TechData Sheet

Naval Facilities Engineering Command
Washington, DC 20374-5065

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Diffusion Membrane Samplers

A Low-Cost Alternative Groundwater Monitoring Tool for VOCs

BACKGROUND

The traditional procedure to sample groundwater is to purge the well and extract the sample with a bailer or pump system. The purged water, typically 3 well volumes, must be tested, handled and properly disposed as investigative derived waste (IDW). The sampling equipment must be decontaminated, maintained and rented or purchased. Additional logistics such as a pump power source and local IDW requirements increase the effort of a sampling event. Excessive pumping rates could be undesirable, since this increases the radius of influence around the well and results in sampling of well water that may be an integration of different water types. Low-flow sampling methods were introduced to target a specific depth, reduce the water column disturbance, and to minimize the amount of purge water and the radius of influence. However, these methods do not eliminate typical pumping logistics or problems inherent in pumping water samples.

For about 10 years, the U.S. Geological Survey (USGS) studied various types of inexpensive, simple diffusion samplers as an alternative groundwater sampling method to eliminate problems associated with the traditional sampling process. Diffusion samplers are polyethylene bags containing deionized water. The samplers are submerged in a well and can "target" specific depths within the screened or open interval (Fig. 1). After allowing the samplers and the well water to equilibrate following deployment, usually for 14 days, the samplers are removed from the well, and the water within the sampler can be analyzed by routine lab methods. Studies have shown the volatile organic compound (VOC) concentration in undisturbed water within the screened interval can be representative of concentrations in the adjacent aquifer. A passive sampling method, then, such as diffusion samplers, has the potential to provide representative concentrations of aqueous contaminants as they exist in the undisturbed subsurface.

SCIENCE AND FIELD IMPLEMENTATION

The samplers operate on the membrane diffusion principle – net chemical migration occurs across a semipermeable membrane until equal chemical concentrations exist on both sides of a membrane (Fig. 2). USGS performed laboratory tests showing the efficiency of membrane diffusion samplers with VOCs of environmental interest. Diffusion samplers were submerged into a chemical cocktail containing over 40 types of VOCs at 21°C. Figure 3 shows results for some typical VOCs from that study.

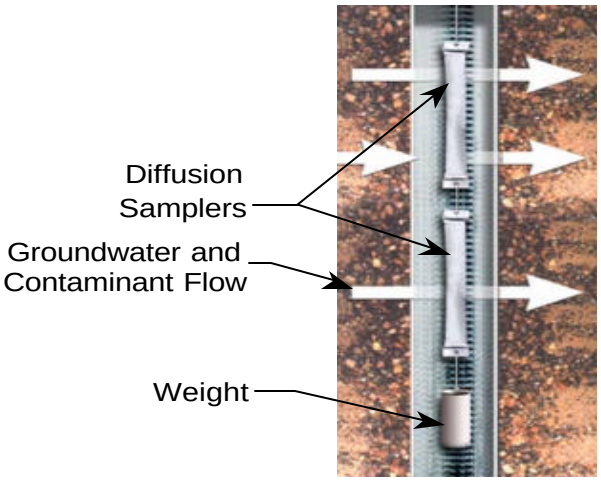

Figure 1 – Diffusion samplers placed at multiple depths to define vertical contamination profile

A sampler(s) can be suspended at one or many depths to better study the condition of different hydrogeologic features and vertically profile the contaminant distribution. Figure 1 illustrates a "stack" of samplers used to study the

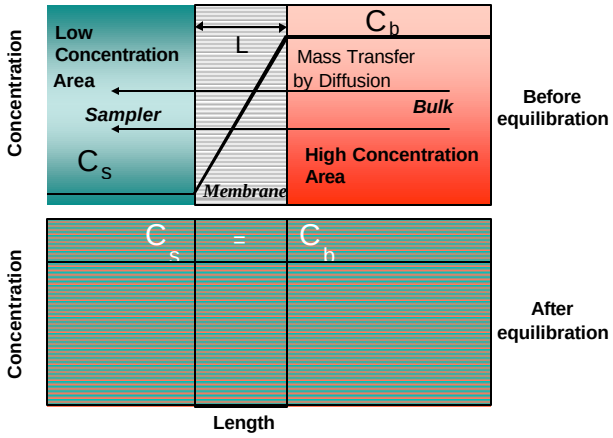

Figure 2 – Equilibration by diffusion

subsurface vertical distribution of contaminant within the screened section of a well.

