Contaminated soil – Online measurement of chlorinated compounds in soil-gas

Application Note

The Problem

Contaminated soil is a serious and wide spread problem that normally has to be solved to avoid pollution of the ground water reservoir. Many remedial technologies are available for solving the problem – which to choose depends on the pollution level, chemical substances in the pollution and the geological structure of the ground.

Chlorinated solvents in the sub-surface are very common pollutants, and especially the two solvents PCE (Tetrachloroethylene) and TCE (Trichloroethylene) are often observed. A source of these pollutants is, for example, dry cleaners.

At an actual site, a very cost effective method for *in situ* treatment of contaminated soil was tested. The operating agent for the project was NIRAS Consulting Engineers and Planners. It was sponsored by three Danish counties and the Danish EPA under the Technology Demonstration and Evaluation Programme.

The Tested Technique

Passive soil vapour extraction relies on naturally occurring variations in barometric pressure. In Denmark, this oscillation primarily results from the passage of weather fronts and can be as high as 25 mBar over a 24 hour period. As the barometric pressure rises air is driven into the soil. When the pressure drops, soil-gas will ascend into the atmosphere. When low permeable layers are present above the polluted volume, one can create a one directional flow from the perimeter of the polluted soil volume towards its centre by use of a number of bore holes and a one-way valve. This principle is outlined in the Fig. 2.

Fig. 1 The soil gas probe with the sampling tube connected

The Monitoring Need

To be able to evaluate the efficiency of the remedial system, the amount of pollutant removed from the soil has to be monitored. This is done by measuring the flow and the gas concentration of the soil-gas leaving the one-way valve.

As different compounds might be cleaned up at different speeds, it was decided to monitor 4 gases, simultaneously, during the test period. The 4 gases were:

- Tetrachloroethylene (PCE)
- Trichloroethylene (TCE)
- 1,1,1-Trichloroethane (TCA)
- Chloroform (TCM)

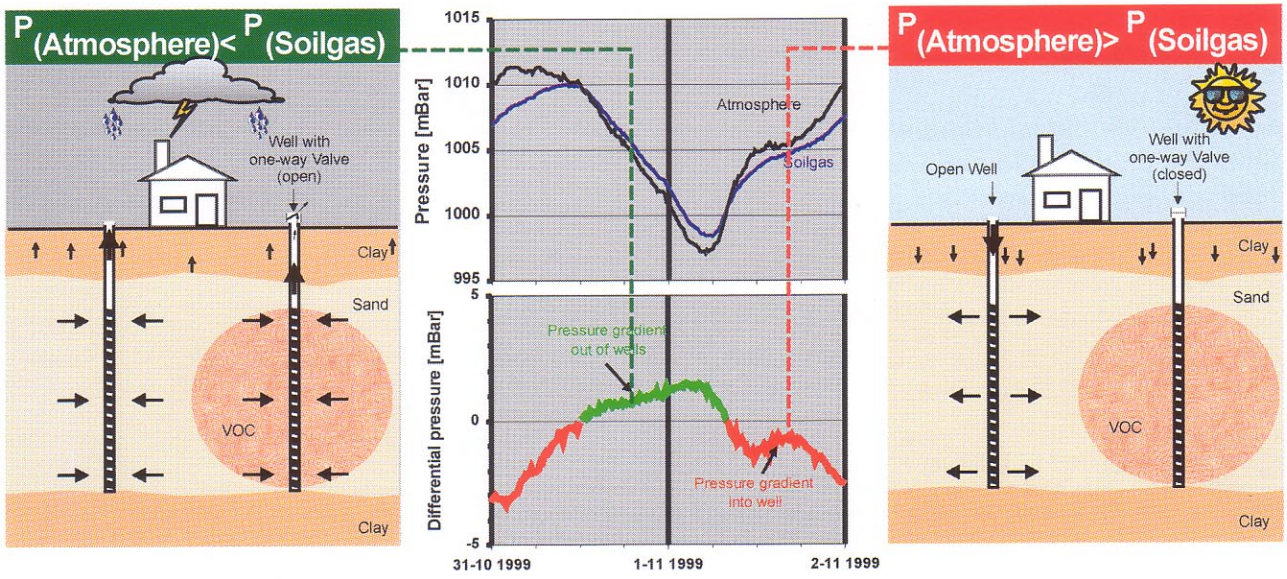

Fig. 2 The working principle of passive soil vapour extraction. (where P = pressure)

