An up-scaled two dimensional study for *in-situ* remediation of DNAPL contaminated aquifers using modified Nano-Zerovalent Iron

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Abstract. *In-situ* remediation of aquifers contaminated with DNAPLs such as PCE has been a challenge for engineers and scientists. Use of polymer modified nanoscale-zerovalent iron (NZVI) is a novel technology for treating DNAPLs in subsurface. However, rigorous study of the placement of NZVI particles in the subsurface for effective remediation has not being conducted under controlled conditions in the field or in the laboratory at appropriate test scales. The objective of this ongoing intermediate scale laboratory study is to evaluate the efficiency of modified NZVI particles in treating the DNAPL source zone without negatively impacting the DNAPL source zone architecture. Our hypothesis based on experimental studies conducted in small 1-D and 2-D test systems is that significant reduction in the amount of contaminant mass released from the source can be achieved if the particles are injected into the source and immediate area downstream of the source zone by entrapment of the free phase DNAPL and reductive dechlorination. Emplacing modified NZVI particles in the source zone and area immediately downstream of the source zone serves the dual purpose of reducing the mass flux generation from entrapped DNAPL and reductive dechlorination of the dissolved mass, thus reducing the total mass loading to the plume. However, some portion of NZVI might deposit on aquifer materials in the source zone as intended while some might remain dispersed and mobile in pore water. The deposited NZVI can change the porosity and thus alter the flow through the reactive zone, which might decrease remediation performance if contaminated water by-passes the ZVI treatment zone. The second issue of interest, given the uncertainty in potential toxicity of nanomaterials, is whether polymeric modified NZVI remaining dispersed in pore water might escape the treatment zone and reach unintended receptors. All these issues are difficult to capture on small scale and can be well understood on a large scale system. Here we present a series of studies performed for various packing configurations in a large two-dimensional test tank with dimensions 2.43m x 1.2m x 0.05m. The present study evaluates the effects of placing modified NZVI particles in the source zone and area immediately downstream of the source zone in a heterogeneous confined environment in a two dimensional tank and compare it to numerical model of rate-limited dissolution and simultaneous dechlorination. An artificial PCE source zone was created to release a plume at steady state. Modified NZVI particles were injected into the source and create a reactive zone of 0.2x0.2x0.05m downstream of the source zone. Prior to NZVI injection, dissolved PCE concentrations were measured in a vertical profile downstream of the source zone till it reached steady state. Dechlorination byproducts were quantified, and the treatment efficiency obtained from injection was calculated. The results constitute a detailed dataset on down-gradient contaminant concentrations and are used as input in the numerical model where the dechlorination reactions and effect of NZVI placement in the source zone is simulated.

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