36 878 PDF

UNTERDRUCK-VERDAMPFER-BRUNNEN (UVB): AN IN SITU SYSTEM FOR REMEDIATION OF CONTAMINATED AQUIFERS

Michelle A. Simon
US EPA
Risk Reduction Engineering Laboratory
Cincinnati, OH 45268
(513) 569-7469 (phone) (513) 569-7676 (fax)

Roger R. Argus and Benjamin L. Hough
PRC Environmental Management, Inc.
4065 Hancock Street, Suite 200
San Diego, CA 92110
(619) 225-1883 (phone) (619) 225-9985 (fax)

INTRODUCTION

Traditionally, contaminated groundwater is pumped to a surface facility for treatment, often by air stripping. An innovative technology, the Unterdruck-Verdampfer-Brunnen (UVB), German for Vacuum Vaporizing Well, is an in situ groundwater remediation technology that combines air-lift pumping and air stripping to clean aquifers contaminated with volatile compounds. Additionally, the developer claims that in some cases the technology is capable of simultaneous recovery of soil gas from the vadose zone. An evaluation of this process is discussed in this abstract.

A UVB system consists of a single well with two hydraulically separated screened intervals installed within a single permeable zone. The air-lift pumping occurs in response to reduced pressure introduced at the wellhead by a blower. This blower creates a vacuum that draws water into the well through the lower screen and the water rises toward the top of the well. A submersible pump ensures a flow rate of approximately 20 gallons per minute (1.26×10^{-3} meter^3 per second). Air stripping occurs as ambient air, also flowing in response to the vacuum, is introduced through a sieve plate located within the upper screened section of the well.

Air bubbles form in the water column causing volatile compounds to transfer from the aqueous to the gas phase. The rising air transports volatile compounds to the top of the well casing, where they are removed by the vacuum blower. The blower effluent is passed through granular activated carbon before being released to the atmosphere.

The transfer of volatile compounds is further enhanced by a stripping reactor located immediately above the sieve plate. The stripping reactor consists of a fluted and channelized column that facilitates the transfer of volatile compounds to the gas phase by increasing the contact time between the two phases and by minimizing the coalescence of air bubbles.

Once the upward stream of water leaves the stripping reactor, the water falls back through the well casing and returns to the aquifer through the

upper well screen. This return flow to the aquifer, coupled with the inflow at the bottom of the well, circulates groundwater around the UVB well. The extent of the circulation pattern is known as the radius of influence, which determines the volume of water affected by the UVB.

The UVB technology is a process patented by IEG mbH in Reutlingen, Germany. IEG Technologies, Inc., located in Charlotte, NC, markets the technology in North America. IEG teamed with Roy F. Weston, Inc. to demonstrate the UVB technology at March Air Force Base (AFB), CA. March AFB allowed the US EPA Superfund Innovative Technology Evaluation (SITE) program to evaluate the technology. The SITE program retained PRC Environmental, Inc. to evaluate the performance of the UVB system at March.

METHODOLOGY

The objective of the demonstration was to determine the efficiency of UVB system, the reduction in concentration of trichloroethene (TCE) in the aquifer, and the radius of influence of the UVB system within the aquifer.

Two series of wells were placed downgradient of the UVB system, as depicted in Figure 1. The first series of wells were placed 40 feet from the system; the second 85 feet away. Each of the two series had three wells: a shallow well screened at a depth of 37 to 57 feet below ground surface (bgs), an intermediate well screened at a depth of 65 to 75 ft bgs, and a deep well screened from 90 to 105 ft bgs. The two shallow wells were screened at the same depth as the UVB system outlet; the intermediate wells were screened at the same depths as the UVB inlet. The deep wells were screened below the anticipated UVB circulation cell. The wells were sampled monthly and samples were analyzed for volatile organic compounds.

A dye trace study was performed on the system. No dyes were detected in the aquifer prior to start of this dye study. A two-dye approach was implemented. Sodium fluorescein, a bright green dye, was injected in the system outlet, in order to determine whether water discharged from the UVB system could be detected in any of the surrounding wells. A bright yellow-orange dye, rhodamine WT (red-purple xanthene) was injected into the intermediate well placed 40 feet downgradient of the UVB system, to determine whether this well was within the system's radius of influence.

