispersivity length with increasing travel distance. For the prediction of the leached mass fraction of pesticides with low leaching potential, the dispersivity length is an important parameter. In general, the sorption and degradation potentials decrease with depth in natural soils.

We investigate how the fate of pesticides in soils with a heterogeneous flow field and a deterministic trend in sorption and decay parameters, i.e. 3 different soil layers with constant parameters, can be described using a simple 1-D flow and transport model. Three different models 1-D models were considered. The first two models are based on a convective-dispersion (CD) concept with the first model assuming a constant dispersivity with depth and the second three soil layers with different dispersivity lengths. The third model is based on a stream tube (ST) concept corresponding with a linear increase of dispersivity with depth. All three models predict the same breakthrough of an inert tracer at 1 m depth. The layered CD and ST models predict the same breakthrough of an inert tracer at the boundaries between soil layers. Despite the similarities of the model predictions of the inert tracer, the models predicted different leached mass fractions of a pesticide, with increasing relative difference for substances with decreasing leaching potential. The largest leached mass fraction was predicted by the homogeneous CD and the smallest by the layered CD. To validate the different 1-D models, transport simulations in 2-D heterogeneous flow fields were carried out. Two cases were considered: a flow field in a soil profile with a unique variance and spatial covariance of the hydraulic conductivity and one in a layered profile with different geostatistical parameters for each layer and no spatial correlation of hydraulic properties across the layer boundary. The leached mass fractions predicted in the heterogeneous flow fields for both cases were closest to those predicted by the ST model. These conclusions are valid for steady state flow conditions. Whether the same results are obtained under transient flow conditions remains to be investigated.