A New Process for the In Situ Remediation of Aged Low-K DNAPL Source Zone by Enhanced Mobilization and Bioremediation

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Background/Objectives. Aged low-k DNAPL source zones represent a substantial challenge for aquifer remediation. The effective delivery and distribution of electron donors and amendement is often limited in heterogeneous aquifers. Traditional injection methods usually result in a preferential horizontal migration of injected fluids through higher permeable aquifer zones, whereas less permeable and higher contaminated areas are often not properly affected. Moreover, contaminants are often strongly sorbed and trapped in the low permeable matrix and not available for biological processes, thus acting as a persistent long-term contamination source.This presentation will describe a complete pilot study conducted at an important operating industrial site in Northern Italy strongly impacted by (chlorinated aliphatic hydrocarbons (CAH) with aquifer concentrations up to 100 mg/L. Most of the residual contaminant mass was retained by low permeable aquifer layers with the prevalence of the lower chlorinated 1,2-DCE and VC. A three-screened 30 meters Groundwater Circulation Well (IEG-GCW) was installed to allow a vertical flux through highly contaminated low-k zones. The extracted water was passed through an "external treatment unit" and reinjected in the aquifer, thus creating two recirculation cells. The external unit included an easy fermentable polymer, Poly-Hydroxy-Butyrrate (PHB), containing the reactor operating as a continuous carbon source to enhance the mobilization of contaminants by cosolvents and to support in situ reductive dechlorination. Moreover, a ZVI reactor allowed the mobilized CAH removal before groundwater reinjection.

Approach/Activities. The double cell GCW system has been operated and investigated under different hydraulic and process arrangements for around one year. The hydraulics of the GCW system (ROI, etc.), polymer fermentation kinetics, mobilization of residual CAHs, removal efficiency, vertical CAH distribution and degradation processes in the treatment zone have been thoroughly investigated also using microbiological tools.

Results/Lessons Learned. Three screened GCW allow the extraction of water at a flow rate up to 0.35 $m^3\ h^{-1}$ from the intermediate very low permeable layer (around 10^{-7} m s^{-1}), whereas around 2 $m^3\ h^{-1}$ were extracted from the deeper permeable zone (around 10^{-4} m s^{-1}). Total extracted groundwater was reinjected through the upper screen in a permeable portion of the saturated zone after flowing through the treatment unit. The mass of chlorinated solvents extracted from the low permeable layer was an order of magnitude higher than from the permeable zone (around 250 against 5 g d^{-1} of total CAH). Fermentation of the biodegradable polymer was still active and efficient after 10 months of operation and VFA was reinjected as anelectron donor at a concentration up to 500 mg L^{-1} into the upper part of the aquifer. The combination of recirculation and injection of an electron donor significantly improved CAH mobilization. Dechlorinating microbial population in the less permeable layer was conclusively enhanced by vertical flushing as revealed by microbiological analyses. The positive results from the pilot test allowed the approval of the full-scale remediation plan which should start in the first half of 2018.