RESULTS

Figure 2 is a graph of the change of the TCE concentration for the inlet versus outlet water. When the system operated properly, the inlet TCE concentrations averaged 33.75 micrograms per liter (µg/L) and the outlet concentrations averaged less than 1 µg/L (97% removal efficiency). Twice during the twelve month period, the system required adjustments.

Figure 3 is a graph of concentration of TCE versus time for the wells located 40 feet downgradient of the UVB system. Prior to UVB system startup, samples from the shallow well had TCE concentrations of 530 µg/L; the intermediate well - 750 µg/L; and the deep well - 100 µg/L. Initially, the TCE concentration in the water from all six wells remained constant or

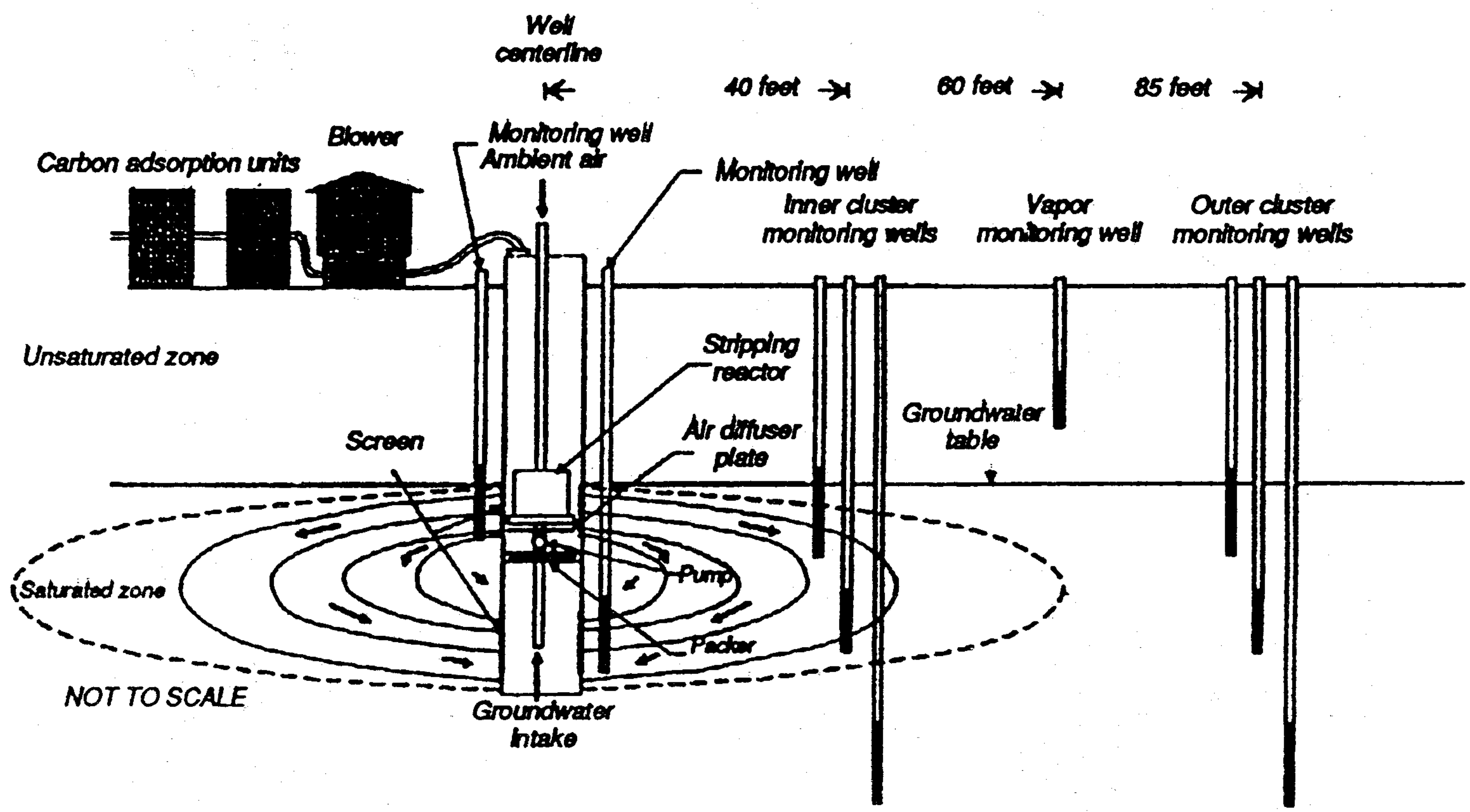

Figure 1. The Unterdruck-Verdampfer-Brunnen Technology as demonstrated.

increased. The TCE concentration in samples from the shallow well and the intermediate well increased to peak values of 620 and 2000 μg/L, respectively, after three months of system operation. Then, the concentration of TCE declined. TCE concentration in the deep well remained constant at 110 μg/L.

