Estimation of Sorbed-Phase Biodegradation Rate in Activated Carbon Barriers Using Microbial Diagnostics, CSIA and In Situ Microcosms

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Background/Objectives. The migration of organic contaminants in groundwater can be mitigated through injection of activated carbon reagents into the subsurface. The approach offers significant design flexibility in strategies ranging from source area containment to barrier configurations. Contaminant flux retardation within the treatment zone may be supplemented with biodegradation. This can extend the time to breakthrough owing to bioregeneration of the sorption sites on the carbon. The barrier longevity may be extended indefinitely if the degradation rate is sufficient. An understanding of the in-barrier degradation rate is therefore important for performance calibration and management.

In situ monitoring of contaminant degradation is typically achieved through groundwater sampling. Ambient rate may be estimated from concentration trends and advection rates (assisted by models) as the system is dominated by dissolved-phase flux. Within barrier zones however, the contaminant mass is predominantly in the sorbed phase. Contaminant concentrations in the dissolved phase may be close to or below detection limits. The consequent challenge of 'clean' water in the barriers limits options for performance monitoring through groundwater sampling. Qualitative indications of on-going degradation may be secured using microbial diagnostic tools, but quantitative estimation of rate - critical for performance prediction and monitoring - remains elusive.

Approach/Activities. A methodology is presented that employs in situ microcosms and isotope analytical tools for estimation of sorbed-phase biodegradation rate in activated carbon barriers. Interference from abiotic factors, including on-going sorption or desorption, are differentiated from biotic changes using passive flux meters, control microcosms, and compound-specific isotope analysis (CSIA). Additional 'lines-of-evidence' context is secured through microbial diagnostic tools. A case study is presented from a chlorinated solvent site in Missouri, USA.

Results/Lessons Learned. Biodegradation of sorbed-phase VOC mass is indicated through CSIA and microbial diagnostic lines of evidence. This further supports the understanding that biodegradation is not restricted to the dissolved-phase. Sorbed-phase degradation rate estimates and isotopic enrichment factors are contrasted with those of other available sources: the ambient dissolved phase, laboratory estimates, and published values. This relatively simple approach is an important first step in refining conceptual site modeling for sites that employ activated carbon-based treatments. Ideally, the results of this study will be leveraged for use in more predictive analyses in conjunction with plume modelling software. Its full potential therefore rests on an adequate understanding of the limits of confidence in the data it provides.