Automating the Monitoring Process

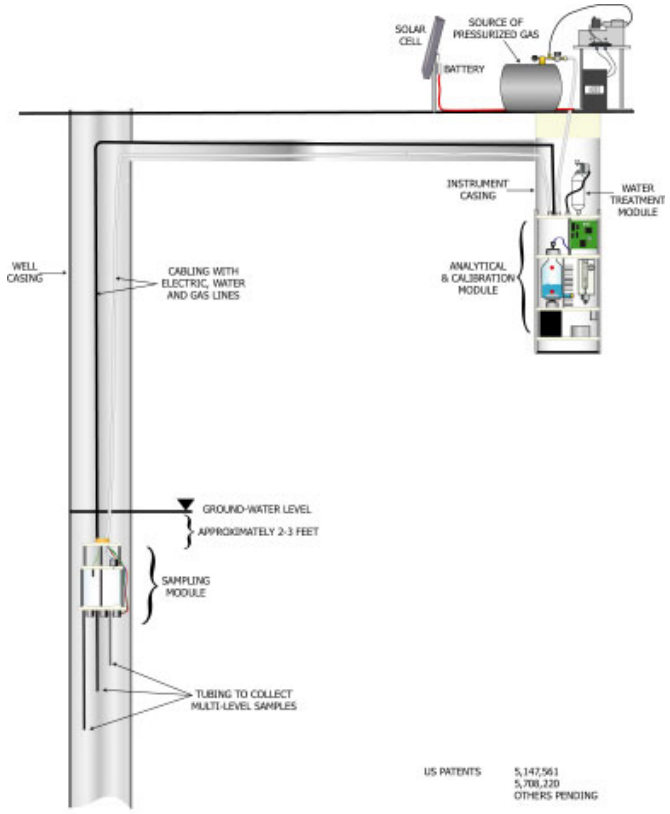
Burge, S.R.[1] and Hoffman, D.

Abstract: Monitoring of contaminants at environmental sites throughout the United States will be required for decades after initial characterization and remediation phases have been completed. The costs for long-term monitoring may, in many cases, exceed the cost of remediation. Automating the monitoring process significantly reduces the cost of long-term monitoring by eliminating manual procedures required by current protocols. Burge Environmental designs and fabricates innovative automated ground-water sampling/analysis systems. One system incorporates a trichloroethene (TCE) specific sensor (optrode) in a multi-level sampling system. This in-situ system is capable of analyzing 2 ppb TCE in ground-water from four separate sampling points. A three-step calibration module calibrates the optrode. This module interrogates the monitor insuring quality data. The self-contained monitoring system is powered by a solar cell. The monitoring system is currently being tested at the former Homestead Air Force Base.

Instrumentation

An automated ground-water monitoring system, based on our research, should contain five components or modules to provide a successful long-term solution to monitoring ground water. The modules necessary for a ground-water monitoring system are:

- **Sampling Module**
- **Sensor Module**
- **Calibration Module**
- **Support Module**
- **Control/Data Handling Module**



The modules must be fully integrated and placed in a controlled environment in the monitoring well or in the vicinity of the monitoring well. The sensor and calibration modules may be placed into an auxiliary well adjacent to the monitoring well to accommodate significant differences in the design and construction of monitoring wells, and varying depths of ground water. Temperature control and maintenance of the monitoring system are also facilitated using this design.

1. Burge Environmental, 6100 South Maple Avenue, Suite 114, Tempe, Arizona 85283
(480) 968-5141 voice • (480) 345-7633 fax • www.burgenv.com • burgenv@primenet.com

Sampling Module

The sampling module was designed to interface with sensors mounted in or adjacent to the monitoring well. The sampling module is capable of multi-level sampling in existing wells (up to eight levels). The sampling module is designed to allow for several modes of operation: 1) mounting of sensors directly in the monitoring well, 2) sampling and transporting water to sensor modules at the surface, or 3) purging of the ground water with a carrier gas and transporting the volatile analyte in the carrier gas. The mode of operation is based on the requirements of the particular sensor being employed and the type of well being monitored. The pressure necessary to transfer the water sample is very low, even for lifts of 200 feet, because small volumes (150 to 200 mL) of water are being transferred.

