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Modeling effective flow and mass transport in a porous media with preferential flow paths: a lab tank experiment

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Flow and mass transport in natural media may often concentrate in preferential flow paths. This may occur due to the presence of strings of high and/or low values of hydraulic conductivity (K), or simply to the existence of certain patterns of connectivity of K, in a highly heterogeneous medium. The porous media features that lead to these preferential zones use to have a typical size smaller than the scale at which mathematical models are formulated, a scale between the size of the Elementary Representative Volume and the discretization size adopted to solve the flow and/or mass transport equations. Thus, mathematical models do not capture the small scale details of flow and mass transport patterns, although we still require the effective behaviour to be represented. In order to study this problem we have built a laboratory tank, monitored to measure pressure and concentration, consisting of a vertical tank of 1400 mm (horizontal length), 400 mm (high) and 50 mm (thickness) mm, establishing a uniform saturated flow along the maximum dimension. Inside the tank two different types of porous media have been made up and tested. The first consisting on a uniform media cut by four diagonal narrow veins of a material with K two orders of magnitude higher. The second, a highly heterogeneous media, with a K field based on data of natural origin, corresponding to a non multiGaussian spatial structure. In both cases, a conservative tracer has been injected upstream and observed for a time close to 100 hours, measuring concentrations by means of image processing. Results in both cases show solute distribution patterns, at a small scale, that are difficult to reproduce by mathematical models, mainly fingering and macrodispersion. However, by means

of mathematical models, calibrated in both cases, we have been able to reproduce, reasonably well, averaged piezometric head and the solute plume evolution. This has required the use of effective K values and has been more difficult in the second type of medium.