REMEDIATION OF A CHC CONTAMINATION IN VIERNHEIM, GERMANY

HIRSCHBERGER, Frank
HYDRODATA GmbH España
e-mail: hydrodata@arrakis.es
alc@iimac.es Web: www.HYDRODATA.de

PROJECT HIGHLIGHTS: Groundwater treatment; UVB technology; Groundwater circulation; Infiltration; Soil gas circulation system

In response to concerns regarding potential groundwater contamination, HYDRODATA GmbH conducted groundwater investigations in the city of Viernheim, Germany. Considerable amounts of CHC were found in the groundwater and as a result of the investigation, a contamination plume, approximately 1 km in length, was determined. The plume originates from a property that was used in the 1960s and 1970s by several dry cleaning companies and develops towards the extraction wells of the waterworks of Mannheim-Käfertal.

The unsaturated soil zone was remediated by using **a soil air circulation process** (BLK), which removed approximately 350 kg of perchloroethylene.

To avoid possible damage to buildings, caused by the lowering of the groundwater table or any annoyance of the occupants of the city of Viernheim, five **groundwater wells using a circulation flow system** (UVB) were installed in the center of the contamination, as well as in the area of the contamination plume. Using this in-situ technology, the groundwater remains in the aquifer and is cleaned in place. The remediation units were installed in underground well chambers or in soundproof containers. Approximately 500 kg of CHC were removed from the groundwater. To intercept the contamination plume and prevent its further migration, a conventional hydraulic remediation unit with pumping, cleaning and re-infiltration (pump and treat) was installed at the leading edge of the plume.

1. HISTORICAL BACKGROUND

The site is located in Viernheim, Germany and was used between 1965 and 1976 by several dry cleaning companies. In connection with the working processes a large quantity

of the solvent perchloroethylene (PER) was infiltrated in the ground. As a result of migration, the contaminants gradually reached the groundwater and developed a contamination plume of approximately 1000 m in length.

2. INITIAL INVESTIGATION

The groundwater contamination due to volatile chlorinated hydrocarbons (CHC) in the inner city of Viernheim was detected the first time in November 1985. The analysis of a groundwater sample, taken from a groundwater well in a schoolyard, showed CHC-concentrations of nearly 27,000 µg/l.

Based on detailed soil, soil vapor, and groundwater investigations in the inner city of Viernheim, CHC-contamination of the groundwater and the unsaturated soil zone could be determined. During the progress of further investigations, a primary introduction zone (a chemical dry cleaning company) was identified.

As part of the soil vapor investigations a very high to extremely high CHC-contamination of the unsaturated soil zone could be proved. In the soil vapor, CHC concentrations of up to 1.800 mg/m^3 were determined. The highest groundwater-pollution was found in the center of the contaminated area, with concentrations up to 8.800 µg/l (sum of CHC).

A second entry point was determined at an inspection manhole of the sewer system. The extremely high contaminant concentrations, which were detected beneath the manhole, were caused by a local entry. It is suspected, that CHCs, which were included in the wastewater of the former dry cleaning company, were the cause of this contamination. These CHC most likely entered the manhole in phase and afterwards seeped through the bottom of the manhole.

3. REMEDIATION CONCEPT

The site was formally declared as a contaminated site and the remediation was formally the responsibility of the „Altlastensanierungsgesellschaft" as part of the „Hessische Industriemüll GmbH". This organization generally oversees the investigation and remediation of sites that cause a significant environmental risk and do not have an owner, or belong to owners that are not able to pay the necessary project costs due to bankruptcy.

HYDRODATA GmbH was contracted to develop a remediation concept for the Viernheim site. The final concept regarding the remediation of the affected media in the center of the contaminated area was presented to the authorities in 1992. The authorities approved the additional final concept for the remediation of the downgradient area of the contamination plume in 1998. The main focus of the remediation concept was on the implementation of groundwater circulation wells. This technology uses a system that

allows the treatment and the cleaning of the groundwater in place (in-situ) without the need for a groundwater extraction and an on-site cleaning.

4. SOIL (GAS) REMEDIATION

4.1 Technical description

The directed soil air circular flow system (BLK) is used for the remediation of soil contaminated with volatile hydrocarbons. In addition, it can be used to inject gas into the soil for the stimulation of biological or chemical degradation.

The BLK process consists of a specially adapted vapor extraction well, an aboveground mounted vacuum blower, and a waste air decontamination system, for example disposable filters or regenerative activated carbon filters (the soil air circular flow system (BLK) is a process patented by IEG Industrie-Engineering GmbH, D-72770 Reutlingen).

The screens built into the borehole are separated into an upper and a lower section, each of which is connected to the aboveground blower. This allows for the withdrawal of air from either segment individually or from both simultaneously. The extracted air, after passing through a suitable remediation unit (i.e,. activated carbon filter), is re-infiltrated into the soil. Horizontal and vertical flow circulations are generated in the soil surrounding the extraction well. The circulation direction is reversible and can be adjusted according to the contaminant distribution in the soil.

BLK, in contrast to other conventional venting methods, is capable of generating a direct circulation through the center of the contamination. No fresh air is added to the circulation system and air passing through the blower is heated, thereby enhancing desorption of contaminants adsorbed onto soil particles. This leads to a more effective remediation of the site.

For stimulating the biological degradation of contaminants, nutrients, in liquid or gas form, can be introduced into the circulation. Chemical conversion of toxic substances into harmless and/or immobile material can be achieved in-situ by introducing, for example, strongly reactive gases into the soil. If only biodegradable substances are to be removed from the subsoil, a BLK system (without an above-ground extraction unit) consisting of an axial ventilator in the screened well can be implemented.

