

Monitoring the Dynamics of LNAPL Distribution in Soils Using Non-Destructive Fluorescence-Based Testing

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Background/Objectives. Light non-aqueous phase liquid (LNAPL) distribution in the ground depends on soil heterogeneities, groundwater levels, and the hysteretic nature of multiphase flow in soils. These factors are reflected in vertical LNAPL distributions, subsurface LNAPL mobility, and LNAPL thickness in monitoring wells. Practitioners often note that LNAPL thickness in monitoring wells reflects seasonal and long-term variability in water table fluctuations thought to be caused by drought, recharge periods, and other hydraulic controls. However, determination of the causes of such field observations may be difficult or flawed if the conceptual site mode is incomplete.

In situ methods for determining LNAPL distributions (high-density monitoring) include hydraulic conductivity profiling as well as membrane-interface and/or laser-induced probes. These methods are destructive and thus are only used once per monitoring location. Boreholes are typically plugged or used to install monitoring wells after these one-time high-density surveys. Therefore, a clear need for a long-term, multi-use LNAPL monitoring method currently exists. The purpose of this work is to develop a non-destructive LNAPL distribution method based on LNAPL fluorescence such that high-density data can be obtained from the same location repeatedly and can be used to inform a stage-dependent conceptual site model.

Approach/Activities. For the proposed method, a borehole is lined with a solid, UV-transparent casing. This casing is unscreened and sealed to hydraulically isolate the well, thereby avoiding concentration of LNAPL in the well annulus. UV-induced fluorescence measured through this monitoring port produces an LNAPL distribution in the soil with respect to elevation. This type of distribution is preferable to the single LNAPL thickness available from a monitoring well. After the initial high-density survey the well casing is left in place, providing a permanent port for future monitoring. Monitoring this port at different times may help us to understand the dynamics of LNAPL distribution in soils.

This presentation will include results of sand tank experiments designed for a) testing the effects of soil heterogeneity and changing groundwater elevations on LNAPL distribution, and b) determining the effectiveness of the described fluorescence-based monitoring method. Stop-motion animations will be used to illustrate the 2-D LNAPL distribution in the sand tank. These distributions will then be compared to the LNAPL distributions mapped via fluorescence within the UV-transparent well and also to LNAPL thickness in the traditional monitoring well.

Results/Lessons Learned. Sand tank experiments reveal that vertical LNAPL distributions within the soil column depend on water saturation levels. LNAPL in water-saturated soil (i.e., two phases) shows reduced mobility, whereas LNAPL in water-unsaturated soil (i.e., three phases) shows increased mobility. Our experiments reveal how the groundwater level history and soil heterogeneities strongly effect LNAPL distributions. LNAPL distributions observed through the glass side of the sand tank are in reasonable agreement with the distributions based on fluorescence within the UV-transparent well. These experiments illustrate the limitations of monitoring wells as compared to high-density methods in informing a conceptual site model. This validates the possibility of using non-destructive, fluorescence-based LNAPL monitoring through permanent transparent wells at actual sites.