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IN-SITU SOIL AND GROUNDWATER REMEDIATION, AN EXAMPLE FROM A CONTAMINATED SITE

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ABSTRACT

A former gas supplying plant associated with deposits of industrial sludges (containing CH's) was chosen to demonstrate a multi-functional approach in remediation procedures of a contaminated site including soil pollution with PAH, BTEX, CH and groundwater pollution with CH. The following in situ treatment was applied: 1. surface ventilation (wells B3 and B4 with initially high recovery rates and rapidly decreasing values - cumulative 6 tons CH's at B4 and 0.4 tons CH's at B3). 2. Groundwater stripping wells with characteristic rise and decline of concentrations reaching finally a very low concentration. The Vacuum Vaporizer Well is an excellent tool for in situ remediation in the downstream area of the contamination center. They demonstrated the recovery of extremely low groundwater contaminations. A strong interdependence of CH-concentration and vibrations of the ground due to near construction activities is demonstrated by an increase in CH extraction from the groundwater.

INTRODUCTION

The application of different treatment processes or the remediation of contaminated areas is the main aim to prevent any risk for future site users. This requirements are not only the task for the German or European legislation but also a challenge to thesstate authorities. The application of well developed standard technologies and modern remediation technologies on contaminated sites has to be shaped specifically to the demands and framework of the area concerned by choosing the correct dimensions and abilities. This is necessary to reach best results.

This paper focuses on diverse applications of surface ventilation, groundwater stripping procedures and the underpressure ventilation well technology and renounces on lengthy descriptions of field or laboratory analytical work. The present example deals with hydrocarbon contamination in soil and ground water. Well known procedures as excavation and recycling of contaminated soils from a depicted gas supplying plant are not mentioned further since similar techniques have been described in many other contributions in sufficient detail. It will be demonstrated additionally that decontamination and recycling of industrially contaminated areas are economically feasible. If proper planning is done this can be very successfully performed within a limited period of time.

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VVW - is a patented technique of the I E G mbH , 72770 Reutlingen, Germany, called UVB.

DESCRIPTION OF ALL RELEVANT BACKGROUND DATA OF THE CONTAMINATED SITE

The following contaminations have already been detected on the area of the former gas supplying plant in Cologne, Germany in the paper of Aslanidis