Figure 4 is a graph of the TCE concentration for the wells located 85 feet downgradient of the UVB system. The TCE concentrations in the samples collected from the outer well cluster initially increased after system startup, also. However, the concentrations peaked after seven months of UVB operation. The shallow well initially had a TCE concentration of 650 μg/L, which increased to 980 after seven months and then reduced to 290 after twelve months. Samples from the intermediate well measured 120, 640, 210 μg/L TCE, for the same respective time periods.

As for the dye study, the fluorescein dye that was injected into the outlet of the UVB was observed at the inner shallow well after 48 days. It was also observed in the deep inner cluster well after 59 days. It was never observed in the inner intermediate well which is located between the these two. The fluorescein dye was not observed in any other wells for the four month duration of the test, including those located 85 feet downgradient of the UVB.

The rhodamine dye that was injected into the inner intermediate well was observed **upgradient** at the UVB system after 85 days. The rhodamine dye was also observed in the inner deep well as soon as 17 days. Rhodamine dye was not detected in any other wells.

CONCLUSIONS

The UVB system can successfully remove TCE from inlet contaminated groundwater to a level less than 1 μg/L in the outlet under normal operating conditions. The dye study confirmed that the radius of influence for this application is at least 40 feet. A modeling study performed by the vendor predicted a radius of influence of approximately 80 feet. The TCE concentrations in samples from wells within the radius of influence initially increased but eventually declined to one-half their original levels after 12 months of treatment. March AFB continued to operate the UVB system for an additional 6 months and monitored its performance. These data show a continual decline in TCE concentration for the wells affected by the UVB.

FOR MORE INFORMATION

Contact Michelle A. Simon at the address above.

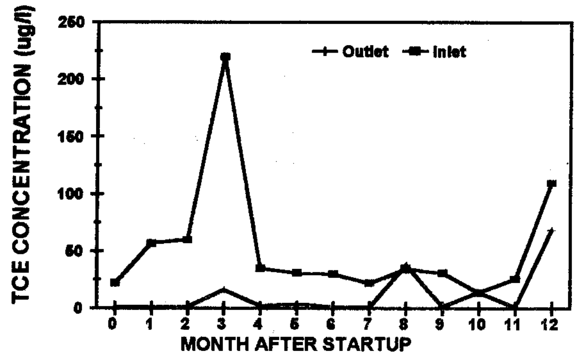

FIGURE 2
UVB SYSTEM INLET AND OUTLET

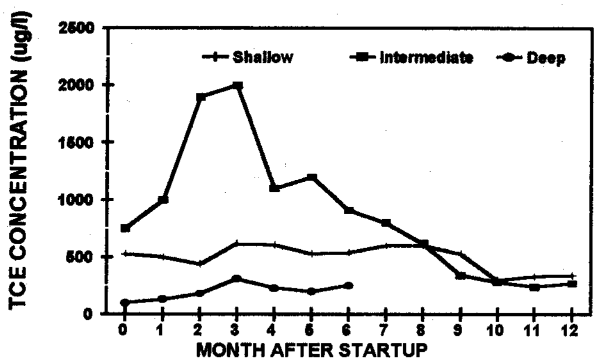

FIGURE 3
INNER CLUSTER OF WELLS

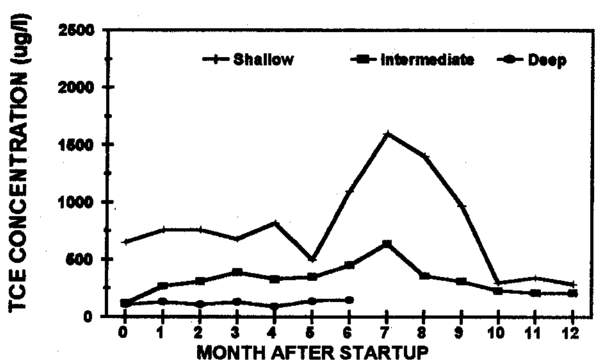

FIGURE 4
OUTER CLUSTER OF WELLS