

Development of nonlinear retardation factor for contaminant transport in a multi-phase system

Meejeong Kim¹ and Song-Bae Kim²

¹*School of Earth and Environmental Sciences, Seoul National University*

²*Environmental Remediation Engineering Laboratory, Program in Rural System Engineering,
Seoul National University*

ABSTRACT

Contaminant retardation factors are usually derived based on either the mass fraction approach or mass balance equation which describes the contaminant transport. There have been a couple of retardation factors reported for the three-phase (aqueous, solid, and colloid) groundwater system as well as for the two-phase (aqueous and solid) system. However, the retardation factor has often been presented by itself and not incorporated into the relevant transport equation, particularly when derived from the mass fraction approach. This may cause a misunderstanding or misinterpretation of the retardation factor especially for the systems where three or more phases exist due to the presence of colloids and/or nonlinear sorption processes are involved. For these systems there has been no published research to recognize whether the two (mass fraction and mass balance) derivation approaches are consistent or not and to clarify the form of the retardation factor incorporated into the transport equation. In our study, a generalized form of the retardation factor for the multi-phase system (aqueous, solid, and multiple colloidal phases) is developed using the mass balance and mass fraction approaches, and alternative forms of the retardation factor for specific conditions are presented along with the relevant transport equation. The resultant demonstrates that the two approaches basically will yield the identical expression of the retardation factor for the multi-phase system. Alternative forms of the retardation factor and relevant transport equation are presented in various combinations of the nonlinearity of involved sorption mechanisms. The retardation factors for specific conditions reduced from the generalized form are compared with the ones available in the literature. This study indicates that more caution should be given in deriving and applying the retardation factor in order to explore the transport behavior of contaminant in the multi-phase system where any

nonlinear sorption isotherm is involved. Finally, presentation of the retardation factor along with the relevant transport equation in this study would help prevent possible misuse of the retardation factor in investigating the contaminant transport in the multi-phase groundwater system.

Keywords: Retardation factor; Nonlinear sorption; Contaminant transport model; Colloid; Multi-phase system