

Coupled nano-bio processes for the effective removal of complex mixtures of persistent pollutants from groundwater

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Background/Objectives

This project aims to remediate groundwater in a site heavily impacted by a complex mixture of persistent pollutants, including organic chlorinated compounds, light hydrocarbons, and metals. The primary contaminant of concern is 1,2-dichloroethane (1,2-DCA), occurring at concentrations in the thousands of micrograms per liter, with significant co-contamination by 1,2-dichloroethylene, vinyl chloride, tetrachloroethylene, and other chlorinated aliphatics. Additionally, chlorinated aromatic compounds and metals such as arsenic, iron, and manganese are present, further complicating the site's contamination profile. Nanoscale zero-valent iron (nZVI) is recognized for its capacity to promote abiotic degradation, but it is not particularly effective for the removal of 1,2-DCA. Therefore, the objective of this project is to develop and optimize a remediation strategy for the aquifer by integrating Enhanced Biodegradation (EBD) with In Situ Chemical Reduction (ISCR), aiming to achieve comprehensive treatment of the diverse contaminant mixture and restore groundwater quality.

Methods

Building on promising laboratory results that highlighted the synergistic effect of organic amendments and nanoscale zero-valent iron (nZVI), two pilot tests were conducted at the site. The first pilot involved sequential injection, with nZVI administered initially, followed by lactate addition one year later. The second pilot featured simultaneous injection of nZVI and lactates. In both pilots, lactates were then periodically injected to sustain remediation. To assess the effectiveness of these interventions, comprehensive chemical, microbiological, and isotopic monitoring was carried out.

Results and conclusions

Microbiological and chemical analyses demonstrated that the combined application of ISCR and EBD created optimal redox conditions within the aquifer in both pilot tests, with slightly better results when nZVI was injected one year prior to the organic electron donors delivery. nZVI induced a significant abiotic dehalogenation of most chlorinated solvents and simultaneously promoted the growth of key microbial families responsible for dichlorination

of 1,2-DCA. This result confirms the high potential of nZVI supported bioremediation processes.

Presentation Types: oral presentation