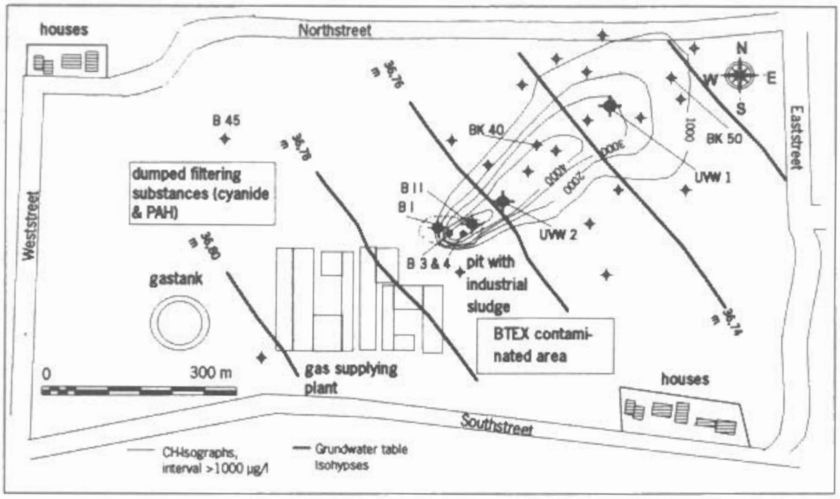

Fig. 1: Groundwater pollution of a contaminated site in Cologne, Germany

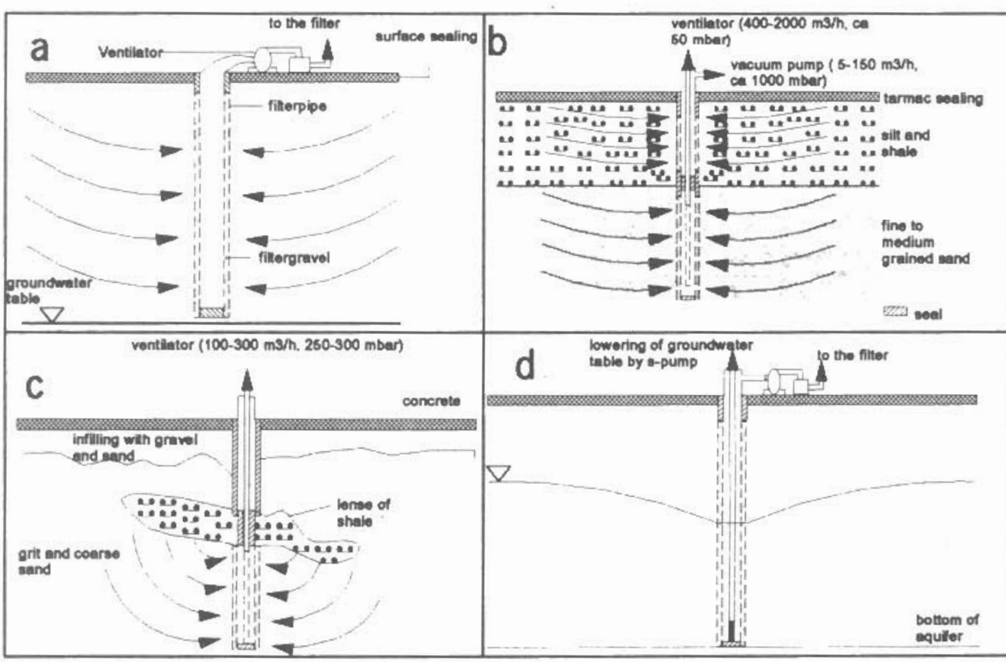

Fig. 2: Four principles of surface ventilation concepts.

et al. (1993; this volume) and a risk evaluation has been set up.

- Polycyclic aromatic hydrocarbons and cyanides in-phase were detected within the unsaturated soil zone. The centre of contamination was excavated according to the rules and regulations of the State Government of Northrhine Westfalia.

• BTEX contaminations, in particular benzol, occurs in the unsaturated zone of the area (Fig. 1). This contamination has been entirely treated with surface ventilation with complete success. No detailed description of this regeneration process is presented here since it is almost identical to the following treatment of the cyclic hydrocarbon contamination.

• chlorinated hydrocarbon contamination (within the area of the former pit refilled with industrial sludge; Fig. 1). The unsaturated soil zone is contaminated by partly in phase trichlorethane and tetrachlorethane. The contaminants were mobilised in the aquifer system distributing a spreading contamination over a certain downstream area. Figure 1 demonstrates the approximate extension of the contaminants. The treatment of soil and groundwater contaminations from this area are presented as a model and are discussed additionally.

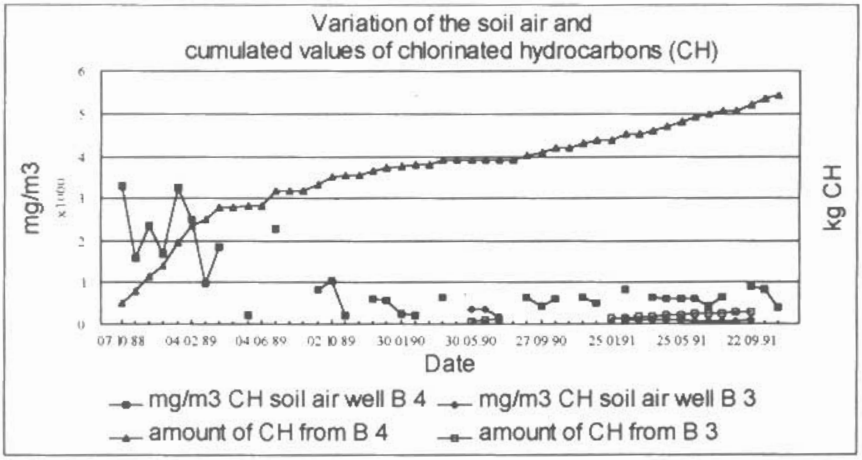

Fig. 3: Concentrations an cumulated values of chlorinated hydrocarbons in soil air surface ventilation.

DESCRIPTION OF THE TREATMENT CONCEPT

The concept of treating the contaminated site includes the following steps:

• Installation of a groundwater well in 1984 (BI, Fig. 1) in the centre of the contaminated area with subsequent groundwater stripping. The cleaned up water was used for further plant requirements.

• Switch over to groundwater stripping on well BII since end of 1988.

• Installation of a surface ventilation plant end of 1988 at wells B3 and B4.

• Installation of VVW 1 and VVW2 (vaccum vaporiser wells) in 1991 and periodic controle measurements along the groundwater wells BK40 and BK50 (Fig. 1).

Similar concepts of treatment processes for different contamination with varying contaminants have been described by other authors (Hoffmann; 1993).

