

Membrane Interface Probe (MIP) for expedited DNAPL delineation

Alex Nadolishny¹, Michael T. Fraser

Abstract: The Membrane Interface Probe (MIP) is a rapid, high-resolution in-situ VOC screening technology that provides real-time data about relative VOC concentrations and soil lithology, as well as the presence of ionic contaminants or a salt-water intrusion. The MIP Technology has been successfully utilized on a number of sites for the purposes of DNAPL delineation and characterization. The technology demonstrated good correlation with analytical results and provided significant cost savings by providing real-time information used for the optimization of the groundwater sampling program. Our MIP team has implemented a number of improvements to the design of the MIP equipment that resulted in significant reduction of on-site downtime and improved overall reliability. A set of Standard Operating Procedures (SOP), QA/QC procedures and the guidelines for the interpretation of the MIP system output have been developed during past two years.

Direct Sensing tools have been first used for the purposes of subsurface environmental data acquisition by vendors and users of Cone Penetrometer Technology (CPT). A number of systems emerged, including LIF (Laser-Induced Fluorescence), ROST (Rapid Optic Screening Tool), and the FFD (Fuel Fluorescence Detector). All of the above tools have been relying on physical phenomenon of fluorescence, characteristic to many contaminants of concern on hazardous waste sites. The principles of operation, combined with the platform (CPT units) led to relatively high cost of deploying these technologies on site. This limited the use of the above tools to very large sites where the benefits of Direct Sensing tools, such as dramatic reduction of Investigation-Derived Waste, lab analysis cost reduction and the availability of real-time information could outweigh relatively high daily cost of the service.

The Membrane Interface Probe (MIP) technology was developed by Geoprobe Systems of Salina, KS as a low-cost alternative to the CPT-deployed sensors. The system relies on transfer of VOC contaminants present in the subsurface across patented heated fluoropolymer membrane (see Figure 1). The contaminant molecules then enter the stream of carrier gas and are transported to the surface, where a detector array is located. The segregation of sensitive and expensive detector equipment from rugged and inexpensive down-hole components of the system made the MIP system compatible with low-cost and prolific percussion-based soil sampling machines.

Initial applications of the MIP equipment were limited to petroleum sites, using Photoionization (PID) and Flame Ionization (FID) detectors. When used on sites contaminated with halogenated solvents, such configuration demonstrated very high detection limits and inconsistent correlation with analytical results, due to poor performance of the utilized detectors with halogenated compounds.

¹ Vice President, Technology Development, Nedatek, Inc., New York Branch, 334 Orchard Road, Jefferson Valley, NY 10535. Ph 914.879.8071, Fax 413.702.8127, alex@nedatek.com

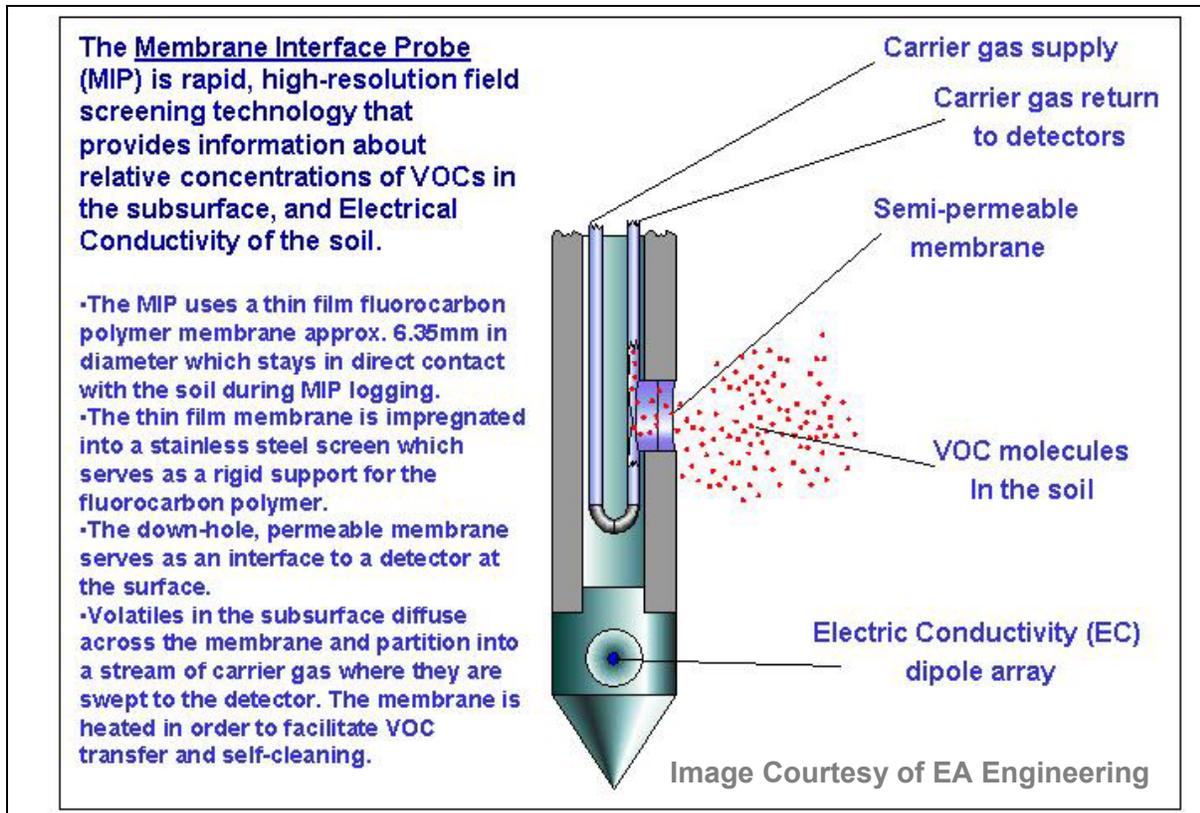


FIGURE 1

The authors have installed Electron Capture Detector (ECD) on a MIP unit owned by ZEBRA Environmental Corporation in 1999. Although ECD is extremely sensitive to halogenated hydrocarbons, initial field trials demonstrated very high interference of water vapor with the ECD response. The water vapor migrates into the carrier gas stream across the MIP membrane; the amounts of the vapor increase with the membrane wear as well as the depth of logging, the latter due to increasing barometric pressure.

