Effect of Equilibration Time of Soil Vapor Probes on Soil Gas Concentrations

John H. Zimmerman[1], Greg Swanson[2], Brian A. Schumacher[1], James Elliot[3], and Blayne Hartman[4]

[1]U.S. Environmental Protection Agency, National Exposure Research Laboratory, Environmental Sciences Division – Las Vegas, NV; [2]Tetra Tech EMI, San Diego, CA;
[3]Tetra Tech, Santa Barbara, CA; [4]Hartman Environmental Geoscience, Solana Beach, CA

Introduction

Soil vapor data are widely used in site investigation and remediation projects to delineate volatile organic compound (VOC) vapor plumes, as a screening tool to refine soil and groundwater sampling efforts, to track the progress of soil remediation, and to assess the vapor intrusion pathway. Vapor intrusion is of particular concern, as it can be one of the main driving forces behind remediation at VOC sites.

A critical aspect in any environmental sampling program is the collection of representative data: that is, data that accurately reflect the in-situ conditions of the media being sampled. The collection of environmental samples necessarily disturbs the sampled media and so care must be taken to minimize the disturbance to the extent possible. The collection of vadose zone soil vapor samples requires that one advance a sampling tool to the targeted sample depth. This is typically accomplished using direct-push drilling equipment (e.g., a GeoProbe rig), or less commonly with other drilling methodologies such as hollow-stem auger or sonic drilling. All of these drilling techniques result in a disturbance to the subsurface. Vapor samples can be collected through the drill rod (e.g., "post-run-tubing," or "micropurge probes") or semi-permanent vapor probes can be constructed in the borehole, which further disturbs the subsurface. Given that drilling to collect a soil vapor sample will necessarily disturb the subsurface environment, it is important to know how long the vapor probe must be allowed to equilibrate with the subsurface in order to obtain a representative sample. The objective of this investigation was to evaluate the time required for equilibration of "micro-purge" vapor probes and industry standard semi-permanent "macro-purge" vapor implants with the in-situ environment to yield a representative sample .

Methodology

The field sampling and analysis portion of this project was conducted at the Installation Restoration Program Site 14 on Naval Air Station (NAS) Lemoore, California. NAS Lemoore is located in the California Central Valley, approximately 40 miles south of Fresno and 180 miles north of Los Angeles.

Figure 1: Locations of Vapor Probe Installation at Lemoore NAS

Methodology (cont.)

The vapor probes used for this investigation were installed at three discrete 4-foot by 3-foot locations adjacent to an existing vapor probe transect (Figure 1). At each of the three locaitons, macro-purge and micro-purge vapor probes were installed at depths of 7 and 10 feet below ground surface. The macro-purge probes, consisted of a 1-inch long gas-permeable membrane sampling probe, attached to 1/8-inch diameter Nylaflow tubing were installed as depicted in Figure 2. The micro-purge probes, consisted of of 0.01-inch diameter stainless steel tubing epoxied into the bottom of a 1.25-inch diameter probe rod (Figure 3). The end of the probe rod is equipped with a stainless steel drop-off point. The probe rod, with the stainless steel tubing running through the center, was advanced to the target sampling depth, and then the rod was withdrawn approximately 1 inch to expose the tubing to the subsurface vapors.

The volume of gas removed from each probe prior to sampling (the purge volume) was set at three system volumes (a system volume is the volume of the gas permeable tip plus the tubing). The sample volume for macro-purgeprobes was set at 20 ml, and the samples were collected in 60-milliliter (ml), disposable, polypropylene syringes. Samples from micro-purge probes were collected in 10-ml glass syringes, with a sample volume of 5-ml. Soil gas samples were analyzed on-site by a modified version of EPA SW-846 Method 8021 (EPA 1996) in a on-site mobile laboratory.

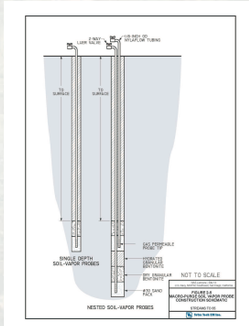

Figure 2: Drawing of macro-purge vapor probe construction

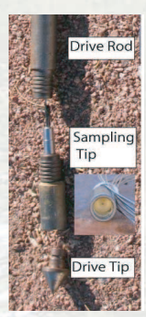

Figure 3: Photo of Micro-purge Vapor Probe Construction

Results for Macro-Purge Soil Gas Samples

In general, the concentrations measured in samples from the macro-purge probes increased steadily with time over approximately the first 8 hours after installation. Concentrations in most of the probes continued to increase more gradually from approximately 8 to 24 hours (Figure 3). Concentrations stabilized after approximately 24 hours (Figure 4). The difference between the maximum and minimum concentrations measured at an individual probes was, with a few exceptions, less than a factor of 3 for TCE and less than a factor of 4 for PCE. It is not clear why a larger variation was observed for PCE.

