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Application of Emulsified Zero-Valent Iron to Marine Environments

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Contamination of marine waters and sediments with heavy metals and dense non-aqueous phase liquids (DNAPLs) including chlorinated solvents, pesticides and PCBs pose ecological and human health risks through the contaminant's potential bioaccumulation in fish, shellfish and avian populations. The contaminants enter marine environments through improper disposal techniques and storm water run-off. Current remediation technologies for application to marine environments include costly dredging and off-site treatment of the contaminated media. Emulsified zero-valent iron (EZVI) has been proven to effectively degrade dissolved-phase and DNAPL-phase contaminants in freshwater environments on both the laboratory and field-scale level. However, the application to marine environments is only just being explored. This paper discusses the potential use of EZVI in brackish and saltwater environments, with supporting laboratory data detailed.

Laboratory studies were performed in 2005 to establish the effectiveness of EZVI to degrade TCE in saltwater. Headspace vials were setup to determine the kinetic rate of TCE degradation using EZVI in seawater. The reaction vials were analyzed by GC/FID for ethene production after a 48 day period using a GC/FID Purge and Trap system. Analytical results showed that EZVI was very effective at degrading TCE. The reaction by-products (ethene, acetylene and ethane) were produced at 71% of the rate in seawater as in the fresh water controls. Additionally, iron within the EZVI particles was protected from oxidation of the corrosive seawater, allowing EZVI to perform in an environment where zero-valent iron alone could not compete.

Laboratory studies were also performed to establish the effectiveness of emulsified zero-valent metal (EZVM) to remove dissolved-phase cadmium and lead found in seawater. EZVM is comprised of a combination of magnesium and iron metal surrounded by the same oil/surfactant membrane used in EZVI. The removal of cadmium and lead from a seawater matrix is a unique challenge. It requires a system that is resistant to the corrosive nature of seawater while removing specific ions that are in a relatively low concentration compared to naturally occurring seawater salts. Laboratory studies conducted show greater than 99% removal of lead and 96% removal of cadmium from a seawater solution spiked at 5 mg/L that was treated with an Emulsified Zero-Valent Metal (EZVM). The cadmium and lead are removed from the solution as they transport across the emulsion membrane and plate out onto the zero-valent metal surface.