The KGB system provides the following specific advantages:

- the temperature increase in the subsurface causes an increase of the diffusion constant of the contaminants which leads to a faster desorption
- the rise of the temperature also leads to the formation of azeotropic vapor-soil gas mixtures

- biological degradation processes are further stimulated by maintaining a constant temperature and moisture level in the subsurface
- adjustment of the circulation pattern according to the contamination to clean up areas with higher contamination levels first

4.2. Remediation development

The remediation of the unsaturated soil zone in the center of the contamination was performed using a directed soil air circular flow technology (BLK).

Due to the significant reduction of the CHC concentrations in the soil vapor, all of the originally installed circulation systems could be shut off after a period of operation of 2 to 4 years respectively.

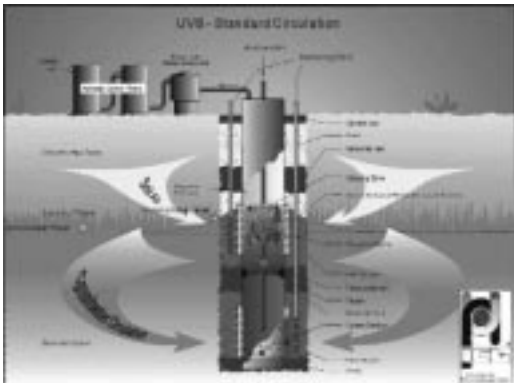
Through sampling of various soil gas monitoring wells performed since then, it could be proved that the CHC concentration remained stable and below the level established in the remediation goals.

During the complete soil vapor remediation from January 1992 to April 1996, approximately 350 kg of contaminants were extracted from the unsaturated soil zone.

5. GROUNDWATER REMEDIATION

5.1 Technical description

The UVB process unit consists of a specially adapted groundwater well that includes a stripping reactor located in a sub-surface vault or in the well itself, an aboveground mounted vacuum blower, and a waste air decontamination system; e.g., disposable filters or regenerative activated carbon filters (the UVB system was developed by IEG Industrie-Engineering GmbH, D-72770 Reutlingen, Germany).



UBV System sketch

An UVB well has at least two screen sections, which are separated by a solid casing. Negative pressure generated by a blower is applied to the air-tight vault or well head. Through a pipe connected to the stripping reactor located in the vault, ambient air is pulled through the stripping reactor.

The rising air bubbles enhance the suction effect at the well bottom (air-lift-pump) and a hydraulic current within the well from bottom to top develops. By adding a

support pump to the UVB system, a specific flow direction can be induced, which produces a vertical flow either upward or downward within the well. The oscillating hydraulic pressure forces the water horizontally back into the formation and in the surrounding aquifer a circulation cell develops with water entering at the base of the well and leaving through the upper screened segment or vice versa, depending on the desired flow direction.

The strippable contaminants are removed from the groundwater. When the contaminated exhaust air passes through the activated carbon filter, no water condensation occurs due to the low humidity of the air. Therefore, a significantly larger part of the activated carbon filter can be utilized for adsorption of pollutants as compared to conventional air stripping.

A flow pattern with a calculable horizontal and vertical component is produced in the aquifer to compensate for the directed water flow within the UVB well. The circulation pattern can be adjusted (normal-reverse flow direction) depending on the location of the submersible pump(s). Thus, treated groundwater circulates through the sphere of influence (within the aquifer) before returning to the well. This causes an intense flushing of less permeable layers or lenses, which would not be treated with conventional pump and treat systems.

The UVB system provides the following specific advantages:

- no draw-down of groundwater; therefore no structural damage to existing buildings from this effect;
- no groundwater extraction; therefore no waste water or discharge fees;
- treated groundwater is enriched with dissolved oxygen which increases the potential for aerobic degradation processes;
- low energy use (a complete system requires approximately 3.5 kW/hr);
- circulation zone can be limited to the polluted area (no fresh water is treated);
- low space requirements (subsurface installation of all components is possible);
- simultaneous treatment of unsaturated zone and capillary fringe by vapor extraction and free product recovery;
- adjustment of the circulation pattern according to the contamination; and
- variety of possible combination with state-of-the-art treatment technologies according to the type of contamination.

5.2. Remediation development

In order to remediate the groundwater both in the center of the contamination, as well as in the area of the contamination plume four groundwater circulation wells (UVB-wells) began operation in 1993. One of the UVBs is located in the center of the contamination and the others are located in the contamination plume. An additional UVB well was drilled and put into operation in 1994.

Underground UVB system located in vault

Between January 1993 and March 1997 approximately **460 kg** of CHCs were removed using the UVB technology.

Based on the positive results and the significant reduction of the CHC concentrations in the groundwater, three of the UVB systems could be taken out of operation in 1996. Initially it was planned to shut down two of the systems for a test period of 6 months. During this time the development of the CHC concentrations in the affected aquifer was monitored.

During the monitoring phase, in the center of the contamination it could be proved that the level of CHC concentration remained stable or decreased. Based on these results, the

Groundwater remediation plant

authorities approved the permanent closure of two UVB units in early 1997 and the UVB unit in the area of the school building was put back into operation.

To define the extent of the contamination plume, a comparison of different variables, based on a model calculation carried out by the university of Karlsruhe, was presented in 1997. As a result of the variant comparison, a hydraulic remediation measurement was selected, the construction works were started in 1997 and finished in March 1998.

The water treatment plant at the end of the contamination plume has been working since August 2000. As of 30 August 2001, 18,000 m^3 of water has been discharged. The CHC-concentration in the inflowing water increased up to 50µg/l.

In the initial remediation phase, the groundwater that was extracted at the foremost area of the contamination plume was re-infiltrated using infiltration wells. These infiltration wells will be substituted by a permanent re-infiltration construction that spreads out over a larger area. This construction work will start in autumn of 2001.