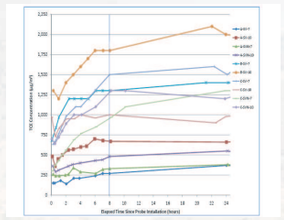

Figure 4: Plot of TCE concentrations in Macro-Purge probes during the first 24 hours

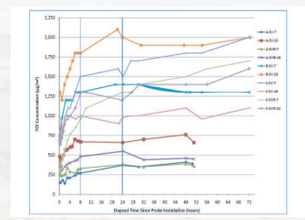

Figure 3: Plot of TCE concentrations in Macro-Purge probes versus elapsed time since installation

Results for Micro-Purge Soil Gas Samples

Concentrations measured in samples from micro-purge probes appeared to reach a maximum more quickly than those from macro-purge probes. The concentrations generally did not increase steadily from installation, but rather increased over the first 2 to 4 hours (Figure 5), and then variably increased and decreased in subsequent samples. Some of the variability observed in the micro-purge results may be due to leaks caused by the high vacuum induced when sampling these probes. The difference between the maximum and minimum concentrations measured at an individual probes was less than a factor of 2 for TCE and less than a factor of 3 for PCE (Figure 6), which indicates less overall variability than was observed with the macro-purge probes.

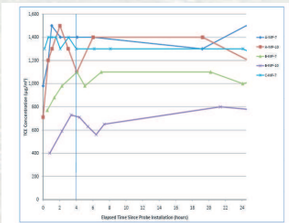

Figure 5: Plot of TCE concentrations in micro-purge probes versus elapsed time during the first 24 hours

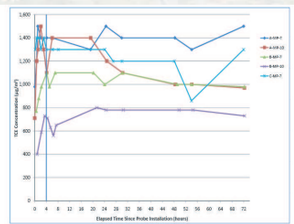

Figure 6: Plot of TCE concentrations in micro-purge probes versus elapsed time since installation

Discussion

On an average, the macro-purge probes reached 56 percent, 68 percent, 72 percent, and 85 percent of the final TCE probe concentrations after 1 hour, 2 hours, 4 hours, and 8 hours, respectively. Concentrations of TCE and PCE continued to increase slightly after 8 hours (Figures 7 and 8). After approximately 24 hours, the measured concentrations appeared to stabilize and are assumed to be more representative of *in-situ* conditions.

Discussion (cont.)

The micro-purge vapor probes appeared to reach equilibrium within the first hour after installation and on an average were within 79 percent of the final TCE probe concentrations immediately after installation. This relatively fast equilibration in comparison to the macro-purge probes is likely because the micropurge system results in much less disturbance to the subsurface during installation. While the macropurge probe construction requires drilling the borehole, removing the drill rod, and then pouring the probe construction materials into the borehole (sand and bentonite), the micro-purge probes are placed directly into the subsurface with the probe-rod, and the rods are left in the ground during sampling. However, the micro-purge samples showed more scatter than the macro-probe data, even after 24 hours. The variability in the micro-purge results may be due to sampling error related to the high vacuum that is used when drawing the samples. Modification of the micro-purge probe design or sampling technique may mitigate some of the variability observed in the VOC concentrations in samples from these probes.

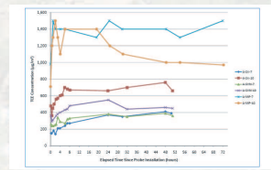

Figure 7: Plot of TCE concentrations in Location A probes versus elapsed time during the first 24 hours

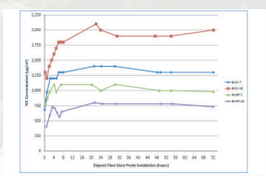

Figure 8: Plot of TCE concentrations in Location B probes versus elapsed time during the first 24 hours

Summary and Conclusions

The decision on how long to wait to sample after installation of industry standard "macro-purge" vapor probes will depend upon how accurate the data need to be. Accuracy within 30 percent is achievable within a couple of hours after installation. Higher accuracy requires longer equilibration times; a minimum of 24 hours is needed to assure accurate results for risk assessment or other accuracy-sensitive uses of the data.

If only one sampling event is planned and probes must be sampled on the same day as installation, the micro-purge probe method may offer advantages. However, further development of the method is needed to assure that reproducible results can be obtained.

References

EPA. 1996. Method 8021B - Aromatic and Halogenated Volatiles by Gas Chromatography Using Photoionization and/or Electrolytic Conductivity Detectors. Test Methods for Evaluating Solid Waste (SW-846). Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C.

259cmb04vapor.db