Field Trial of a New Commercially Available Diffusive Ground-Water Sampler

by Andrew W. Alexander and Thomas L. Lammons

Abstract

Field trials of a new commercially available diffusive ground-water sampling device were conducted at two industrial properties in the Blue Ridge Province of North Carolina. The test sites have extensive monitoring well networks and more than five years of historical water quality data. Volatile organic compounds (VOCs) including purgeable aromatics (petroleum hydrocarbons) and halogens (chlorinated solvents) have impacted the ground water of the subject properties. These target compounds were used as a basis to evaluate the effectiveness of diffusive ground-water samplers.

The diffusive sampling devices consist of a polyethylene membrane capsule suspended in a flexible protective covering. They are filled with supermarket-grade distilled water, sealed, and suspended in the saturated zones of monitoring wells. Natural diffusion of VOCs from the ground water into the sampler occurred until chemical equilibrium was reached. The devices were then removed and the water within the sampler was analyzed for VOCs by standard laboratory methods.

In the field trials, data from laboratory analysis of the diffusive samples was compared with laboratory data from contemporaneous conventional bailing and sampling. The results demonstrate favorable comparison between the data sets. The diffusive samplers provide an inexpensive and accurate alternative to conventional bailing and sampling methods. The devices have been shown to be suitable for long-term ground-water quality monitoring of VOCs and may also be useful for site screening or other assessment programs.

Introduction

The use of diffusion technologies for environmental sampling has been well documented in the literature (Vroblesky and Hyde, 1997; Karp, 1993, Vroblesky et al. 1991, 1992, 1994, 1996). The previous studies have relied on the ability of the subject target compounds, usually volatile organic compounds (VOCs), to diffuse across a polyethylene membrane. The majority of the published work has been performed as part of either soil vapor studies or experimental ground-water sampling projects using custom-made devices specifically designed for the project. A commercially produced device has not been available for use, until now.

Bunnell-Lammons Engineering, Inc. (BLE) adapted the earlier diffusive sampling devices for field trials at two industrial sites in North Carolina. EON Products, Inc. (EON) of Lithonia, Georgia manufactured the devices in response to BLE's technical input. The device's practical design is based on field testing.

The purpose of this study was to evaluate the accuracy, ease of use, and cost savings of the diffusive samplers as compared to a conventional bailing and sampling program. Dissolved VOCs, including petroleum hydrocarbons and chlorinated solvents, are present in the ground water of the test sites. The ground water from 28 wells, including standard 2-inch diameter monitoring wells, 6-inch diameter open bedrock wells, and a 6-inch diameter recovery well was tested using diffusive samplers. The results are presented herein.

The diffusive samplers are capsules constructed of flexible 4-mil polyethylene membrane. They are filled with supermarket-grade distilled water, sealed, and suspended in the saturated zones of the test wells until the dissolved VOCs in the ground water reach chemical equilibrium with the distilled water in the sampler. The devices are then removed and the water in the samplers is analyzed in the laboratory for VOCs.

Methodology

The devices are approximately sixteen inches long. The polyethylene membrane capsule is suspended in a protective flexible mesh polyethylene covering. The samplers were completely filled with approximately 300 ml of distilled water and sealed with a solid polyethylene plug at the posterior end (bottom) of the sampler. The plug is held in place by friction, no glue or welding is necessary. The anterior section (top) is constructed with a flexible polyethylene loop for easy connection to a securing line with quick-connect attachment. The aforementioned posterior section (bottom), is constructed of ridged polyethylene. A stainless-steel weight and hanger attaches to the bottom of the sampler.

Once filled, the samplers are lowered into the test well to a predetermined depth where natural ground-water flow is occurring. These depths are variable and are based on the screened interval of the well, the available water column, and the location of water bearing fractures or strata in the borehole. The samplers are left in place until chemical equilibrium with the ground water in the well has occurred. The samplers in this study were left in place for 26 to 27 days.

At the designated time, the samplers are retrieved and the distilled water in the sampler is transferred into standard environmental-laboratory-grade 40-ml VOC vials. This process is easily performed by removing the solid plug in the bottom of the sampler and pouring the contents into a vial in a manner similar to that used for a standard bailer. The samples are then transported to a laboratory for analysis of VOC concentration. The samples in this study were analyzed in a North Carolina certified laboratory for purgeable halocarbons and aromatics by EPA Methods 601 and 602, respectively.

