Modeling Contaminant Mass Transport and Degradation in a Gas-Evolving Electrolytic Permeable Reactive Barrier

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Abstract. Permeable reactive barriers (PRBs) have become a popular technology for controlling the migration of groundwater contamination away from source zones. System performance models are useful in the design and diagnosis of traditional in situ applications, such as granular zero-valent iron PRBs. Previous efforts to model PRB systems have used either plug-flow or convection-dispersion models to capture the nonuniform flow fields through the system. PRBs that use planar mesh electrodes for the reactive substrate sandwiched between an inert Geonet material (e-barriers), may provide a greater degree of applicability (independence from field conditions) and operating flexibility (easily manipulated reaction rates) than traditional applications. The vast difference in physical configuration between e-barriers and other PRB media is a significant shift in the conceptual model of the hydrodynamic and mass transfer environment within a subsurface implementation.

Research using e-barriers to degrade common contaminants has been previously conducted at Colorado State University. Water electrolysis, and subsequent gas generation, has occurred concomitant with contaminant degradation in these studies. Utilizing empirically derived relationships for reactant transport to a gas-evolving electrode and gas-evolution-induced mixing, a general system model was developed. Comparison with experimental results using ferricyanide as a representative contaminant in a laboratory-scale e-barrier demonstrated that incorporating gas generation into the model was necessary for accurate performance predictions as a function of operating conditions. Further insights were obtained by introducing dimensionless variables (Peclet and Damkohler numbers) that could be related for given flow and gas production rates. The model provides a basis for the design of e-barriers and a framework for further research on these systems.

The presentation will review reactor operating principles and provide an overview of the process model. Specific performance aspects that will be discussed include how conversion responds to flowrate and gas generation rate. The applicability of this approach to field system design and analysis will also be discussed.

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