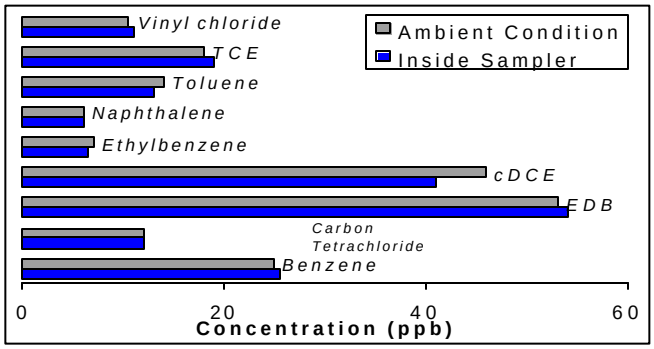

Figure 3 – Membrane diffusion efficiency, after 14 days

ADVANTAGES OF DIFFUSION SAMPLERS

- Retrieves groundwater samples at a very low cost
- No purge water to handle, test, and dispose of
- No equipment decontamination required
- Simple logistics and operation (no moving parts)
- Reduces personnel exposure time to chemicals
- Samples represent formation water adjacent to the well
- Provides vertical profiling of a water column
- Appropriate for long-term monitoring

LIMITATIONS

- Requires equilibrium time, usually 14 days
- Current membrane does not work for some contaminants including methyl tertiary butyl ether (MTBE), polychlorinated biphenyl (PCB), and metals contaminants.

CURRENT DEVELOPMENTS

The Navy, Air Force, Interstate Technology Regulatory Cooperation, and USGS are working together on a joint sampling protocol and distribution is expected in mid-2000. The DON Remedial Action Operation Long Term Monitoring Optimization Working Group studied their effectiveness and recommended diffusion samplers for long- term monitoring at some sites.

NAVY CASE STUDY

Engineering Field Division South performed a pilot project using diffusion samplers. At Naval Support Activity (NSA) Mid-South, diffusion samplers were used to gather groundwater samples to compare cost and performance with the traditional purge and low-flow pump method. The material cost for diffusion samplers and the traditional purge and pump is shown in Figure 4. Initial costs of the traditional technique included the rental of electrical generator, pump, and water quality monitoring instruments. These costs *exclude* technician labor, and IDW handling, testing and disposal. Using diffusion samplers, the field work took 4 days. Traditional sampling was expected to take over 2 weeks. Thus, material and labor cost avoidance are expected when using the diffusion samplers compared to traditional purge and low-flow sampling techniques.

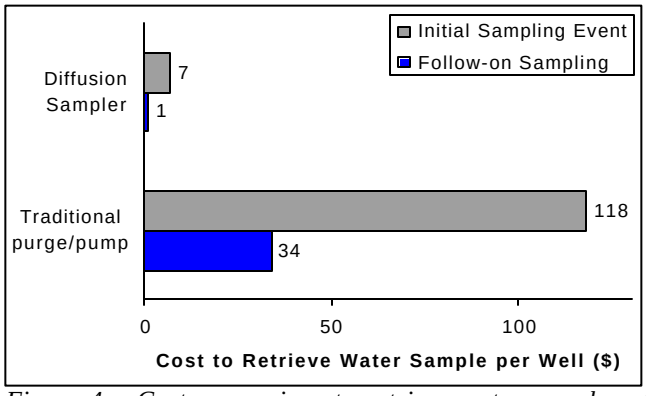

Figure 4 – Cost comparison to retrieve water samples at NSA Mid-South

The laboratory results from water samples gathered by the conventional purge/low-flow pump technique is very similar to those obtained with diffusion samplers. To compare, one well water column was characterized by suspending five 2-foot diffusion samplers over a 10-foot screened section. The traditional pumped sample was taken at the midpoint of this investigation zone. The results are presented in Figure 5. The results clearly show a concentration gradient as a function of depth over this 10-foot section.

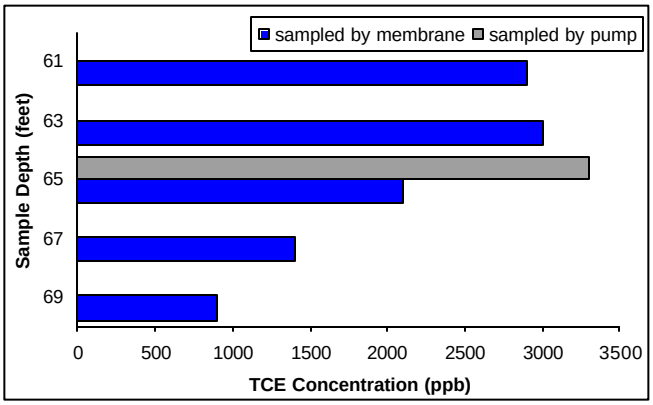

Figure 5 – Lab results comparing samples obtained by diffusion membrane and low-flow pumping

FOR FURTHER INFORMATION...

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REFERENCE:

Casey, Cliff. "New Sampling Method Cuts Time and Cost." NAVFACENGCOM South, RPM News. Summer 1999.