CONCISE DESCRIPTION OF APPLIED TREATMENT PROCEDURES

• Surface ventilation

A detailed description and listing of the possibilities of treatment for this process in the unsaturated soil zone is given by Schützle et al. (1989). At this point only some of the filtering and surface ventilation well arrangements are demonstrated which have been applied in the present project of the former gas supplying plant.

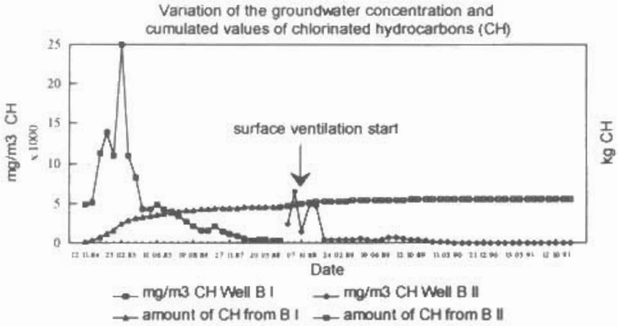

Fig. 4: Concentration of chlorinated hydrocarbons in the groundwater including the accumulated recovery of chlorinated hydrocarbons in tons

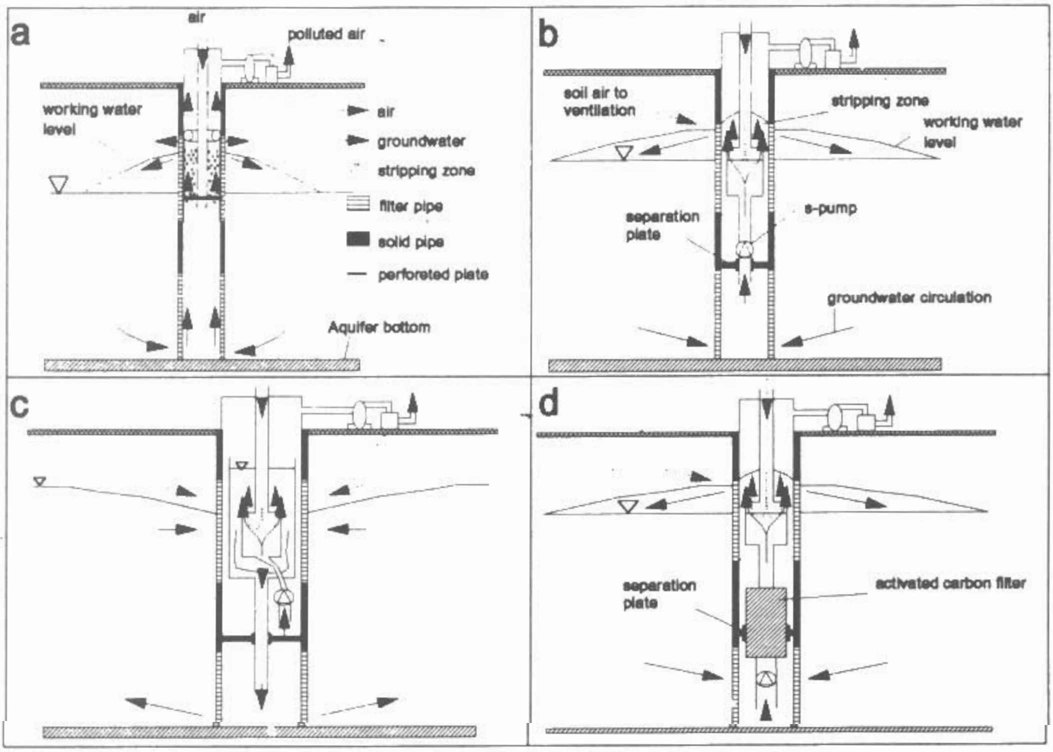

Fig. 5: Vacuum vaporizer well applications in different directions of water flow with or without submersible pump (a-c), d: with activated carbon filter to accelerate bioremediation of hydrocarbons.

