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SURVEILLANCE AND MONITORING OF GROUNDWATER QUALITY

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ABSTRACT

Monitoring oil pollution of groundwater is a stepwise process in which, according to physical phenomena, a network of observation wells is installed and observed. While in first phases there prevails surveillance using geophysical, geobotanical and remote sensing methods, monitoring itself is based mostly on hydrochemistry. Besides spectrophotometry and chromatography, ORP and oxygen measurements seem to be promising indirect on-the-spot methods for the detection of dissolved hydrocarbons. They make use of change in the physico-chemical properties of water due to the presence of organic matter.

INTRODUCTION

The best way how to protect groundwater from deterioration is early detection of contaminats. Oil hydrocarbons (apart from agricultural chemicals) are the main threat to groundwater quality and will therefore be dealt with in the present paper.

In surveillance of pollution use is made of newly developed geobotanical methods, combined with conventional and infrared photography based on the response of plants to pollutants. According to evaluated differences in pictures taken in visible and infrared region of light, a proper program for sampling both soil and water can be worked out. Hydrochemical methods, however, are still the most usefull and reliable ones.

STEPWISE DESIGN OF THE MONITORING NETWORK

Before designing a network, basic knowledge of local hydrogeology must be acquired. For this purpose we use a four-phase program, which also provides information on changes in contaminants both in space and time.

Information gathering phase

Surveillance includes identification of sources, determination of the extent of pollution and of the mechanism of pollutant transport. Water quality is derived from sampled springs, wells and test boreholes. From the last mentioned we obtain data related to groundwater flow and aquifer permeability, as well as to water table fluctuations.

Geophysics is employed to find possible pathways for contaminants in consolidated rocks. Combination of several methods (e.g. electrical profiling, thermometry and emanation measurement) is desirable for the optimal siting of observation wells.

Installation and testing phase

The network of wells is installed, pumping tests and sampling are performed.

Verification phase

Quality monitoring is carried out on the most critical spots. Suitable time intervals must ensure its proper function. The final report includes directions for operation strategy. The monitoring network is then handed over.

Supervision phase

Hydrogeologists supervise proper monitoring which is carried out by users (owners) of the plant being monitored. Table 1 lists recommended indirect methods for surveillance (or monitoring).

Uncertainties exist with respect to the boundary between the terms "surveillance" and "monitoring". Monitoring is generally considered as a more advanced system (using sophisticated instruments) for obtaining long-term series of data. Another difference between the two terms is suggested by Baker (1979) : "Monitoring commonly implies measurements repeated at intervals and compared with a standard, and the term surveillance is used in cases where measurements are repeated at intervals but a standard has not been defined".

Czechoslovak Drinking-Water Standard specifies 0,01 mg/l hydrocarbons as a permissible limit. This value is often exceeded in aquifers not affected by spills. Anthropic low oil contents in groundwater are mostly caused by small, scattered, but permanent sources of oil from transport, agriculture and industry including atmospheric pollution. Periodical sampling was carried out in important "not polluted" Czech hydrogeological structures. The arithmetic value 0,035 mg/l, derived from 392 samples, can be considered as the regional background level.(A local one, of course, should be known before monitoring). Background concentrations vary not only in place but also in time. Lower hydrocarbons contents during summer compared with winter, may be caused by microbiological processes. No significant relationship with geological medium was found. The background level is much more affected by extent and intensity of anthropic influences.

TABLE 1

Indirect surveillance methods concerning oil pollution

	Method	General Hydrogeology, Geology	Pollution
Geophysics	Electrical sounding and profiling	tectonics lithological boundary flow patterns of g.w.	presence and thickness of oil body (oil pancake)
	Thermometry	tectonics presence and flow patterns of g.w.	-
	Emanation measurement	tectonics	-
Hydrochemistry	CO_2 gasometry	tectonics presence of carbonated mineral waters	location of old pollutions
	Hydrocarbons gasometry	-	location and stratification of fresh pollutions
	ORP measurement	flow patterns of g.w.	presence of dissolved hydrocarbons (organic matters)
	Oxygen measurement	flow patterns of g.w.	presence of dissolved hydrocarbons
	Specific conductance measurement	response to recharge events flow patterns of g.w.	presence and thickness of oil layer in wells
Geobotanics	Differences between hydrophytes and xerophytes	presence of shallow aquifers and springs	-
	Differences between oil-philic and oilphobic plants	-	location of spillages leakage from pipelines and tanks
Remote sensing	Aerial conventional and infrared photography, multiband photography	shallow g.w. patterns springs	location of effluents, location of surface spillages, presence of oil body in shallow aquifers

REMARKS ON MONITORING

(Problems based on our sever-years experience are rather pointed out than completely solved).

