Geophysical Research Abstracts
Vol. 14, EGU2012-7329-1, 2012
EGU General Assembly 2012

Numerical Generation of Dense Plume Fingers in Unsaturated Homogeneous Porous Media

C. Cremer and T. Graf

Institute of Fluid Mechanics and Environmental Physics in Civil Engineering, Leibniz Universität Hannover, Appelstrasse 9A, 30167 Hannover, Germany (cremer@hydromech.uni-hannover.de)

In nature, the migration of dense plumes typically results in the formation of vertical plume fingers. Flow direction in fingers is downwards, which is counterbalanced by upwards flow of less dense fluid between fingers. In heterogeneous media, heterogeneity itself is known to trigger the formation of fingers. In homogeneous media, however, fingers are also created even if all grains had the same diameter. The reason is that pore-scale heterogeneity leading to different flow velocities also exists in homogeneous media due to two effects: (i) Grains of identical size may randomly arrange differently, e.g. forming tetrahedrons, hexahedrons or octahedrons. Each arrangement creates pores of varying diameter, thus resulting in different average flow velocities. (ii) Random variations of solute concentration lead to varying buoyancy effects, thus also resulting in different velocities.

As a continuation of previously made efforts to incorporate pore-scale heterogeneity into fully saturated soil such that dense fingers are realistically generated (Cremer and Graf, EGU Assembly, 2011), the current paper extends the research scope from saturated to unsaturated soil. Perturbation methods are evaluated by numerically re-simulating a laboratory-scale experiment of plume transport in homogeneous unsaturated sand (Simmons et al., Transp. Porous Media, 2002). The following 5 methods are being discussed: (i) homogeneous sand, (ii) initial perturbation of solute concentration, (iii) spatially random, time-constant perturbation of solute source, (iv) spatially and temporally random noise of simulated solute concentration, and (v) random K-field that introduces physically insignificant but numerically significant heterogeneity.

Results demonstrate that, as opposed to saturated flow, perturbing the solute source will not result in plume fingering. This is because the location of the perturbed source (domain top) and the location of finger generation (groundwater surface) do not coincide. Alternatively, similar to saturated flow, applying either a random concentration noise (iv) or a random K-field (v) generates realistic plume fingering. Future work will focus on the generation mechanisms of plume finger splitting.