MIGRATION OF NON AQUEOUS PHASE LIQUIDS IN HETEROGENEOUS SUBSURFACE

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1. OUTLINE

Volatile organic compounds (VOCs) such as trichloroethylene (TCE) or tetrachloroethylene (PCE) are known to exist in the contaminated subsurface as undiluted liquid called DNAPL (dense non-aqueous phase liquid) as well as vapor and solution. DNAPL could be retained in the pore space as a blob or a pool in the subsurface contamination process. DNAPL retained is generally referred to as residual DNAPL. Residual DNAPL becomes a persistent source of groundwater contamination due to its immobility and low solubility. Therefore, an evaluation of the mechanism for DNAPL migration is important in the site characterization from the aspects of DNAPL source volume and migration, as well as solute transport. In this research, the entrapment behavior of DNPAL in the porous media was modeled using the numerical code which could account for the hysteretic effects in the S–p relation (Guarnaccia et al. 1998), whose validity was verified by comparing to the profile of residual DNAPL obtained in the multiphase column tests under water-DNAPL two-phase system (Kamon et al. 2003). Furthermore, entrapment and dissolution behavior of DNAPL in the sandy medium containing the silt lens was analyzed to evaluate the spatial distribution in the subsurface and the mass flux of dissolved DNAPL. A main focus is placed on the effect of heterogeneity in the subsurface (permeability, entry pressure, size of silt lens) on the mass flux of dissolved DNAPL, which is considered to be an index of the environmental impact.

2. METHODS

Figure 1 shows the cross section for numerical analyses (30 m width × 20 m depth) and boundary conditions. Fully saturated sandy medium containing a silt lens below the TCE spill point (Case 1: No silt lens, Case 2: 2 m thickness x 4 m width, Case 3: 2 m thickness x 8 m width) was considered as the analytical domain. The bottom boundary was composed with the clay layer. Table 1 shows the parameters used in numerical analyses, related to the physical properties of sand and clay layers, and the characteristics of TCE infiltration and dispersive transport. Lateral groundwater flow with the hydraulic gradient of 0.05 or 0.005 was supplied by fixing H_2O pressure head at the left-hand side boundary for the water phase. It was assumed that TCE was spilled into the sandy medium with different rate and duration.

Details on analytical results and discussions are delivered on the thesis.

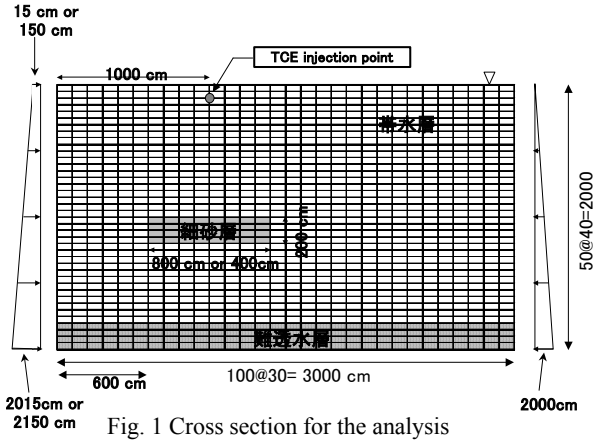

Fig. 1 Cross section for the analysis

Table 1. Parameters used in the 2-D numerical analyses.

Parameters for soil		Unit	Value	
			Sand	Silt
Intrinsic permeability	K	cm^2	1.02×10^{-7}	1.02×10^{-8} / 1.02×10^{-9}
Porosity	n_s	–	0.38	0.40
Soil bulk density	ρ_d	g/cm^3	1.63	1.50
Residual water saturation	S_{Wr}	–	0.15	0.20
Residual TCE saturation	S_{Nr}	–	0.20	0.25
VG: drainage α for air-water	${}^d\alpha_{NW}$	1/cm	0.01	0.001 / 0.005
VG: imbibition α for air-water	${}^i\alpha_{NW}$	1/cm –	0.02	0.002 / 0.01
VG: parameter for soil	n		5.0	3.0