Lessons Learned Performing Amendment Injections into Low-Permeability Media

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Background/Objectives: Low-permeability media often contain significant amounts of chlorinated solvent source material, but create special challenges for biological treatment. Soluble amendments like emulsified vegetable oil (EVO) or lactate are difficult to inject into low permeability soils and will move preferentially through more transmissive lenses in heterogeneous soils. The best option in these cases is often a solid amendment, which can be injected under high pressure to overcome both soil permeability and heterogeneity limitations. EHC® is one of the most common amendments used for this purpose and combines a plant-based substrate with micro-scale zero valent iron.

Approach/Activities: This presentation will draw on the author's experience in designing and implementing half a dozen pilot and full-scale bioremediation programs involving low-permeability media. This includes injection of more than 100,000 kilograms (kg) of EHC® and other amendments into a variety of media, including plastic clay, silt, interbedded sand, silt, and clay, and saprolite in North America and Europe. Injection depths varied from 2 to 20 meters (m). In all cases, the amendment distribution in the subsurface was carefully mapped using confirmation soil cores and magnetic susceptibility measurements. In some cases, many years of groundwater performance monitoring data are now available.

Results/Lessons Learned: There are multiple methods of injecting solid amendments into the subsurface, including pneumatic and hydraulic fracturing and direct injection. While the best method to use may be location-specific, in our experience simple direct injection through a Geoprobe™ rod has provided the most consistent and uniform amendment distribution while minimizing amendment surfacing. Obtaining consistent amendment distribution is directly correlated to using the proper equipment and operating at appropriate injection pressures and flow rates. Where present, amendment surfacing is primarily related to preferential pathways in the subsurface, such as old boreholes or poor soil seals around the Geoprobe™ rod. In particular, special care needs to be taken during clearance activities so as to not compromise the integrity of the subsurface. The injected amendment typically follows discrete pathways that move horizontally from the injection point, although some bending toward the surface may be observed. The radius of injection (ROI) obtained for each injection is largely a function of the amount of amendment applied at each injection interval. An ROI of 1.5 to 2.2 m is routinely observed when 50 kg of amendment is injected per interval.

The iron component of the EHC® may have several benefits, but one of the most important may be modification of the pH in low-pH environments to facilitate reductive dechlorination. Complete remediation of soil likely requires the diffusion of both amendment fermentation products (e.g., volatile fatty acids) from the discrete injection locations into the formation and back-diffusion of contaminants out of the formation to the reactive zone. However, the approach appears to be quite effective at rapidly remediating groundwater. Whereas the manufacturer's estimates of a 5-year lifespan for EHC® is consistent with our experience, TOC measurements may not be as useful as an indicator of ongoing biodegradation activity in the same way they are for other electron donors.