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Simulating solute transport and transformation in unsaturated zone using a random-walk model

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Solutes from damaged sewers infiltrate in the soils and lead to their pollution, having a negative impact on the groundwater resources. For modelling their transport and transformations, one should deal with a complex system of processes and interactions between a mixture of reactive solutes as well as between these and the soil matrix. In order to predict the fate of solutes in the subsurface, the process of coupled movement of the water and the solutes has to be well understood. A new reactive transport modelling approach and examples of its application are presented, dealing with the impact of de/nitrification processes on the spreading of solutes related to sewer leakage, in unsaturated zone. The modelling concept applied quantifies the mass transfer between mobile fluid phase and immobile solid phase and of reactive processes using a random-walk approach. Accordingly, the water flow is balanced by moving particles representing a defined water volume. Also, by defining mass loadings for each particle, the mass transport is represented and thus the unsaturated water and mass transport are computed together. When a particle moves, it brings the solute mass from one location to another one; at the same time it exchanges mass with the immobile solid phase. This approach is implemented in the numerical model Water and Solute Transport Model and in order to quantify the mass fluxes from point sources, a series of simulations have been performed. The modelling results indicated that the water content distribution, an important parameter in relation to the transformation processes, is dependent on the infiltration conditions and the hydraulic soil parameters. As no analytical solutions are available for model validation purposes, simulation results are compared to measurements from the 1D and 3D lab-scale experiments. The simulation results indicate that the model can be regarded as a valuable tool for predicting leakage uptake or release in/from unsaturated media.