In Situ Ozone and Hydrogen Peroxide Remediation of 1,4-Dioxane in the Coastal Plain Region of North Carolina

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Background/Objectives. An ozone and hydrogen peroxide injection system was installed to remediate chlorinated volatile organic compounds (CVOCs) and 1,4-dioxane in groundwater at a former manufacturing facility in the Coastal Plain region of North Carolina. The system targeted groundwater and saturated soil between approximately 1 and 6 meters below ground surface (mbgs) over an area of approximately 4,200 square meters. The objective of the system was to reduce the source area contaminant mass to accelerate attenuation of the larger dissolved plume.

Approach/Activities. Ozone and hydrogen peroxide injection was selected as one of few technologies known to effectively degrade 1,4-dioxane. Injected ozone gas and liquid hydrogen peroxide act as individual chemical oxidants while the combination of the two materials can generate the hydroxyl radical, a stronger oxidant. Hydroxyl radical treatment processes, also known as advanced oxidation processes, are commonly used to treat 1,4-dioxane in ex-situ water treatment systems.

The presentation will describe the system design, installation, and operation. The design and operations plan was developed based on a 3-month pilot test, soil and groundwater sampling results, site lithology, evaluation of multiple system design options, and larger project objectives. Injection was performed using 48 wells constructed within 24 borings with each boring containing two casings extending to 0.2-meter long screens set at approximately 4 mbgs and 7 mbgs. System equipment was designed to inject 10 kilograms (kg) of ozone per day based on source area contaminant mass estimates and a targeted operational period of 3 to 8 years. The system was activated in December 2015 and was operated until June 2020. System operations included significant troubleshooting, maintenance, and repair along with programming adjustments to increase injection in areas of persistent contaminant concentrations.

Results/Lessons Learned. Semi-annual groundwater monitoring was performed throughout the injection period. Dissolved contaminant mass estimates were generated based on site-wide groundwater monitoring data collected annually since 2014. Based on these estimates, injection area total CVOC and 1,4-dioxane dissolved mass decreased by 96-percent and 97-percent, respectively, by May 2018. Gradual decreases continued through May 2020 by which time injection area total CVOC and 1,4-dioxane dissolved mass had decreased by 98-percent and 99-percent, respectively, versus the 2014 baseline. Monitoring continues in order to assess contaminant phase-transfer and dissolved concentration rebound. Data for groundwater samples collected in November 2020, May 2021, and November 2021 will be reviewed to assess the extent of dissolved concentration rebound following system deactivation.

The presentation will include lessons learned during system design and operations. Included in this discussion will be oxidant exposure safety, high system downtime, hydrogen peroxide costs and benefits, injection screen and well layout design, tubing and fitting costs, air and oxygen pressure and flow considerations, key sensors and alarms, ozone generator preventative maintenance and redundancy, and dissolved concentration rebound.