Evaluation of Volatilization from NAPL Sources under Low Velocities with Implications for the Vapor Intrusion Pathway

Benjamin Petri[1], Tissa Illangasekare, Toshiro Sakaki, Carolyn Sauck and John Christ[2]
Environmental Science and Engineering Division, Colorado School of Mines, Golden, Colorado

Abstract. Volatile organic compounds (VOCs) have been identified as a major source of soil and groundwater contamination. These contaminants pose a risk to more than just groundwater supplies; their volatility allows them to partition into soil gas in the vadose zone where they may threaten air quality in adjacent occupied buildings. The process by which VOC vapors migrate into buildings is termed “vapor intrusion” (VI) and represents an exposure pathway of concern at numerous remediation sites nationwide.

While the VI exposure pathway has long been known to represent a risk, the processes that govern VI are not well understood. For instance, VOCs are known to partition between the soil, water, gas and NAPL phases. This partitioning affects their migration in the subsurface. However, only two approaches are available to predict this partitioning behavior. These include the assumption of equilibrium partitioning between these phases, or use of rate-limited models developed for soil vapor extraction (SVE). SVE typically occurs under much higher pressure gradients and velocities that typical of the ambient conditions under which VI occurs. However, little experimental work has evaluated this partitioning behavior at the ambient pressure gradients typical of VI. Thus VI screening models usually assume equilibrium, but it is unknown how well the equilibrium assumption captures the true behavior of the VI pathway. Generating an improved understanding of this partitioning behavior will enable more informed assumptions to be made and give greater confidence to screening-level models used for VI risk management and decision-making.

The objective of this research is to experimentally evaluate vapor generation from NAPL source zones and dissolved phase plumes, and make suggestions for improved approaches for prediction of this partitioning. Experimentation is being carried out in several laboratory apparatus to evaluate this vapor generation. Direct NAPL volatilization is being studied in a small 1-D flow cell (10 cm) with residual NAPL and water saturation present, and at air velocities as low at 4.5 m/day to determine the impact to mass transfer. Preliminary results from the 1-D cell indicate that even at very low velocities, rate-limited behavior is still observed under some conditions. It is hypothesized that this rate-limited behavior is due to source zone heterogeneity at the pore scale. As experimentation proceeds, additional work includes up-scaling to a larger 2-D cell (30 x 40 cm) and large tanks (120 x 240 cm) to understand the impact of scale on this rate-limited behavior. Then through the utilization of models, this information will be used to generate informed hypothesis about how partitioning may be expected to behave at the field scale. This presentation will include results from the first series of 1-D cells, the accompanying modeling work and the first 2-D cell run.

[1] Environmental Science and Engineering Division
Colorado School of Mines; Email: bpetri@mymail.mines.edu
[2] Department of Civil and Environmental Engineering, United States Air Force Academy, Colorado Springs, Colorado