



July 1998

Selection Criteria

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for

Passive Soil Gas Technology

as recommended by W. L. Gore & Associates, Inc.

Why Passive Soil Gas?

The primary objective of employing a passive soil gas technology is similar to all environmental screening level methods. The objective is to reduce the overall cost of an investigation or long-term monitoring program, while increasing the sampling density relative to conventional methods.

Passive soil gas technology was developed and has evolved due to the limitations of other screening techniques, particularly active soil gas. For sites with impact from VOCs and permeable soils, active soil gas methods have been proven effective.

However, active soil gas methods are not applicable on sites with low permeability or poorly-drained soils. This is primarily due to the lack of available soil gases for detection in the short sampling intervals used. The time-integrated, sorbent based approach of passive sampling overcomes these limitations and has been validated on these type of sites.

For investigations where SVOCs or PAHs are the target compounds, passive soil gas technology can be applied successfully. (Research shows that compounds up to and including pyrene can be detected successfully in the vapor phase.) Active soil gas systems are normally limited to VOC investigations.

Passive soil gas systems have also been successfully applied in delineating deeper ground water plumes (up to 100 ft. with appropriate conditions). Due to their limited sensitivity, active methods are normally only applied for shallow soil or ground water investigations.

Finally, it is possible to apply some passive collectors in the saturated zone or directly in monitoring wells to help reduce the cost of long term monitoring programs. The flexibility of passive systems is the result of research & development aimed at addressing the needs of environmental professionals and filling the gaps left by conventional soil gas methods.

Developing and producing an effective passive soil gas survey requires an experienced multidisciplinary team. Understanding the limitation as well as the strengths of passive soil technologies leads to appropriate and successful applications and can avoid misinterpretation and a misunderstanding of the results.



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Collector Installation to Recommended Depths

Soil gas collectors should be designed for installation and retrieval at depths greater than 2 feet without additional casing of the pilot hole.

NJDEP¹ and NGWA² guidelines clearly state that the recommended depth for any soil gas should be 2 to 3 feet below ground surface. Significant loss of sensitivity will occur when sampling for soil gas at shallow depths. This loss of sensitivity is a function of higher outgassing rates near the soil surface, increased microbial activity, and greater impact on the shallow soil environment from precipitation, temperature, and other atmospheric parameters. Under paved or impermeable surfaces, the potential for concentrating soil gas vapor and horizontal migration of soil gases increases the need for adhering to the guidelines for installation depths.



Unimpeded Vapor Migration to the Sorbents

The combination of liquid water condensing inside the collector and the natural tendency for closed-end containers to impede the migration of gases has a significant impact on overall sensitivity.

Allowing soil gases (organics as well as water vapor) to migrate freely or "flux" past the sorbents is important. Closed-end collectors, such as glass vials or tubes, impede the natural migration of vapors to the sorbent. Additionally, glass vials promote condensation on the inside of the collector when installed in the subsurface. This condensed water acts as a "sorbent" by "scrubbing" organic gases back into the dissolved phase making them less available for adsorption on the solid sorbent.

Protection of Sorbents from Soil and Liquid Water

Collector design must employ materials of construction that are chemically itert, and must ensure that the sorbents are protected from direct contact with liquid water or soil particles.

The collector materials must be chemically inert and rugged enough to withstand handling in the field, insertion and retrieval from the subsurface, exposure to the subsurface, and shipping. Direct contact of the sorbent with liquid water or soil particles destroys the integrity of a soil gas sample.

Sorbent Type

Selection of a single sorbent system that optimizes sensitivity to target compounds, hydrophobicity, and minimization of competition for sorption sites by different target compounds is the responsibility of the passive soil gas provider.

Research has been completed that focused on measuring each of these parameters for a wide variety of sorbents. Clearly, the use of activated carbon as a sorbent is unacceptable due to the high uptake of water vapor - some types adsorb up to 70% of their own weight in water vapor.

The result is decreased sensitivity as less sorption sites are available for organic soil gases.



FIGURE Is Water Sarptian Data for Selected Sorbents

Sorbent Packaging

The use of collectors with poorly packaged sorbents introduces variability that impacts results adversely and cannot be measured.

