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Field Study of Chlorinated Aliphatic Hydrocarbons Degradation in Contaminated Groundwater via Micron Zero-Valent Iron Coupled with Biostimulation

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Abstract : Chlorinated aliphatic hydrocarbons (CAHs) pollution poses a severe threat to human health and is persistent in groundwater. Although chemical reduction or bioremediation is effective, it is still hard to achieve their complete and rapid dechlorination. Recently, the combination of zero-valent iron and biostimulation has been considered to be one of the most promising strategies, but field studies of this technology are scarce. In a typical site contaminated by various types of CAHs, basic physicochemical parameters of groundwater, CAHs and their product concentrations, and microbial abundance and diversity were monitored after a remediation slurry containing both micron zero-valent iron (mZVI) and biostimulation components were directly injected into the aquifer. Results showed that groundwater could form and keep low oxidation-reduction potential (ORP), a neutral pH, and anoxic conditions after different degrees of fluctuations, which was benefit for the reductive dechlorination of CAHs. The injection also caused an obvious increase in the total organic carbon (TOC) concentration and sulfate reduction. After 253 days post-injection, the mean concentration of total chlorinated ethylene (CEE) from two monitoring wells decreased from 304 µg/L to 8 µg/L, and total chlorinated ethane (CEA) decreased from 548 µg/L to 108 µg/L. Occurrence of chloroethane (CA) suggested that hydrogenolysis dechlorination was one of the main degradation pathways for CEA, and also hints that biological dechlorination was activated. A significant increase of ethylene at day 67 post-injection indicated that dechlorination was complete. Additionally, the total bacterial counts increased by 2-3 orders of magnitude after 253 days post-injection. And the microbial species richness decreased and gradually changed to anaerobic/fermentative bacteria. The relative abundance of potential degradation bacteria increased corresponding to the degradation of CAHs. This work demonstrates that mZVI and biostimulation can be combined to achieve the efficient removal of various CAHs from contaminated groundwater sources.

Keywords : chlorinated aliphatic hydrocarbons, groundwater, field study, zero-valent iron, biostimulation
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