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Overview of Approaches for Applying Gases to Groundwater for Cometabolic Bioremediation

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Background/Objectives. Aerobic cometabolism is increasingly being considered for the treatment of a variety of different emerging contaminants in groundwater, including 1,4-dioxane (1,4-D), N-nitrosodimethylamine (NDMA), 1,2-dibromoethane (EDB), as well as treatment of a variety of chlorinated alkanes and alkenes. This approach, which typically entails injecting air or oxygen and one of several different gaseous substrates (e.g., methane, propane, butane), is particularly attractive at sites in which initial contaminant concentrations are low and/or where the generation of secondary products from anaerobic treatment approaches (e.g., sulfide, dissolved metals, dissolved fatty acids) is problematic. During this presentation, the pros and cons of several different approaches for adding gaseous substrates and nutrients to groundwater will be discussed and case studies will be presented.

Approach/Activities. There are a variety of different field techniques available for adding gaseous compounds to the saturated zone, including in situ biosparging, passive in-well gas addition, and groundwater recirculation with active gas addition. During the past several years, we have evaluated each of these different approaches at field sites for treating several different groundwater pollutants. These field studies include two biosparging applications with propane, two passive gas addition demonstrations with propane and ethene, respectively, and one demonstration in which ethane gas was added during active groundwater recirculation. These remedial approaches proved to each have significant benefits and limitations, which will be discussed during this presentation along with results from the various studies.

Results/Lessons Learned. Cometabolic biosparging with propane in air proved to be highly effective for treating two different emerging DoD contaminants, 1,4-D and NDMA, at field sites. The alkane gas was widely and effectively distributed during sparging and no issues with well fouling were observed. Passive gas addition using in-well membrane units (with or without groundwater recirculation) proved to be locally effective for treating NDMA and vinyl chloride, respectively, during two field applications, but the gas distribution was limited to a small radius around the gas injection wells, limiting the broader application of this approach to small sites or sites where relatively tight well spacing and/or placement of multiple treatment fences is possible. Achieving desired ratios of oxygen and alkane/alkene gas can also be difficult with this design. In a final test, ethane gas was effectively used to treat EDB in a groundwater recirculation design. This approach was highly effective for distributing gas within an aquifer, and EDB was treated to < 0.002 µg/L during the test, but injection well biofouling became an issue over time. An overview of each of these different application technologies, lessons learned, and field results will be provided.