The packaging of sorbents for use in the subsurface must ensure that no sorbent is lost during field use or shipping (every collector must have an identical amount of sorbent). This is a critical consideration due to the relative nature of passive soil gas results. The primary value of the results is the relative distribution of adsorbed compounds across the area of interest.

Sorbent Amount

The impact of having too little sorbent in a passive soil gas collector minimizes overall sensitivity and increases the chance of sorbent saturation at high soil gas concentrations.

Analytical Method

When specifying the analytical method, it is important to consider the overall objective of the soil gas survey and the expectations for applying the results.

The selection of an analytical method is an important criteria as this can have a significant impact on compound identification, QA/QC, data quality, data integrity, and cost. The facility analyzing the soil gas samples must follow a relevant QA/QC plan, have experience in soil gas analysis, and have supporting credentials and approvals for soil gas analyses.

"Field Sampling Procedures Manual, ed. J.R. Schoordeber and P.S. Morton, New Jerrey Department of Environmental Protection and Energy, 364pp., 1992



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GORE SORBER® EXPLORATION SURVEY GORE SORBER® SCREENING SURVEY

ANALYTICAL METHOD SUMMARY & QA PROCEDURES

Instrumentation consists of state of the art gas chromatographs equipped with mass selective detectors, coupled with automated thermal desorption units. Sample preparation simply involves cutting the tip off the bottom of the sample module and transferring one or more exposed sorbent containers (sorbers, each containing 40mg of a suitable granular adsorbent) to a thermal desorption tube for analysis. Sorbers remain clean and protected from dirt, soil, and ground water by the insertion/retrieval cord, and require no further sample preparation. Samples remain frozen until analysis and unanalyzed sorbers are archived in the freezer for potential future analysis.

Analytical Method Quality Assurance:

The analytical method employed is a modified EPA method 8260A/8270B. Before each run sequence, two instrument blanks, a sorber containing Sug BFB (Bromofluorobenzene), and a method blank are analyzed. The BFB mass spectra must meet the criteria set forth in the method before samples can be analyzed. A method blank and a sorber containing BFB is also analyzed after every 30 samples and/or trip blanks. Standards containing the selected target compounds at three calibration levels of 5, 20, and 50µg are analyzed at the beginning of each run. The criterion for each target compound is less than 35% RSD (relative standard deviation). If this criterion is not met for any target compound, the analyst has the option of generating second- or third-order standard curves, as appropriate. A second-source reference standard, at a level of 20µg per target compound, is analyzed after every ten samples and/or trip blanks, and at the end of the run sequence. Positive identification of target compounds is determined by 1) the presence of the target ion and at least two secondary ions; 2) retention time versus reference standard; and, 3) the analyst's judgment. As an option, data deliverables can be provided for all samples and blanks analyzed.

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Impact of Passive Soil Gas Collector Design and Installation Depth on Sensitivity

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Objective

The objective of this experiment was to identify the impact that installation depth and collector design (sorbent housing) have on the sensitivity of passive soil gas surveys. Comparisons were made between sorbent housed in small, inverted glass vials (open on one end) and GORE-SORBER[®] Modules, both installed to different depths below the ground surface.

Site Description

The test site is an industrial facility that has been impacted with chlorinated solvents. The subsurface geology consists of silty clay shales and the depth to groundwater is approximately 10 feet bgs.

Field Sampling

GORE-SORBER Modules were installed at 3.0 inch and 30.0 inch depths across an area of the site with known groundwater impact. The same sorbents (types and amounts) were placed in small (10 ml) inverted glass vials, and installed in separate pilot holes directly adjacent to the GORE-SORBER Modules. The glass vials, installed to 30 inch depths, were placed in pilot holes that were cased with a 1.0 inch ID copper pipe to allow for installation and retrieval from this depth. All four installations were no more than 12 inches apart to insure sampling of a similar subsurface environment. Exposure time was 14 days for all samples. All of the sorbents used were of an engineered design to be "hydrophobic", which minimizes the sorption of water vapor leaving more capacity for the sorption of volatile organic compounds (VOCs).

Analysis

After exposure, all samples were retrieved and returned to the laboratory for analysis via thermal desorption, gas chromatography and mass selective detection.

