Assessing Volatile Organic Chemicals in Soils via Passive Sampling

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Background/Objectives. Soils at many sites are contaminated with volatile organic compounds (VOCs) such as fuel-derived hydrocarbons (e.g., benzene, toluene, and the xylenes: BTEX) and chlorinated solvents like trichloroethylene (TCE) and tetrachloroethylene (PCE). In order to evaluate the human health risks, the potential for groundwater resource damage, and the effectiveness of remedial efforts, investigators commonly rely on relatively difficult/costly soil sampling, soil chemical analyses, and assumptions about sorption. We suggest that measures of contaminants' soil gas concentrations can be effective means for addressing these objectives.

Approach/Activities. In order to accomplish site characterization via measures of soil gas concentrations, we have developed and tested a passive sampling approach (i.e., one in which no soil gas pumping is used). We use low density polyethylene (LDPE) which can absorb nonionic organic compounds from the surroundings; knowing those chemicals' polyethylene-air partition coefficients, the resultant concentrations of the accumulated VOCs in the polyethylene can be used to deduce their corresponding soil gas concentrations.
This passive sampling approach involves insertion of polyethylene (PE) strips into soils at sites of concern, leaving them in place for a day or two, and then upon retrieval, measuring organic contaminants accumulated in this plastic. Hence, we developed methods for deploying the LDPE films underground. We used laboratory measures to quantify the LDPE-air partition coefficients. We also tested multiple methods of measuring VOCs in LDPE. Finally, we used this passive sampling system in the lab and at two industrial field sites to evaluate its efficacy.

Results/Lessons Learned. Numerous metrics indicate this approach is successful. First, we have been able to insert and recover LDPE strips into soils by hand to depths of 2 meters and by Geoprobe to depths of 8 meters. Next, the data enabled us to identify the diverse VOC contaminants at each site. Using time course sampling in the field, we find that compounds like BTEX, TCE, and PCE (and many more!) were accumulated to stable concentrations in the LDPE in less than 2 days. Further, multiple samplers (N=4 or 5) deployed with about 50 cm separations at a specific depth (e.g. 50 cm below ground surface) showed accumulated LDPE concentrations with coefficients of variation (standard deviation divided by mean) between 30 and 60%. Detection limits proved to be about 0.1 mg PCE/m^3 soil air, 1 mg TCE/m^3 soil air (ECD or MS detection), and about 0.1 mg individual BTEX/m^3 (FID or MS detection). Finally, deployment of a series of passive samplers at multiple depths below ground readily revealed soil gas concentration gradients indicative of transport potential both to groundwater below and people above. We conclude these data can then be used for site-specific risk assessments (e.g., estimating exposures) and monitoring.