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Bioventing Revisited: Enhanced NSZD Outperforms Hydraulic LNAPL Recovery

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Background/Objectives. Light nonaqueous-phase liquid (LNAPL) associated with historical fuel releases are present in the subsurface at many environmental sites. Research on natural source zone depletion (NSZD) rates at petroleum-affected sites has demonstrated that the rate of natural LNAPL depletion is typically significant; on the order of hundreds to thousands of gallons of LNAPL per acre, per year. Both academic and industry research studies and measurements made by practitioners have shown that the rate of LNAPL mass depletion by NSZD is often greater than what can be or has been achieved through active LNAPL recovery efforts. These findings suggest that enhancing NSZD may be more effective than hydraulic LNAPL recovery, even at sites where LNAPL transmissivity measurements indicate that LNAPL hydraulically recoverable.

Conceptual models of NSZD that are reinforced by empirical data collected at LNAPL sites show that the soil gas above the LNAPL/air interface is rich in methane and depleted of oxygen. These observations indicate that there is anaerobic zone in the vadose zone that typically coincides with a portion of the LNAPL smear zone. Inducing oxygen flow into the smear zone converts the environment from anaerobic to aerobic, which represents a viable approach to accelerating NSZD.

Bioventing is not a novel technology; bioventing and bioventing rate testing has existed since the 1990s where EPA published a two-volume guidance document on implementation. While the remediation science has not changed, the conceptual model for LNAPL biological depletion and the petroleum hydrocarbon biodegradation signal observed in biovent field tests and full-scale operation have changed markedly since the 1990's.

Approach/Activities. Three case study sites where bioventing was implemented are presented. Mass depletion rates were found to exceed hydraulic recovery rates, even in areas with relatively high LNAPL transmissivity values. Petroleum removal rates via bioventing are compared to hydraulic recovery performance and baseline NSZD rates. The mechanisms responsible for the performance of bioventing, NSZD, and hydraulic recovery under various site conditions are discussed.

Results/Lessons Learned. Bioventing is a potentially cost-effective alternative to hydraulic recovery that not only degrades the mobile fraction (limits of hydraulic recovery) but also the residual fraction of LNAPL. Additionally, the observation that the biologically-mediated processes responsible for LNAPL depletion do not appear rate limited under most circumstances indicate that mass removal through enhanced biological depletion can be sustained over longer periods of time than for hydraulic recovery technologies.