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Comparison of experimental methods to determine solute concentrations in porous media flow tank experiments

M. Konz (1), Ph. Ackerer (2), A. Younes (2), P. Huggenberger (1), and E. Zechner (1)

(1) University of Basel,Applied and Environmental Geology Group, Switzerland (m.konz@gmx.de), (2) Université Louis Pasteur, Institut de Mécanique des Fluides et des Solides, CNRS, UMR 7507, Strasbourg, France

Laboratory-scale experiments (158 cm x 98 cm x 4 cm) are often used to study flow and mixing processes in porous media. We describe and compare photometric and resistivity measurement methodologies to determine solute concentrations in porous media flow tank experiments. The photometric method directly relates digitally measured intensities of a tracer dye to solute concentrations, without first converting the intensities to optical densities. Both breakthrough curves (BTCs) and concentration isolines can be derived from the images. The resistivity measurement system uses two different input voltages at gilded electrode sticks to enable the measurement of salt concentrations from 0 to 300 g/l as BTCs. Transmission and reflection intensity measurements can be used for photometric concentration determinations in 2D flow tank experiments. The two options are compared and evaluated regarding their applicability in the study of flow and transport phenomena. Major perturbations of the transmission images are lens flare effects and light dispersion within the bead-water-Plexiglas system which smear the front of the plume. The resistivity method is highly precise and the major perturbations are caused by temperature changes, which can be controlled in the laboratory. The two measurement approaches are compared with regard to their usefulness in providing data for benchmark experiments aimed at improving process understanding and testing numerical codes. Due to the unknown measurement volume of the electrodes, we consider the image analysis method more appropriate for intermediate scale 2D laboratory benchmark experiments for the purpose of evaluating numerical codes. Reflection intensities outperform the transmission data and image analysis using reflection measurements is considered to be the most appropriate methodology to determine concentration data in flow tank experiments.