The interference has been minimized after installing an in-line sample dryer. This allowed achieving detection limits of 500 ppb for several halogenated compounds, while the remaining moderate quenching of the ECD signal reflected on the log provided valuable information about location of the groundwater interface. A somewhat lower sensitivity of the system to polar compounds was observed after the installation of dryer.

The MIP was subsequently used on several large sites for the purposes of precise delineation of DNAPL and dissolved-phase halogenated hydrocarbons. The detection limits were further improved after implementing a different logging protocol based on matching logging regime to the physical properties of target compounds. The authors were able to achieve consistent detection of TCE and DCE in groundwater (in silty and sandy formations) at concentrations as low as 190 ppb.

Dense Non-Aqueous Phase Liquid (DNAPL) has been positively identified using the Membrane Interface Probe system after establishing a site-specific correlation between

the detector response and the presence of free product. Typically, DNAPL conditions produce a very characteristic MIP log featuring detector saturation at a certain detector Range and signal Attenuation settings. The actual value on the micro Volt scale of the ECD detector corresponding to the DNAPL conditions is site-specific and depends on several factors, such as the soil grain size, specific compound being detected, depth of logging and thermal adsorption capacity of the formation. An empiric correlation is easily obtained by performing a “reference” MIP log either at a location with a known concentration of the contaminant, or by performing a subsequent discrete groundwater sampling at the location.

In the example below (Figure 2), the MIP logging indicated potential DNAPL conditions at the 55-58’ bgs interval (Detector 1 is PID and Detector 2 is ECD). A discrete groundwater sample collected from the interval contained globules of a separate phase product (freon).

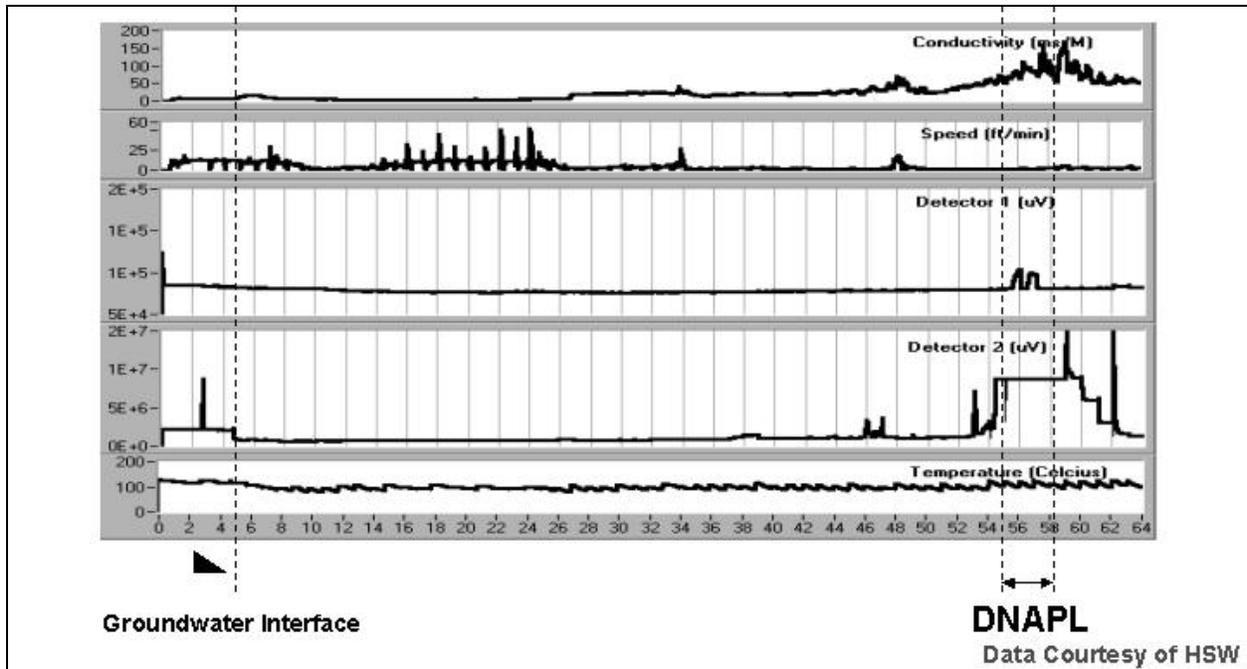


FIGURE 2

The use of the MIP technology in conjunction with discrete groundwater sampling to delineate contaminant plumes provides an average 20% cost saving when compared to conventional sampling-based approaches.

References

Calderone, G.M., P.A. Conde, A. Nadolishny, and M. Evans. 2000. Using Membrane Interface Probe for Delineation of Chlorinated Solvent Plume. Paper presented at the EnviroExpo, Session on Innovative Technologies for Site Remediation, Boston, Massachusetts. 11 May.