A Bioventing System Destroys Multimillions of Pounds of Petroleum Hydrocarbons: An Inquiry into the Mass Removal Mechanisms

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Background/Objectives. There is growing recognition that natural source zone depletion (NSZD) often contributes to significant loss of light non-aqueous phase liquid (LNAPL) mass. However, at some sites with extensive impervious ground cover, for example, NSZD rates can be limited. In response, the industry is taking a fresh look at existing technologies that can enhance NSZD processes. One of those options uses the traditional method of vadose zone aeration or bioventing. The concept to be explored in this presentation begins with the hypothesis that NSZD is limited at these impervious cover sites due to mass transfer limitations of the subsurface biogas. A case study illustration of bioventing to provide atmospheric oxygen, facilitate gas exchange, and increase mass removal rates is presented. The case study site is large consisting of portions of both a large manufacturing facility and an international airport. The objective of the presentation is to dispel an old myth that bioventing should not be applied to site containing LNAPL and demonstrate that not only can bioventing be used to remediate a large LNAPL site, but it can also be used to enhance NSZD processes that are largely occurring within the saturated zone, below, and seemingly isolated from the zone of aeration.

Approach/Activities. Bioventing was the selected method for remediation of a 46-acre zone of free-product jet fuel at a 60-year old aircraft engine manufacturing and testing facility in the southwestern United States (Site). The bioventing system was approved by the State regulatory agency in October 2005 and startup occurred in May 2009. The treatment train consists of two air injection blowers, an extraction blower, and a thermal oxidizer and scrubber. The system operated in three different phases.

- An initial extraction-dominated phase with a total extraction flow rate of 2,500 standard cubic feet per minute (scfm) and an injection flow rate of 1,500 scfm,
- A second injection-dominated phase with a total injection rate of 2,600 scfm and extraction rate of 1,300 scfm, and
- A third and final air injection-only phase of 2,600 scfm.

Results/Lessons Learned. After approximately eight years of operation, the bioventing system removed over 10 million pounds of petroleum hydrocarbons, reduced methane concentrations (<1%), and increased oxygen concentration (>5%) in the entire target treatment area. Additionally, it reduced LNAPL thicknesses in monitoring wells from an average of approximately 1 foot in 22 monitoring wells to intermittent detections in only two wells with significantly reduced LNAPL transmissivity. Remediation was shown to be effective primarily through enhanced biodegradation, removing almost 10 times as much mass as volatilization. This presentation will provide a summary of the bioventing system operation and a discussion of mass removal mechanisms of volatilization and biodegradation. Finally, it will seek to assess contributions from NSZD processes that occurred during times when the LNAPL smear zone was submerged.