Results

The results are depicted on the attached figure. These results illustrate clearly that for deeper installations sensitivity is increased significantly (one order of magnitude for similar collector housing) These findings support recommendations in the NJDEP (1992)¹ and DeVitt et al. (1987)² for optimum soil gas sampling at depths greater than two feet.

Further, the results demonstrate a more sensitive soil gas response for sorbents housed inside the GORE-SORBER Modules when compared to sorbents placed inside the inverted glass vials. One potential reason for the limited sensitivity to soil gas collection and detection in the glass vials includes the elimination of soil vapor flux past the sorbents in a closed-end container. In addition, the effect of water vapor condensation on the inside wall of the glass vial allows VOC gases to be dissolved back into the liquid phase, making them unavailable for detection in the vapor state.

Fleid Sampling Procedures Manual, ed. J.R. Schoonleber and P.S. Morton, New Jersey Department of Environmental Protection and Energy, 364pp., 1992

Devit, Dale A., Evans, Roy B., Jury, William A., and Starks, Thomas H., Soil Gas Sensing for Detection and Mapping of Volatile Organics, National Groundwater Association, Dublin, OH.



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Passive Soil Gas Results for Sorbents in Glass Vials and GORE-SORBER[®] Modules

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Installation Depth Guidelines for Passive Soil Gas Sampling

The depth of soil gas sample collection can have a significant impact on the success or failure of a soil gas survey. The following are primary justifications for installing soil gas collectors below the first foot (1.0 ft.) in the subsurface and preferably to a depth of 2-3 ft. below grade. This does not ignore the fact that on certain sites this may be the only option, such as those with UXO concerns. On these sites caution should be taken and the following points should also be considered when interpreting results:

- lateral migration of soil gases can occur at shallow depth below concrete, paved surfaces, packed surface soil or frozen soil, potentially exagerating the lateral dimensions of a subsurface source (see diagram) and resulting in false positive information.
- potential for near surface background contamination/interference from vehicle exhaust and other ambient air contaminants.
- potential for shallow soil contamination from surface spills that may interfere with the true objective of the investigation.
- barometric pressure, wind, temperature gradients and temperature fluctuations near the surface can cause rapid changes in, or even totally deplete, surface soil gas availability (see attached).
- biological activity and soil saturation in wet weather are most pronounced in the upper few inches of the soil profile and can mitigate or block organic vapors.



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COMPARISON OF PASSIVE SOIL GAS SAMPLING METHODS USED FOR DELINEATION OF A TCE PLUME US ARMY CORPS OF ENGINEERS, OMAHA DISTRICT

OBJECTIVE

- Determine the extent of subsurface impact by TCE, and yield data to support an appropriate site characterization strategy.
- Compare the effectiveness of two different passive soil gas sampling technologies, the GORE-SORBER® Screening Survey (GSSS) and the EMFLUX® Passive, Non-Invasive Soil-Gas Survey (EMFLUX).

SITE INFORMATION & SURVEY DESIGN

- The site is an abandoned Atlas missile facility in the central plains. Site soils are composed of glacial till and loess deposits. Depth to groundwater ranges from 21 to 28 feet, and has a east to southeast direction of flow. A portion of the site was concrete-paved. At the time of surveys, the upper soil horizons were frozen. Additionally, soils to the west of the silo were waterlogged and had occasional standing water.
- One monitoring well at the site contained TCE. TCE and 1,2-DCE were detected in grab soil and/or groundwater samples collected from soil borings east and west of the silo. Vinyl chloride was detected east of the silo.
- The EMFLUX collectors were installed in accordance with the manufacturer instructions, and exposed during a period of favorable earth tides, as predicted by the manufacturer. The GORE-SORBER® modules were installed as directed by the manufacturer instructions, and exposed for 14 days, in accordance with the client's schedule.

RESULTS

- TCE was detected at low levels by both soil gas surveys east of the silo in the vicinity of the monitoring well. To the west of the silo, where soils were poorly drained and had occasional standing water, the GSSS also reported low levels of TCE. No detectable levels of TCE were reported in the EMFLUX survey in this area.
- *Cis-* and *trans-1,2-DCE* were detected at high levels by the GSSS, with a similar distribution to that observed for TCE. EMFLUX reported 1,2-DCE as non-detects at all sample locations.
- Vinyl chloride was detected in high levels by the GSSS at one location with correspondingly elevated levels of 1,2-DCE. Vinyl chloride data were not reported by the EMFLUX system.

