XVIII International Conference on Water Resources
CMWR 2010
J. Carrera (Ed)
CIMNE, Barcelona 2010

LABORATORY AND NUMERICAL INVESTIGATIONS OF VARIABLE-DENSITY FLOW AND TRANSPORT IN HELE-SHAW CELL

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Summary. The presence and migration of pollutant elements from different sources (mineral, organic or bacteriological) in groundwater is a common issue in hydrogeology. Groundwater ensures the propagation of pollutant and the contaminant extent through the aquifer system. The knowledge of transport mechanisms involved is therefore essential to handle groundwater pollution. The prediction accuracy of pollutant spreading inside a porous medium is useful to qualify and quantify the treatment of contaminated zone.

In many groundwater flow systems, physical properties such as density and/or dynamic viscosity of the fluid can vary with the concentration. In order to: (i) visualize and measure the concentration distribution inside the mixing zone without disturbing the flow field and (ii) minimize the local permeability perturbations which could generate gravitational instability a laboratory experimental model, represented by a transparent Hele-Shaw cell, was used. The measurement system is based on an original LIF (Laser Induced Fluorescence) technique. It enables temporal and spatial concentration distributions in any point of the physical model to be detected.

Experimental data, obtained by injection of a marked salt solution at different concentrations and flow rates, were numerically analysed using numerical solutions of the classical Hele-Shaw cell equations by taking into account an anisotropic dispersion tensor whose components depend on fluid properties. The employed numerical code is based on a combination between the mixed hybrid and discontinuous finite element methods. The first one is applied to fluid mass balance and momentum equations as well as to dispersive term of the solute mass balance equation while the second one, coupled with a slope-limiting technique, is used to solve the convective part of the same solute mass balance equation.

The good agreement between experimental and numerical results clearly shows that the analogy between the Hele-Shaw cell and an isotropic and homogeneous 2D porous medium strongly depends on the local Péclet number variation.