DNAPL MIGRATION ANALYSIS BY MEANS OF A COUPLED TVD FINITE DIFFERENCE METHOD WITH RANDOM WALK PROCESS

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The recent progress of numerical methods on DNAPLs (Dense Non-Aqueous Phase Liquids) migration and their application to field sites have posed some possibilities of measures against groundwater contamination.

The DNAPL motion in porous media is characterized as droplets traveling, irregular fingering and entrapment on stochastic processes. The fingering phenomena of immiscible fluid in porous media reviewed and some of DNAPL penetration have been reported. In the last 20 years many multiphases simulators came from the petroleum reservoir engineering and some of them were applied to study NAPL contamination problems.

However, even if their models were adopted to the simultaneous transport formulation with such contaminant fluids as solute, gas, and non-aqueous phase liquids, it would be difficult to attain a satisfactory simulation without taking interaction among different phases as well as entrapment effect of droplets into consideration.

Aiming at DNAPL penetration near a leaked source area, the authors applied a set of governing equations on DNAPL vertical transport by a coupled finite difference with random walk method (FD-RWM)[1)] including entrapment and fingering effects referring to experimental results and field data. The results on it gave a good accordance with the experiments[2)]. It composed of the random walk model representing sedimentation of DNAPL droplets, an entrapment modeling in pore spaces, and the finite difference method of advection dispersion equation expecting a high accurate and stable implicit TVD scheme.

Moreover, the ordinary advection dispersion equation of DNAPL solute by two dimensional TVD finite difference method (FDM) is introduced in a far field.

In the study, after coupling FD-RWM in the vertical domain near a source with FDM on the horizontal plane, a finite difference method with random walk process (FDM-RWP) is introduced for simulating typical patterns of traveling droplets and DNAPL fingering as well as probable solute concentration using identified entrapment coefficient λ=0.2~0.05(m^{-1}), based on experiments and field data. According to adaptation of FDM-

RWP to field data, dispersion lengths α_{aL} and α_{aT} in a dispersion coefficient D_a and initial DNAPL concentration C_0 at a polluted source are identified as α_{aL}=100m, α_{aT}=10m and C_0 =22.2mg/ℓ, respectively.

The results presented here may suggest that the formulation of entrapped coefficient λ is important to model DNAPL migration in groundwater, and a new mathematical model (FDM-RWP) can realize DNAPL droplets penetration process and its quantification in addition to the deterministic modelization.

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