

Evaluation of Tracer Techniques for Characterization of NAPL Volumes and Distribution in Heterogeneous Aquifers

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Partitioning and interfacial tracers are emerging as tools for identifying and characterizing the presence of non-aqueous phase liquids (NAPLs) in the subsurface. When sweeping a candidate region of the subsurface with both nonreactive and reactive tracers, the inferred presence of NAPL manifests as a retarded breakthrough for the reactive tracer in comparison to the nonreactive tracer. The retardation is directly influenced by the amount of the NAPL present in the swept volume and the nature of the distribution of the NAPL during the tracer test. The tracer partitioning between the phases is a function of both the equilibrium relationship and any kinetic limitations arising from subsurface heterogeneities and or/spill geometry. Although these techniques have been successfully utilized at a number of field sites, current application is limited largely to NAPL at residual saturation. Partitioning and interfacial tracers, however, may also be useful for identifying NAPLs whose retention volumes are higher than residual. Such occurrences include, but are not limited to, macro-entrapment zones of interspersed NAPL fingers and pools. Tracer applications involving such complexly distributed occurrences have not yet been investigated in sufficient detail by researchers.

Dr. Dai's research focuses on the evaluation of the efficacy of utilizing tracer technologies for characterizing heterogeneously distributed source zones with NAPL saturations higher than residual. The researches include:

- Controlled laboratory column tests to evaluate the influence of NAPL distribution and saturation in porous media. Configurations included evenly distributed residual NAPL saturation (0.1) in a homogenous, medium-grain sand (NAPL at residual saturation) and high NAPL saturation (0.7) trapped in a fine-grain sand lens adjacent to a medium-grain sand lens (NAPL pooled), each prepared with the same amount of NAPL.

The influence of NAPL entrapment configuration on partitioning and interfacial tracer behavior is evident in preliminary results. Amount of NAPL was adequately estimated (92 % of added amount) from measured retardation for the homogeneously distributed NAPL residual saturation (Figure 1a). Conversely, NAPL amount was significantly underestimate (only 40% of the added amount) when measured from the high NAPL saturated lens (Figure 1b). A incorrect prediction of the

NAPL morphology and distribution also found for the non-residual saturation when partitioning and interfacial tracer computational analyses (NAPL morphology index (1)) were applied.

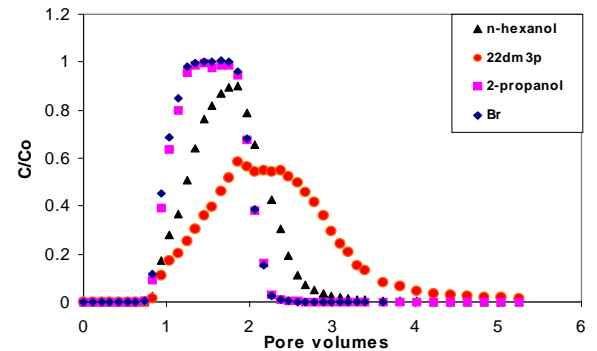


Figure 1a. Influence of Entrapment configuration on Partitioning Tracers BTCs (NAPL at residual saturation)

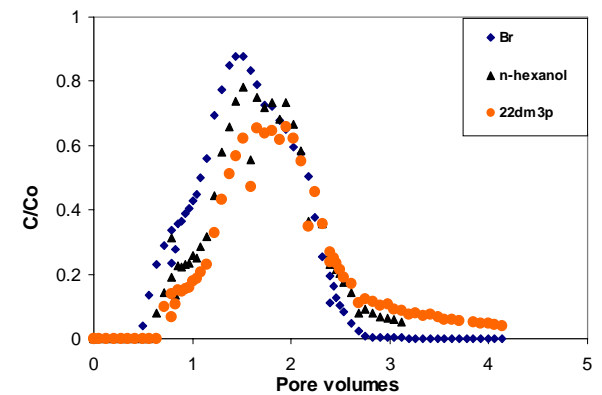


Figure 1b. Influence of Entrapment configuration on Partitioning Tracers BTCs (NAPL pooled)

- Two-dimensional intermediate scale tracer experiments in a large, intermediate-scale tank to evaluate up scaling results, to investigate discrete and composite tracer signals from complex combinations of NAPL entrapment, and to validate upscale information for use in field applications.

Reference Cited

- Annable, M.D., Jawitz, J.W., Rao, P.S.C., Dai, D.P., Kim, H., and Wood, A.L., 1998a. Field Evaluation of Interfacial and Partitioning Tracers for Characterization of Effective NAPL-Water Contact Areas, *Ground Water*, 36 (3), 495-502