Shifting from Tradition: A Long-Term NSZD Approach for an Active Oil and Gas Facility

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Background/Objectives. Active oil and gas facilities often operate for decades, and it is highly probable that at least one release will occur during that time. Owners of these facilities are typically obligated under regulations to address subsurface impacts resulting from a release through either long-term monitoring or active remediation. However, an active approach is not always the most sustainable for sites where the plume is contained, and decommissioning is years away. A long-term natural source zone depletion (NSZD) strategy can help define degradation rates and assess plume persistence and migration. In addition, this type of strategy can reduce safety hazards, carbon footprint, and waste associated with collecting environmental samples.

Approach/Activities. We tested this NSZD approach at an active facility in Saskatchewan. This facility has had several releases, primarily crude oil and condensate, resulting in a light non-aqueous phase liquid (LNAPL) plume with an average areal extent of ~19,000 square metres (m^2). To deal with the LNAPL plume, a series of spill busters and skimmers were installed at various monitoring wells with measured LNAPL thicknesses over a 4-year period. While over 8,100 liters (L) of LNAPL were removed during this period, questions regarding the stability and persistence of the LNAPL plume remained. In fall 2021, a soil sense network consisting of 17 individual locations was installed across the LNAPL plume, including background, fringe, and source. Soil sense is a novel technology developed to continuously monitor NSZD and plume dynamics during either active remediation and/or monitoring phases. Each soil sense collects data every 30 minutes including soil gas (CO_2, O_2, CH_4), pressure, air and soil temperatures, relative humidity, and PHC vapor concentrations.

Results/Lessons Learned. So far over 10 million data points have been collected from this soil sense network. The data indicate the plume is confined to the site limits and is decreasing in both area and volume. Specifically, mean NSZD rates from October 2021 to June 2022 were estimated to be 26.4 grams of benzene per square meter per day ($g_{C6H6}\ m^{-2}\ day^{-1}$) ranging from 0.02 $g_{C6H6}\ m^{-2}\ day^{-1}$ to 111.5 $g_{C6H6}\ m^{-2}\ day^{-1}$. NSZD rates decreased from November to March which is to be expected as lower soil temperatures would decrease biological activity. Additionally, average site wide degradation rates were estimated at 2.9 kilograms of benzene per day ($kg_{C6H6}\ day^{-1}$) over this period. Following four months of baseline data and roughly 6.5 million data points, an optimization and cost benefit analysis was conducted to assess how changing the density of the soil sense network alters the precision of the NSZD estimates. It was determined that 12 units will provide enough information to meet site objectives, namely ensuring that the plume is stable and/or shrinking resulting from NSZD processes.