Aerobic Degradation of 1,4-Dioxane in a Fixed-Film Bioreactor with Toluene, Other Volatiles and Phenolics as Co-Contaminants

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Background/Objectives. A treatment system was constructed at a Federal Superfund site in the Northeastern United States to treat groundwater. This system allowed off-site hauling to be discontinued (hundreds of tanker trucks per year), and facilitated the addition of five new groundwater extraction wells. Groundwater is impacted by several VOCs, 1,4-dioxane (14Dx) and, to a lesser extent, SVOCs (largely phenolics). VOCs in the influent are dominated by toluene, benzene, trichloroethene, cis-1,2-dichloroethene and chlorobenzene.

The treatment system has several unit processes, one of which is a fixed-film, aerobic bioreactor. The bioreactor was included in the system to remove many of the biodegradable constituents and minimize the use of liquid- and vapor-phase carbon that are associated with downstream processes. An advanced oxidation unit is present downstream of the reactor, and its principle purpose is the destruction of 14Dx to acceptable levels. Although not intended for 14Dx degradation, a reduction of 14Dx concentrations across the bioreactor has been observed, and was explored during this study.

Approach/Activities. The concentration of 14Dx in the influent to the groundwater treatment system has averaged more than 200 ug/L since start-up in early 2014. Based on the results of process monitoring performed within the system during routine operations, an average reduction of more than 20% has been observed before the advanced oxidation unit. Moreover, the percent reduction of 14Dx has increased over time since startup, with some reductions over 30% observed in the past year. The reduction of 14Dx was suspected to be due to aerobic biodegradation within the fixed-film bioreactor, perhaps via toluene co-metabolism given the dominance of that constituent in the influent (with concentrations consistently above 5,000 µg/L). Phenolics are also present in the influent, but at much lower concentrations.

To help explain the reduction of 14Dx concentrations across the bioreactor, samples were collected from the influent and effluent for analysis of seven microbiologic targets associated with the metabolic and co-metabolic degradation of 14Dx. The results for six monooxygenase targets were positive and significant; only the results for aldehyde dehydrogenase were insignificant. Based on the microbiologic results, samples were also collected for two-dimensional compound-specific stable isotope analysis.

Results/Lessons Learned. The data collected to date suggested that aerobic biodegradation is responsible for the reduction of 14Dx concentrations across the fixed-film bioreactor. We will present the microbiological data and the CSIA results that were obtained to further strengthen this hypothesis. The treatment system will be briefly described, and the chemical characteristics of the influent will be presented, with focus on the constituents that the bioreactor was installed to address as well as the constituents that have been shown to be inhibitory to the degradation of 14Dx.