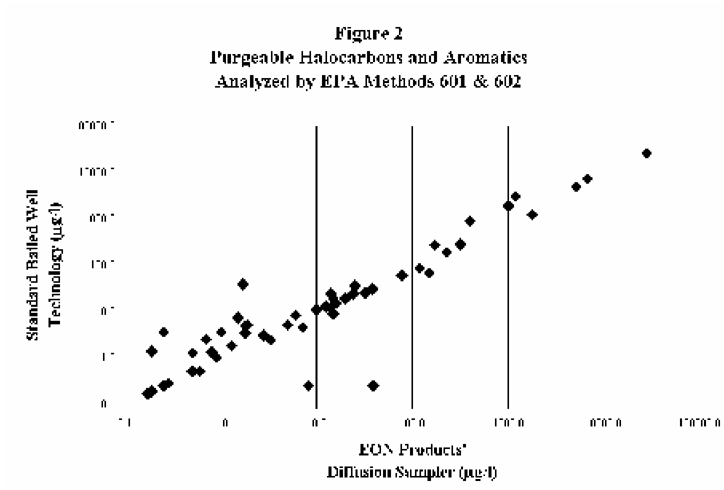
In this study, quality control (QC) samples were maintained, collected, and submitted for analysis. The QC samples included laboratory blanks of the supermarket-grade distilled water and field blanks of the sampler water from diffusive samplers that were filled but not deployed. The laboratory blanks of the supermarket-grade distilled water were sampled directly from the store-bought containers at the time the diffusive samplers were filled. The field blank samples were collected from diffusive samplers that were held in reserve and stored in sample coolers during the field equilibration period. The diffusive field blanks were transported to the site and exposed to the site conditions (ambient air) during deployment of the remaining samplers. The diffusive sampler blanks were filled contemporaneously with the diffusive samplers that were field deployed.

The results of this study are from a one-time event conducted at both properties during December 1997 through January 1998. The ground-water contaminants at Site A include 1,2-

dichloropropane and 1,2-dichloroethane. The contaminants at Site B include benzene, toluene, ethylbenzene, and xylenes (BTEX) and tetrachloroethene (PCE) with associated breakdown products. Twenty-eight samples were collected from ground-water monitoring or recovery wells. Four QC samples were also collected for analysis.

Results and Discussion

A summary of the laboratory data is presented on the attached Table 1. Those results are also plotted on Figure 2 (at right). The plotted data set includes "non-detect" values plotted as ½ of the laboratory detection limit. Including non-detects, 180 data points are shown. Those data points (excluding non detects) include the following compounds with their associated number of occurrences and normalized percentage of the data set shown on the table below.



Compound	Number of Occurrences	Percentage of Data Set
1,2-dichloropropane (1,2-DCP)	9	20%
1,2-dichloroethane (1,2-DCA)	2	4%
benzene	1	2%
toluene	1	2%
ethylbenzene	1	2%
xylenes	1	2%
MTBE	1	2%
tetrachloroethene (PCE)	4	9%
trichloroethene (TCE)	7	16%
chloroform	1	2%
vinyl chloride	2	4%
1,1-dichloroethene (1,1-DCE)	3	7%
1,1-dichloroethane (1,1-DCA)	1	2%
1,1,1-trichloroethane (1,1,1-TCA)	3	7%
cis-1,2-dichloroethene (1,2-DCE)	8	18%

The distribution of the concentrations shown indicate that the diffusive sampler results closely match those of the results of the standard bailing and sampling program at concentrations ranging from non-detect to nearly 30,000 parts per billion. Some scatter occurs in the data below 10 parts per billion. The variability in the data can be attributed to the lack of precision of the analytical laboratory instrumentation at very low detection limits (Smith, 1997). No compounds were detected in the QC samples.

The diffusive samplers are easy to use and require only minimal training for their use. Personnel with experience in conventional bailing and sampling programs will be able to fill, deploy, retrieve, and empty the samplers with minimal effort. If the diffusive samplers are used as part of long-term ground-water monitoring program, the new samplers can be deployed as the old samplers are retrieved for analysis, thus reducing field time requirements. Quick-connect fasteners can speed this process considerably. The samplers can also be used for discrete interval sampling in a single wellbore, allowing for the collection of undisturbed samples from specific target depths. Additionally the equipment requires no maintenance or decontamination.

It is estimated that a cost savings of 50% to 75% can be expected when diffusive samplers are used over conventional bailing and sampling programs. The cost savings include the following time and material items that are normally incurred during conventional bailing and sampling programs: 1) personnel for ground-water purging, 2) purge water storage, transportation, and disposal, 3) the need for extensive personal protective equipment for sampling personnel, and 4) decontamination and maintenance of purging and sampling equipment.

Conclusions

Diffusive ground-water samplers are an inexpensive and accurate alternative to conventional bailing and sampling. The devices are suitable for long-term ground-water quality monitoring of VOCs and may also be useful for site screening or other assessment programs. Other programs may include sampling of vertical water quality variability within a borehole, pond, or other media. The use of the technology in small diameter boreholes and for compounds other than VOCs are under development.

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Biographical Sketches

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