

## Challenges in subsurface in situ remediation of chlorinated solvents

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# In Situ Remediation'14

2<sup>nd</sup> – 4<sup>th</sup> September 2014

## In Situ Remediation Conference '14

2<sup>nd</sup> - 4<sup>th</sup> September 2014

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## **Session 3**

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**Permeable reactive barriers, in situ chemical oxidation, enhanced abiotic and thermal treatment technologies**



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Chlorinated solvent source zones in the subsurface pose a continuous threat to groundwater quality at many sites worldwide. In situ remediation of these sites is particularly challenging in heterogeneous fractured media and where the solvents are present as DNAPL. In situ remediation by chemical as well as biological degradation of chlorinated solvents is a contact sport and requires direct contact between the contaminant and the reactants and/or degrading microorganisms. In fractured geologic media, where contaminants have spread to the low permeability matrix by diffusion, the contact between contaminant and reactant is limited by slow back diffusion of contaminant and in-diffusion of reactant if the only access for the reactant is via the high permeability fractures/conduits. Where DNAPL is present the mass distribution is very heterogeneous and the reactive degradation is often limited by dissolution of the DNAPL. Most recent research has been aimed at overcoming these challenges by enhanced and targeted reactant delivery methods. These include a wide range of very diverse technologies such as: enhanced injection methods, including fracturing; electrokinetic enhancement of delivery; ZVI-clay mixing for contact; hydrophobic and/or mobile nano-reactants targeting DNAPL. The complexity of the technologies varies greatly and the current level of implementation ranges from multiple full scale applications to bench scale testing. However, the basic degradation reaction involved is usually well established. Enhanced injection with fracturing increases the access to contaminants in clay/clayey media matrixes by shortening the diffusive distance and with ZVI-clay technology by physically mixing the reactant with the contaminated clay/clayey media. The efficiency of the injection technologies has been very variable and rather unpredictable in heterogeneous geologic media, hence, further developments are needed. The novel techniques involving electrokinetics induce migration of primarily ionic species/reactants independent of hydraulic permeability differences, hence transporting the reactant into the contaminated matrix and may be applicable for limestone/bedrock as well as clayey media. Only laboratory studies of electrokinetic enhancement have yet been published, and there is a need for thorough pilot scale studies and supporting laboratory studies. Injectable nano-particles with an affinity for DNAPL surfaces (or phases) may overcome dissolution limitations and provide direct contact with contaminant, limiting reactions with other reactive sites in the subsurface. Challenges lie in obtaining stability and mobility in water, affinity for DNAPL and at the same time maintain reactivity with contaminants. Upscaling to production for pilot studies without loss of efficiency is not trivial. In conclusion there continues to be a need for research and development and in particular for well documented pilot/full scale field studies.



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