CONCLUSIONS

- The GSSS provided definition of TCE, 1,2-DCE, and vinyl chloride contamination that was consistent with the limited soil and groundwater data.
- The levels of TCE, 1,2-DCE and vinyl chloride in soil gas, confirm that natural attenuation is
 occurring across the site. This observation is important to the development of subsequent site
 sampling and site remediation strategies.
- The EMFLUX system did not detect known 1,2-DCE contamination.
- The EMFLUX system did not detect known TCE contamination in the area of poorly drained soils and
 occasional standing water west of the silo.

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DETECTION OF 2.4.6-TRINITROTOLUENE SOIL VAPORS WITH A GORE-SORBER® SCREENING SURVEY AT A FORMER SHELL WASHOUT AREA

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OBJECTIVE

The objective of this survey was to demonstrate the applicability of GORE-SORBER® Screening Surveys (GSSS) in delineating the relative distribution of low volatility, high molecular weight nitroaromatic explosives in the subsurface, specifically 2,4,6-trinitrotoluene (2,4,6-TNT). These compounds are often associated with the manufacturing of explosives, as well as the processing and loading of shells and munitions at military sites. The study area was selected because of the known presence of explosive residues in surface soils and water.

SITE INFORMATION & SURVEY DESIGN

The site is a former shell wash-out area located in the eastern United States. A drainage swale leads from the shell washout area to a lagoon located downgradient. "Pink water" was visually evident in surface waters adjacent to the lagoon. Twenty-six (26) GORE-SORBER® Screening Modules were emplaced within the shell washout area, at a depth of approximately three feet. Each module contained three replicate sorbers filled with Tenax®-TA. The modules were deployed along two perpendicular transects, centered over the outlet of the swale, and left exposed for nineteen days.

FIELD RESULTS

After retrieval, exposed modules were analyzed via thermal desorption / gas chromatography / mass spectroscopy (TD/GC/MS) at Gore's laboratory, while replicate samples were also analyzed via HPLC/UV (SW846, Method 8330). Results for both methods are shown in the attached contour maps. 2.4.6-TNT was detected in 12 modules via TD/GC/MS, while it was detected in 10 modules with HPLC/UV. The distribution of 2.4.6-TNT on the two maps shows the two methods compared favorably in detecting this compound from the exposed soil vapor modules at this site. The soil vapor results also compared favorably with analyses of soil and surface water samples collected from the area surveyed. These results are also posted on the attached maps.

BENCHTOP WORK

Three soil and two surface water samples were also collected from the site for additional laboratory experiments. The objective was to more directly identify the efficacy of adsorbing 2.4.6-TNT in the vapor phase and determine the validity of using TD/GC/MS as a method of desorption and analysis for this nitroaromatic explosive.

GORE-SORBER[®] Modules were exposed to the headspace of these samples in sealed containers for two weeks. Modules were analyzed via HPLC/UV and via TD/GC/MS with results for 2,4,6-TNT shown in the table below. Low levels of other nitroaromatics, especially 2,4- and 2,6-dinitrotoluene, were also detected.

The soil and surface water samples were also found to contain significant levels of RDX and HMX. These compounds were not detected in the exposed Screening Modules by either method. This may indicate that these compounds do not have sufficient vapor pressure to be detected by soil gas techniques.

In summary, sorbers exposed to the headspace of soil and surface water matrix samples contain 2.4.6-TNT in proportion to the matrix samples. 2.4.6-TNT detected in Screening Modules using Gore's TD/GC/MS screening method was in good agreement with analysis via Method 8330.

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Soil or water Sample	Sou or water Sample	Screening Module	Screening Module
Identification	8330 LC/UV	8330 LC/UV	TD/GC/MS 👘
iS	2100 mg/kg	31.0 µg	10.1 µg
25	290 mg/kg	9.2 µg	2.4 µg
3S	3600 mg/kg	14.0 μg	11.9 µg
1W	15000 mg/L	22.0 µg	14.4 μg
2w	016 me/l	0.08.0.0	n d

Note: The amount of soil and surface water in the "TD/GC/MS modules" was half of that in the "HPLC/UV modules". Tenax is a registered trademark of Buchem, N.V.



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