Title:

Bioremediation of Contaminated Aquifers: Engineering Approaches to Facilitate the Degradation of Toxic Pollutants to Benign By-Products Using Subsurface Microorganisms

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Abstract:

Chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) are the most widespread groundwater contaminants in the United States, detectable in as many as 34% of drinking water wells across the country and present at 80% of Superfund sites. They can be highly toxic even at low concentrations (drinking water standard for PCE and TCE is 5 ppb), and their high densities and low aqueous solubility make complete remediation difficult. Bioremediation, the use of bacteria to degrade these contaminants, has come to the forefront of subsurface remediation technologies in recent years due to its high versatility, effectiveness, and relatively low cost. Despite these strengths, however, complete biodegradation of chlorinated solvents to benign ethene can be impaired or stalled at an intermediate toxic byproduct (e.g., vinyl chloride) for a number of reasons. Delivery of microorganisms when sufficient quantities are not present in the aquifer (bioaugmentation), as well as substrates critical to their growth (biostimulation) can present an enormous challenge due to subsurface heterogeneities and incomplete contaminant location data. Additionally, consumption of injected substrates by non-target microorganisms can lead to unfavorable physicochemical conditions (i.e., permeability loss due to formation of metal sulfide precipitation), inhibiting delivery of additional amendments and thus, contaminant degradation. Biogeochemical processes are currently being studied in an effort to overcome these limitations and assist site remediation managers design more effective treatment schemes. Further, techniques to address challenges of effective substrate delivery are under investigation; for example, by targeting substrate delivery at the contaminant-water interface (i.e., injection of short-chain fatty acid electron donors), microbes associated with biodegradation of chlorinated solvents may be able to gain a competition advantage over indigenous microbes not associated with the degradation process. Overall, the development of novel techniques for the stimulation and monitoring of bioremediation are critical to the success of ongoing remediation efforts.