Natural Source Zone Depletion (NSZD): Advances in Remote Monitoring and Processing Using Temperature Data

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Background/Objectives. Many DoD sites are affected by historical releases of light non-aqueous phase liquids (LNAPL), with costly active technologies traditionally being applied as the presumptive remedy for most LNAPL sites. Over the past decade, natural source zone depletion (NSZD) has emerged as a passive remedy approach that offers the potential for greater rates of LNAPL destruction when compared to active remedies, a more sustainable remediation approach, and lower long-term costs. This study explores new advances in temperature-based monitoring and the associated data processing at two DoD facilities. The objective was to answer and understand the outcomes to the following questions: (1) How do less expensive, cloud-based temperature monitoring sensors and equipment perform; (2) What is the preferred temperature-based calculation method to separate the heat signal associated with biodegradation of petroleum from seasonal and other sources of temperature fluctuations in soils; and (3) Can NSZD rates be reliably quantified beneath paved surfaces with temperature-based NSZD methods?

Approach/Activities. This study evaluated two DoD facilities impacted by historical LNAPL with different climates and environmental conditions. Five temperature monitoring stations at each site were installed to observe the biodegradation heat signal with depth over an 18-month period. Temperature-based NSZD rates were compared with co-located Carbon Traps and vertical soil vapor profiles. Three methods to calculate NSZD rates were compared: (1) the Annual Average Temperature Method (Warren and Bekins 2015); (2) the Correction Using Background Location (e.g., Karimi Askarani et al., 2018; Kulkarni et al., 2020, and the Single Stick Method (Karimi Askarani & Sale, 2020).

Results/Lessons Learned. The questions asked above are answered by the following:

1. The second generation equipment provided real-time, hourly data for analysis, interpretation, and troubleshooting when problems arose. Less expensive thermal monitoring sensors allowed for a greater quantity to be installed, thus increasing the vertical resolution of the temperature data. While offering some clear advantages, additional work may be required to fully validate the second generation monitoring equipment.
2. The three main temperature-based methods used for this showed variable NSZD rates at each site but were generally within an order of magnitude. Overall, additional field demonstration would be needed to determine which temperature-based method yields the most accurate estimates of NSZD, especially for shorter-term NSZD rates (e.g., monthly or seasonal).
3. Overall, both sites showed some evidence of NSZD at impacted locations underneath paved surfaces, although the signal was weak at one of the demonstration sites. The general theory, results from these two sites, and results from other published studies (e.g., Smith et al., 2021) provide further evidence that temperature-based methods are suitable for quantification of NSZD rates beneath paved surfaces.