<u>Where to monitor</u>

The monitoring network should be installed in the vicinity of great sources of potentional pollution in the most vulnerable parts of significant hydrogeological regions. Their density depends on physical conditions and available finances related to possible ecological impacts. Each well may tap only one aquifer. Direct contact of the packed screen with the ground - water table is vital throughout the monitoring. The material of tubing and screens must not affect water quality; poorly resistant protective paint coatings and plastics are not recommended. The most important wells are cased with stainless steel, others with ceramics or unpainted steel. The inner diameter of 200 mm allows proper monitoring and also clean-up activity if necessary. All wells are provided with standard watertight terminals protecting them against weather and malicious damage.

Composition of the infiltrated oil and the age of contamination determine special analytical methods in laboratory. Ultraviolet spectrophotometry, being more sensitive to aromatics, is used when a light product has been spilt, and with recent spills. Infrared spectrometry, which is more sensitive to alkanes, is suitable in other instances. If several different pollution sources are to be identified the best way is chromatography or mass spectrometry.

On-the-spot methods are by orders of magnitude less sensitive than the laboratory ones, which analyze 0,01 - 0,001 mg l^{-1} hydrocarbons. One of the few existing in-situ-analyzers, Horiba OCMA 200, is capable of detecting 1,0 mg l^{-1} . Soil hydrocarbon gasometry (e.g. Portafid, test tubes) and CO_2 gasometry (interferometers and test tubes) are also more suitable for surveillance than for monitoring.

Indirect estimatión of dissolved hydrocarbons appears to be a promising method. Measurements of ORP and oxygen are quick, simple and sensitive. These parameters measured in a Cretaceous aquifer east from Prague predicted the arrival of an oil plume. Changes of an oxidative medium to a reductive one due to biochemical oxidation of hydrocarbons were measured in 8 boreholes. The results obtained from borehole No.57 are presented in Table 2.

The monitoring of bulk (free) oil is carried out exclusively during decontamination. The thickness of floating hydrocarbons is estimated with mechanical devices (oil film up to 20 cm), or electro-optical ones (1 cm to several-meter layers).

Apart from pollutants or their manifestations, the data that should be measured include groundwater table, specific conductance and water temperature to find response to recharge events.

TABLE 2

Monitoring physico-chemical properties of groundwater

Borehole No.57	3.8.78	6.10.78	20.12.78	22.2.79
r^H	22,9	22,4	17,18	-
O_2	0,95	1,0	0,6	-
hydrocarbons	0,06 mg/l	0,74 mg/l	oil film	oil layer

$r^H = \frac{Eh}{0,029} + 2\ pH$ Eh - measured potential (mV)

When to monitor

The frequency of data collecting should be highest in the first phases. The final intervals are as long as possible. They will, of course, be quite different in shallow and deep aquifers. Shallow groundwaters are characteristic for very rapid changes in quality and sometimes also for their cyclic fluctuations. Several distinct masses of contaminants extend down a flow line, resembling a string of beads (Pettyjohn, 1976). The "tail" of one pollution plume may be misinterpreted as the very end of pollution.

CONCLUSIONS

Monitoring networks consisting of two up to tens of observation wells have been installed in the case of point pollution sources, according to the extent of facilities and groundwater endangering. Besides these local systems, a monitoring network on a regional or state level will be established to protect significant hydrogeological structures. Proper design involves the necessity of making use of other state observation networks which have for years collected data concerning climatology and hydrology. Pollution monitoring will be considered less time- and cost-consuming if we realize that the sooner pollution is detected, the easier and cheaper will be the remedy, and that potable water in inland countries is becoming an irreplaceable commodity.

REFERENCES

1 J.M. Baker, Ecological Impact of Refinery Effluents in the Marine and Estuarine Environment. Report No. 5, Concawe, Den Haag, 1979, Ch.III.,pp.8-9

2 V. Houzim, State Research Program C 52 347 101/04 (Research Project-Hydrochemistry) Unpublished Research Report, Stavební geologie, N.C.,Prague, 1980, p.266.

3 J. Kněžek and J.Švoma, Indikační vrty (Monitoring Boreholes), Project of Stavební geologie, N.C., Prague, 1978, p.25.

4 W.A. Pettyjohn, Monitoring Cyclic Fluctuations in Ground-Water Quality, 1976, Ground Water, Vol. 14, No. 6, pp. 472-478.

5 H.O. Pfannkuch and B.A. Labno, Design and Optimalization of Ground-Water Networks for Pollution Studies, 1976, Ground Water, Vol. 14, No. 6, pp.455-462.

6 J.Švoma, Location and Area Measurement of Rock and Ground Water Contamination by Surface Methods. International Symposium on Groundwater Pollution by Oil Hydrocarbons, Prague, 1978, pp.309-317.