Long-Term Performance and Methanogenesis Associated with Four Remedial Amendments: Indiana Sites

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Background/Objectives. Aquifers impacted by chlorinated hydrocarbons (CHCs) can be effectively remediated by stimulating enhanced reductive dechlorination (ERD) reactions and/or inducing conditions conducive to in situ chemical reduction (ISCR). In some cases, however, indigenous methanogens (Archaea) compete with dechlorinating microbes thus generating excessive methane which can have a negative impact on remedial efficacy and, potentially, safety. Hence, the ability to actively control excessive methanogenesis during remedial actions can be beneficial in terms of cost and performance.

Approach/Activities. Data were compiled from groundwater remediation actions undertaken at four sites throughout Indiana impacted by chlorinated solvents, namely PCE, TCE, 1,1,1-TCA and their catabolites of anaerobic degradation. Site 1 = Terre Haute: Molasses (1,840 lbs of 100% product) was applied in 2007 to stimulate ERD. This was supplemented in 2009 with an emulsified vegetable oil (4,510 lbs EOS® @60% EVO). Site 2 = Indianapolis: Neat vegetable oil (Cap-18®) was applied in 2007 (6,100 lbs 100% product) and an additional 16,575 lbs were applied in 2009 to stimulate ERD. Site 3 = Evansville: a total of 83,160 lbs of EVO (EOS® at 60% EVO) was applied circa 2012 to stimulate ERD. Site 4 = Seymour: 28,850 lbs of an older, conventional ISCR amendment (EHC®) was injected in 2013. Due to performance, this was supplemented with 52,500 lbs of EVO (EOS® at 100% EVO) in late 2015 and an additional 9,240 lbs in August 2017. However, these supplemental EVO treatments uniquely contained 606 lbs and 110 lbs, respectively, of Provect-CH4® antimethanogenic reagent (AMR technology). Each site was monitored quarterly or (semi)-annually to document remedial performance as determined by changes in COI concentrations, various aquifer biogeochemical parameters, and the production of methane other gasses

Results/Lessons Learned. The use of conventional (no active control of Archaea) ERD and ISCR substrates yielded variable extent of removal of targeted COIs, and all amendments employed generated methane. Some of the amounts generated were significant from a regulatory perspective, and some of the amendments continued to yield methane for many years. Site 1 = Terre Haute: Molasses + conventional EVO (EOS®) treatment removed over 90% of the COIs but produced 17 ppm methane in the treatment area and 7 ppm off-site in samples 3+ years post treatment. Site 2 = Indianapolis: Neat vegetable oil (Cap-18®) removed a majority of the PCE but produced >10 ppm methane in the treatment area which required active and passive vapor mitigation. Site 3 = Evansville: EVO (EOS®) treatment removed 90+% of the COIs but it produced >25 ppm methane in groundwater and > 13,000 ppm methane vapor in soil gas from the capillary fringe (26 ft bgs). Site 4 = Seymour: EHC treatment exhibited variable amounts of mass removal of the COIs and produced methane following application, with ca. 4 ppm observed after several years. Supplemental treatment with EVO + AMR technology reduced more than 85% of the COIs, but without the generation of excessive methane production (i.e., only 0.8 to 1.7 ppm detected in groundwater). Advanced formulations of the AMR technology include Provect-CH4 Ego™ which is a mixture of Essential Garlic Oil (Ego) in combination with Red Yeast Rice extract (RYR) to more effectively control the growth and proliferation of Archaea. Site-specific remedial designs (dosing, application, etc.) will be summarized with other conditions including aquifer lithology, hydrogeology, type and extent of COI impact, and biogeochemistry and compared among the four sites in attempt to normalize observations and discern factors that impact the results observed.