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Travel distance and transformation of injected emulsified zerovalent iron nanoparticles in the subsurface during two and half years

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ABSTRACT

Nanoscale zerovalent iron (NZVI) such as Toda Kogyo RNIP-10DS has been used for site remediation, yet information is lacking regarding how far injected NZVI can travel, how long it lasts, and how it transforms to other minerals in a groundwater system. Previously we reported effective mass destruction of chlorinated ethenes dominated by tetrachloroethene (PCE) using emulsified zerovalent iron (EZVI) nanoparticles of RNIP-10DS in a shallow aquifer (1–6 m below ground surface, BGS) at Site 45, Marine Corps Recruit Depot, Parris Island, South Carolina, USA. Here we report test results on transport and transformation of injected EZVI in the subsurface. We employed two EZVI delivery methods: pneumatic injection and direct injection. Effective delivery of EZVI to the targeted zone was achieved with pneumatic injection showing a travel distance from injection points of up to 2.1 m and direct injection showing a travel distance up to 0.89 m. X-ray diffraction and scanning electron microscopy studies on particles harvested from well purge waters indicated that injected black colored NZVI (α-Fe^0) was transformed largely to black colored cube-like and plate-like magnetites (Fe_3O_4, 0.1–1 μm, 0–9 months), then to orange colored irregularly shaped lepidocrocite (γ-FeOOH, 0.1–1 μm, 9 months to 2.5 years), then to yellowish lath-like goethite (α-FeOOH, 2–5 μm, 2.5 years) and ferrihydrite-like spherical particles (0.05–0.1 μm) in the top portion of the aquifer (1–2 m BGS). No α-Fe^0 was found in most monitoring wells three months after injection. The formed iron oxides appeared to have a wider range of particle size (submicron to 5 μm) than the pristine NZVI (35–140 nm). Injected NZVI was largely transformed to magnetite (0.1–1 μm) during two and half years in the lower portion of the aquifer (3–6 m).

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