Assessing MTBE Degradation in an Alluvial Aquifer

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Background/Objectives. Degradation of contaminants in the subsurface is generally quantified using a bulk natural attenuation rate, often estimated as a first-order decay constant. The use of a bulk attenuation rate as a surrogate for intrinsic biodegradation rate can lead to underestimation of plume persistence in an aquifer, because it reflects contributions from both non-destructive physical processes (e.g., advection, dispersion and dilution) and destructive processes (e.g., intrinsic biodegradation). Conversely, the bulk attenuation rate derived using the centerline approach may underestimate intrinsic biodegradation of contaminants, given that biodegradation mostly occurs at the plume fringes where electron acceptors from the surrounding uncontaminated zones mix with the plume by dispersion and diffusion. Studies comparing the two rates have rarely been reported.

Here we present a field study attempting to compare the bulk attenuation rate with the intrinsic biodegradation rate of methyl tertiary-butyl ether (MTBE) in an unconfined alluvial aquifer. An onsite hydraulic containment system has been operated continuously since 2010. The remedy has prevented continued migration of MTBE into the downgradient area, but led to the temporary presence of a separate off-site plume lasting less than 3 years that was disconnected from the contaminant source.

Approach/Activities. There is over a decade of groundwater monitoring data available for this site, with an extensive monitoring well network that permits estimation of the first-order decay rates of MTBE using the centerline approach. An evolving off-site plume allows for direct calculation of MTBE mass within the off-site plume through spatial moment analyses. Multiple estimates of the bulk attenuation rate and intrinsic mass reduction rate are made and statistically compared to draw conclusions. Prior to estimating degradation rates, an exploratory factor analysis (EFA) of geochemical parameters including dissolved oxygen (DO), oxidation-reduction potential (ORP), nitrate, sulfate and methane concentrations was conducted to gain insights into the conditions supporting MTBE degradation at the site.

Results/Lessons Learned. DO and ORP values for samples taken from monitoring wells located outside the off-site plume are significantly higher than in the wells inside the plume. There is also evidence based on nitrate, sulfate, and methane concentrations supporting the observed off-site plume attenuation. Results indicate bulk attenuation rates averaging 0.4 to 1.17 per year and a half-life of 0.6 to 1.6 years, assuming groundwater velocities of 2.0 to 3.3 feet per day. The estimated average intrinsic MTBE mass reduction rate is 1.0 per year with a half-life of 0.7 years. The intrinsic degradation rate is considered more reliable given that its estimation is independent of groundwater flow velocity and provides a more defensible basis for the evaluation of the long-term effectiveness of the site remedy.