Drawing courtesy of NIRAS

The *INNOVA* Solution

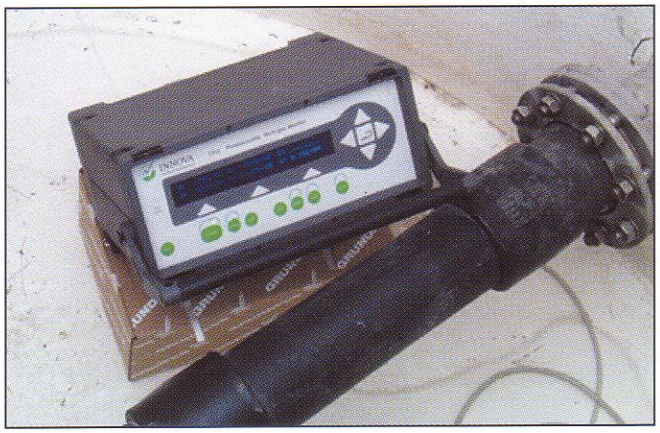

Fig.3 The Photoacoustic Multi-gas Monitor 1312

The Photoacoustic Multi-gas Monitor 1312-5 was chosen for this application because of its following features:

- Long term stability.
- Possibility to measure all four gases simultaneously.
- Ability to compensate the measured values for any interference generated by water vapour or other gases.
- Low detection limit.

The low detection limit and the long term stability of the 1312-5 are characteristics of the photoacoustic measurement principle employed. Low drift (as low as one detection limit per 3 months) is common for this measurement principle.

The interference compensation feature is a mathematical matrix equation, which allows signals from an interfering gas to be cancelled when both the gas in question and the interfering gas are measured. The high quality of the interference compensation is mainly due to the construction of the 3 element optical filters used to define the infrared measurement range for each gas. If needed, the 1312-5 can be configured to measure up to 5 gases and water vapour.

Among the 1312-5 features useful in soil monitoring is the built-in data-logger facility, and the 12 channel multiplexer option.

Measurement Result

The monitoring period lasted 34 days where the soil-gas was measured for chlorinated compounds every 15 minutes. The following maximum concentrations were observed:

Chemical	Max. concentration (mg/m^3)
PCE	15
TCE	350
TCA	61
TCM	5

The measurement showed that the dominating substances in the soil-gas were TCE and TCA.

By multiplying the flow rate in the soil-gas stream by the gas concentrations, the mass removal rate of the four substances was calculated.

The mass removal rate of the TCE/TCA was 45g/24hrs, or 180 - 200g TCE/TCA for the total measuring period.

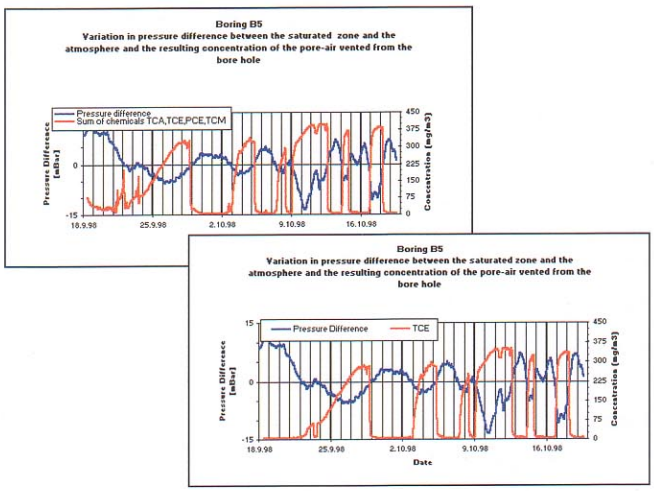

Fig.4 Concentration changes of soil-gas from bore holes
Graphs courtesy of NIRAS

At this site, the removal rate of volatile compounds (primarily PCE and TCE) is expected to be 5kg per year. A quarterly monitoring of the gas concentrations and ground water concentrations is scheduled to indicate the long term effect of the remedial actions.

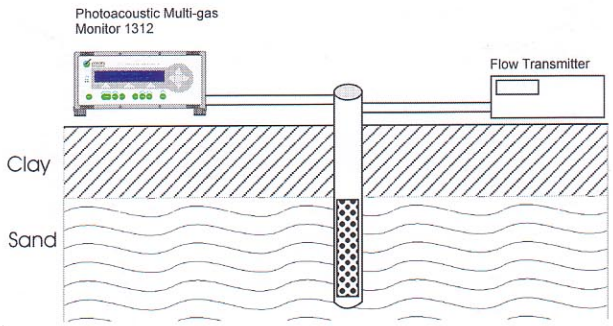

Fig.5 The measurement setup

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