More Data, Less LNAPL: Insights from Over 15 Years of Research on Natural Source Zone Depletion (NSZD)

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Background/Objectives. Natural source zone depletion (NSZD) has emerged over the past 15 years as a viable alternative for remediation of LNAPL-impacted sites. At individual sites, many researchers have explored spatial and temporal variability in NSZD rates, the impact of temperature and rainfall events, and the impact of water level fluctuations (e.g., Sihota et al. 2011, 2016, 2018; Eichert et al. 2017; Van De Ven et al. 2021; Ganna et al. 2022; Davis et al. 2022). However, this study involves a meta-analysis of site-average NSZD rates in order to provide additional insights into the factors that influence NSZD rates.

Approach/Activities. In this study, we compiled measured NSZD rates and other key site data from 40 LNAPL source zone sites in the United States (U.S.), Australia, and Canada. Specifically, we evaluated site-average NSZD rates as an overall metric for use in Conceptual Site Models. These site-average NSZD rates encompassed multiple sampling events, various locations per site, and multiple measurement methods. Subsequently, this dataset was applied to evaluate the following key research questions:

I. Across the range of sites, what are the range of measured site-average NSZD rates?
II. Do site-average NSZD rates change with fuel type?
III. How comparable are NSZD rate measurement methods when employed at the same site, and is there method bias across sites?

Results/Lessons Learned. The complete dataset showed the following:

- Site-average NSZD rates ranged from 70 to 16,250 gallons per acre per year (gal/acre/yr), with a median value of 1,020 gal/acre/yr.
- Median site-average NSZD rate by type of fuel spill did not show a statistically significant difference between fuel types.
- When comparing the different measurement methods applied at the same site, the site-average NSZD rates differed by up to 4.8 times (i.e., ratio of faster rate to slower rate), with a median difference of 2.1 times.
- No clear bias was observed between NSZD rate measurement methods.
- At four sites with sufficient data over all seasons, NSZD rates were typically higher during summer and fall compared to winter and spring. The implications of this evaluation suggest that increasing mean annual soil temperature at a site using engineered methods could potentially increase the biodegradation rate.

Overall, the evaluation of NSZD rates measured at these LNAPL sites indicates that measurable NSZD occurs across a broad range of LNAPL sites. While NSZD rates vary across sites, fuel type and measurement method are not the primary factors explaining observed differences in rates.