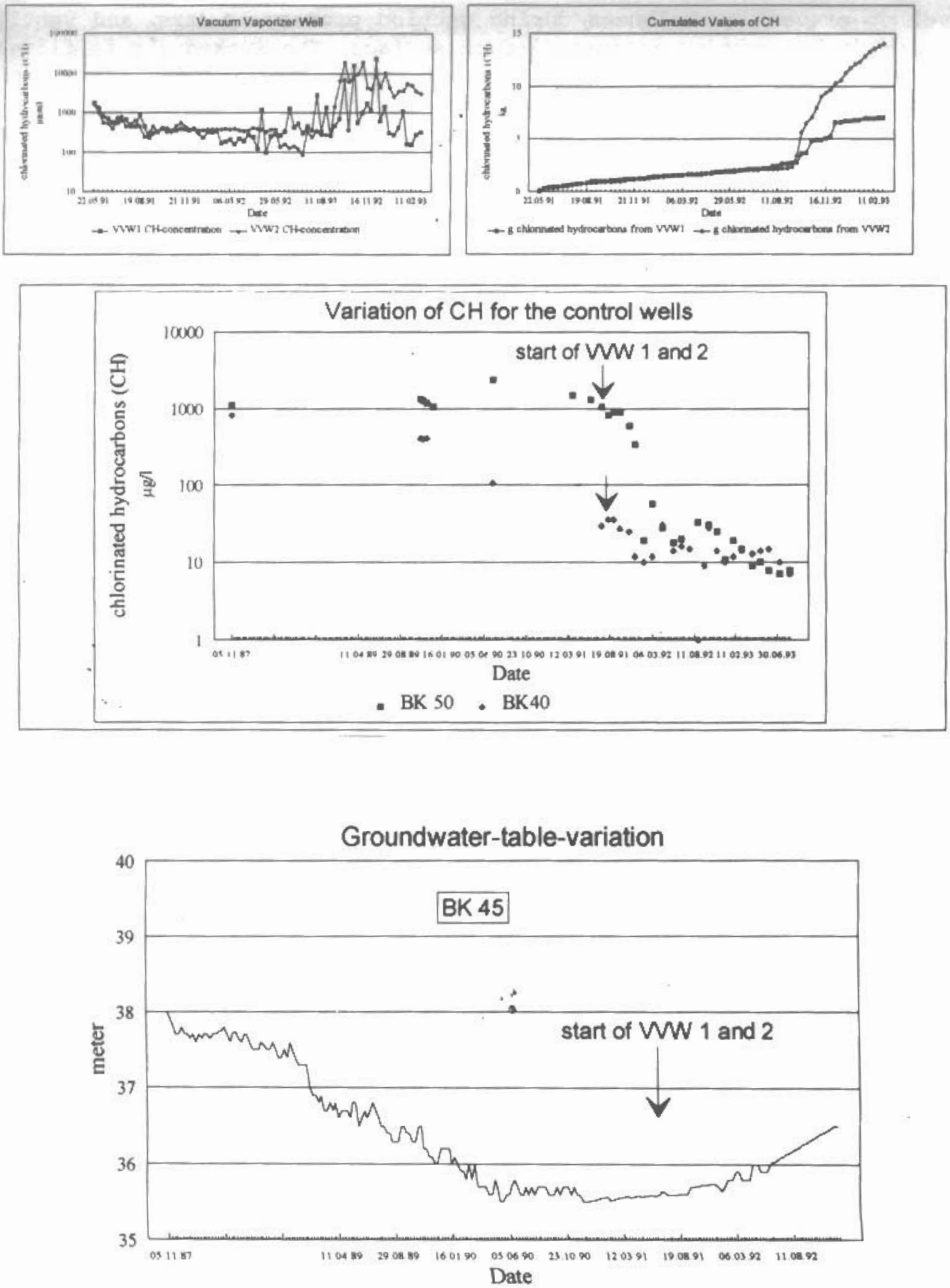

Fig. 6: Diagrams of VVW-groundwater remediation. Explanation see text.

• In Figure 2 different methods of surface ventilation concepts are presented.

a: above the groundwater level a filter pipe is installed filled with gravel to prevent turbulences during suction process. A pump and ventilation device for suction is installed on surface. The sucked air is filtered in activated carbon filters. In order to raise the efficiency a sealing of the surface with a foil or bitumen layer is recommended.

b: Two layers of different permeabilities have been identified. An inner pipe is introduced in the pore air of the main pipe, the silt/clay material is extracted with a ventilator exhibiting a considerable vacuum but a low output. Otherwise certain channels in the soil may occur, since clay has only a limited removable mobile pore volume. If air is rapidly extracted during suction process, fracturation results which produces air which originates not from the clay but from other more porous sources below. Only a little output but the best possible amount of contaminants should be extracted. A packer seals the two soil formations from each other. Within sandy soils a high output but a low vacuum are preferred since a certain porosity is available and also enough air in the pore system.

c: Indirect suction from lenses of silt-clay material embedded in sands or gravels. Best results are obtained with a medium output.

d: Situation of a high groundwater level and a low surface distance. Groundwater is pumped out of the ground so that the groundwater level is lowered subsequently and air can be sucked from the dry zone above the lowered groundwater level.

