Quantifying Delivery of Particulate Amendments in Heterogeneous Aquifers Using Electrical Resistance Tomography

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Background/Objectives. An in situ remedial technology combining the synergistic effects of adsorption by colloidal or granular activated carbon (AC) and degradation by reactive amendments has recently been developed and commercialized by a number of vendors. Examples of such AC amendments include PlumeStop® – a colloidal AC product developed by REGENESIS, Inc; BOS 100® and CAT-100® – granular AC products developed by Remediation Products, Inc. (RPI); and COGAC™ – a granular AC product developed by Remington Technologies, LLC. These amendments are designed to adsorb contaminants in the aqueous phase, thereby reducing contaminant dissolved phase concentration and flux, while simultaneously promoting biological and/or chemical degradation. Uniform amendment distribution and delivery in heterogeneous media is perhaps one of the most significant challenges of in situ remedial design and implementation. Because the treatment efficiency of the different AC amendments relies on direct contact between the amendments, (specifically with solid particles) and the contaminants, effective delivery of AC amendments within the target treatment zone is critically important. DoD recognized this need and funded a demonstration to evaluate time-lapse electrical resistivity tomography (ERT) for evaluating particulate amendment distribution, with specific objectives:

1. Assess the delivery and distribution of AC amendments using DPT injection, direct injection with shear-thinning polymers and hydraulic fracturing
2. Improve the technical understanding of how AC particles are distributed in the subsurface
3. Demonstrate and validate the use of time lapse 3D ERT to evaluate the emplacement and distribution of the AC amendments in the subsurface.
4. Collect performance and cost data to develop guidance on the costs and benefits of ERT for real-time monitoring of AC amendment emplacement and distribution in the subsurface.

Approach/Activities. A field demonstration was performed to assess the delivery of three commercially available AC amendments using applicable (DPT injection, direct injection with shear-thinning polymers and hydraulic fracturing) injection methodologies. Conventional monitoring (groundwater and soil confirmation sampling) and advanced geophysics monitoring (ERT) was used to quantify AC amendment distribution behavior. The field demonstrated included three test cells instrumented with monitoring locations and electrodes for the ERT evaluation. ERT, geochemical monitoring in groundwater were conducted before, during and after each injection.

Results/Lessons Learned. The ability of ERT to resolve amendment distribution depends on many factors, which ultimately reduce to the locations of ERT electrodes, the native bulk conductivity, the bulk conductivity contrast provided by the injected amendment and its carrier fluid (or mix water), the size of the amendment plume, and noise levels in the ERT data. To assess the anticipated imaging performance, we conducted a series of numerical simulations that explore the range of scenarios that might be encountered at the demonstration site. Laboratory studies using commercially available activated carbon (AC) particles (e.g., BOS-

100®, BOS-200®, colloidal Carbo-iron, and Plumestop®) were tested for ERT response (electrical conductivity) using a spectral induced polarization (SIP) system. Study results verified that amendments distributed into the subsurface can be monitored (imaged) using ERT in the field demonstration. ERT successfully imaged each amendment type. Injection and delivery performance will be summarized along with lessons learned.