Burge Environmental participated in the ETV program in August of 1999. The tests were performed in a 92-foot high standpipe with sample points located at SP3, SP10, SP12 and SP14 at depths of 90, 53, 35 and 16.5 feet, respectively. The experiment included filling the standpipe with water containing a mixture of organic compounds (1,1-dichloroethene, 1,2-dichloroethane, benzene, trichloroethene, 1,1,2-trichloroethane, and tetrachloroethene). The Burge Environmental sampling module was configured to monitor the four sampling depths within the standpipe. Selected results for TCE are presented on *Table 1*.

Table 1
ETV Results for Trichloroethene
TCE Concentration and %RSD

Level Name	Level Depth, ft	Burge µg/L %RSD	Reference µg/L %RSD	Control Pump µg/L %RSD
Low Conc/Deep	SP3	9.9	10.5	10.3
	90feet	6.6	11.1	12.1
Low Conc/Mid Deep	SP10	13.2	15.4	
	53 feet	10.6	14	
Low Conc/Mid Shallow	SP12	12.1	15.9	
	35 feet	15.5	16.1	
Low Conc/Shallow	SP14	12.3	14.7	12.6
	16.5 feet	5.8	11.1	10.5

The study indicated that multi-level sampling demonstrated good correlation with reference samples and control pump.

Sensor (Optrode) Module

The principle of detection is a quantitative, irreversible chemical (Fujiwara) reaction that forms visible light-absorbing products. The operational basis of the optrode is the measurement of the time history of the development of a colored product formed by the reaction of target compounds (TCE and chloroform), with specific reagents. The rate of change in color is directly proportional to the concentrations of target compounds to which the optrode is exposed.

Approximately 3 to 4 minutes are required to perform an analysis after an equilibrium concentration of TCE is presented to the optrode. The limit of detection for TCE in ground water is 1 to 4 ppb with a linear dynamic range of 5 to 100 ppb. The optrode is specific for TCE and there is no response to tetrachlorethene, trichlorethanes, dichloroethenes or dichloroethanes.

Calibration Module

The calibration module injects a known volume and concentration of standard into the sample vessel. The system is capable of presenting the sensor with a blank and one to four calibration concentrations of TCE. Calibration standards of 30 and 60 ppb TCE concentrations are commonly used in 500 mL of water.

Support and Control/Data Handling Modules

The support modules include the delivery of compressed air (12-volt air compressor) and power (solar cell) to the monitoring system. The data handling system includes the control of the modules, data acquisition and calculations.

Results of the Automated Monitoring System

The monitoring system is currently being tested at the former Homestead Air Force Base southwest of Miami, Florida. Results of the monitoring system compared with laboratory analysis (GC/MS, EPA Method 8260B) are presented on *Table 2*.

Table 2
Former Homestead Air Force Base Study
September/November 2000

Time	Burge TCE	GC/MS TCE	cis-1,2-DCE	Trans-1,2-DCE	PCE	VC
12:54	77	77	66	17	1.9	<1
13:30	83	82	68	18	1.5	<1
14:08	80	81	70	17	1.4	<1
14:37	87	86	70	17	1.4	<1
15:08	87	89	70	17	1.6	<1

The results indicate excellent correlation between the TCE concentrations measured by the Burge instrumentation and the laboratory analysis. The results also indicate the specificity of the optrode to TCE. The testing program will continue through the summer of 2001. We wish to acknowledge the EPA Office of Solid Waste (OSW) Methods Team, EPA Technology Innovation Office (TIO) and Air Force Center for Environmental Excellence (AFCEE) for sponsoring this program.