In our example method (a) has been applied, as optimum.

- In Figure 3 two wells have been installed which worked with method (a). At first well B4 was working with several interruptions. Well B3 was working from mid 1990 onwards but with frequent longer intervals of interruptions. Since February 1991 it is run permanently. The interruptions originate from logistic problems (exchange of active carbon filters and retardation in supply of new filter systems at the same time).

A diagram of cummulative recovery for well B4 is demonstrated starting with a steep gradient which grows shallower subsequently until it reaches a plat form. In summary approx. 6 tons have been extracted from this well and it was stopped in november 1991. Well B3 produced approx. 400 kg of contaminants and has been stopped presently for legislative reasons.

Two wells for groundwater remediation processes have been installed in the area. In 1984 the stripping plant started operation in location BI. Figure 4 shows a rapid rise of concentration during the early phase of operation. This proves that the well has not been placed in the centre of contamination since highest values were produced some time after the operation started. Afterwards a logarithmic decline occurs which shows only very low values after a period of approximately 3 years. This is the reason for the shut off of the stripping procedure. Afterwards location BII started operation. This well produced high values during the first 6 months (2000- 6000 mg/l), afterwards the values stabilized at 20-100 mg/l. The cumulative curve for both wells from the period 1984-1991 shows an extraction of approximately 5 tons.

VACUUM VAPORIZER WELL (VVW)

After the centre of contamination had been treated with groundwater stripping and surface ventilation procedures the bench mark of contamination of < 10 mg/l was reached. However, in the down stream area of control wells concentrations of 2000 mg/l were measured. These high contaminations were obviously not reduced during the 7 year period of pumping in the centre of contamination. This is where the VVW technology is applied with best efficiency.

There are four possibilities how the vacuum vaporizer wells work (Fig. 5). In the present case study, method b was utilized. The principle of VVW is to produce a circulation flow within the surrounding groundwater. Water is sucked into the lower screen, transported upwards inside the VVW by an air lift pump, cleaned by fresh air in the stripping zone below atmospheric pressure (quasi vacuum) and flows out of the well through the upper screen. The borehole reach between the two screen sections should be made impermeable.

One well should not connect different aquifers. In this way water does not leave the aquifer. In the stripping zone air bubbles are generated, which produce a pump effect during rising to the surface moving the water and thus is cleaned as well. The contaminants are adsorbed by activated carbon. In order to avoid precipitation the circulation of the stripping air is closed which keeps those contaminants not adsorbed away from the atmosphere. Only clean air escapes to the atmosphere. The circulation flow creates a permanent flow and consequently cleans the soil within the zone of the well (HERRLING & STAMM, 1991; BÜRMANN, 1991). Detailed descriptions and recent improvements of the system may be obtained from these three authors.

In the present case study the VVW method was applied for the downstream remediation process.

In Figure 6 the VVW technic and associated effects are demonstrated. The upper two sub-figures show a strong interpendence of the mobilization of chlorinated hydrocarbons by vibrations caused by construction activities (ramming rods, geoshocks etc.). Construction works began in May 1992 (excavation of construction base). A short time later the amount of recovered CH's rose considerably. With some kind of retardation effect the amount of CH's in the groundwater was decreasing to less than 10 mg/l. Consequently the line of cumulative recovery rises steeply beginning from august 1992 (within the stripped air from VVW).

The process of optimizing the recovery was supported by a low groundwater level. The ventilation process could have been transferred to deeper zones of the mobile pore volume in the saturated soil zone.

CONCLUSIONS

This example demonstrates that the best adaptation to applications is provided by a combination of several existing and already tested methods which lead to a superior quality in the remediation processes. Obtained results exceed the boundary values set up by the standards of the European Community or the Federal Republic of Germany. It is important to note that preliminary reconnaissance surveys have to estimate the approximate dimension of the contamination or group of contaminants in order to calibrate economic application procedures with an optimun of efficiency.

If high concentration of chlorinated hydrocarbons in the unsaturated soil zone are found, surface ventilation has to be applied. At the same time or shortly afterwards semi-mobile water stripping plants have to be installed to extract and clean highly contaminated groundwaters (above 200 mg/l). Vacuum vaporizer wells are used for cleaning the centres or downstream areas of contamination (from 200 to <10mg/l), because with this technology low concentrations of contaminants in the groundwater can be removed in a controlled manner and cosiderable period of time.

Only in the case of aquifers with a high permeability, a stripping plant can work, although VVW may be applied also in these areas. VVW can be used also as protection wells in drinking-water supplying plants as a prevention measure.

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