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ENVIRONMENTAL SCIENCE AND TECHNOLOGY BRIEFS FOR CITIZENS

adapted by P. Kulakow

A Guide to In-Well Vapor Extraction

Adapted from "In-well Vapor Stripping"

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What is in-well vapor extraction?

In-well vapor extraction is a method used to clean up hazardous chemicals that contaminate groundwater. In-well vapor extraction is also called in-well vapor stripping, *in situ* vapor stripping, or *in situ* air stripping. All of these names refer to the same cleanup method. In-well vapor extraction will remove volatile organic compounds (VOCs) such as trichloroethylene (TCE) and vinyl chloride. The chemicals are extracted from the water in place without removing the water from the ground.

In the in-well vapor extraction process, contaminants that are dissolved in groundwater are released from the water as vapor or gas. The gas is removed from the soil and released to the air or treated if necessary. Groundwater is not removed from the ground, but is circulated back into the well to facilitate further vapor removal (See Figure 1).

How does in-well vapor extraction work?

The in-well extraction or stripping process involves the creation of a groundwater circulation pattern around a well through which contaminated groundwater is cycled. Several commercial variations of the basic in-well extraction process have been developed. In general, the in-well stripping well consists of an inner and outer casing hydraulically separated from one another (See Figure 1). This separation, generally accomplished by a packer assembly, metal plate, or grout seal, ensures one-directional flow of water into the well at its base (through the lower screen in the inner well) and out of the well above the water table (through the upper screens in both casings). The outer well may also be screened above the water table if the well is to be used for soil vapor extraction.

The following outlines the general steps in the in-well stripping process (See Figure 1):

- **Air** (or an inert gas) is **injected into the inner well** through a gas injection line using a vacuum blower, releasing bubbles into the contaminated groundwater. The **resulting bubbles aerate the water,** forming an air-lift pumping system and causing groundwater to flow upward in the well.
- The **gas bubbles rise through the water in the well and also lift the water** due to a density gradient (groundwater containing air bubbles is less dense than groundwater without bubbles outside of well).
- As the bubbles rise through the VOC-contaminated groundwater, these **compounds are naturally transferred from the dissolved to the vapor phase** through an air- stripping process.

- The **air/water mixture rises until it encounters the dividing device** within the inner well, above the contaminated zone. The dividing device is designed and located to maximize volatilization.

- The water/air mixture is forced out of the upper screen below this divider.

- The outer casing is under a vacuum, and **vapors are drawn upward** and are collected at the surface for treatment, or may be in the soil to be biologically treated in place.

- The **groundwater,** from which some VOCs have been removed, **re-enters the contaminated zone.**

- As a result of rising groundwater lifting at the bottom of the well, **additional water enters the well at its base.** This water is then lifted via aeration.

The partially treated water re-entering the aquifer is eventually cycled back through the process as groundwater enters the base of the well. This pattern of groundwater movement forms a **circulation pattern** around the well, **allowing the groundwater to undergo sequential treatment cycles** until cleanup goals have been met. The area affected by this circulation pattern where the groundwater is being treated, is called the radius of influence of the stripping well.

Will it work at every site?

Most of the field applications of this technology have involved volatile organic compounds (VOCs), such as trichloroethylene (TCE), and petroleum products/constituents such as benzene, toluene, ethylbenzene, and xylene (BTEX). Applications of in-well stripping to other chemicals have been proposed based on modifications of the basic remedial process.

In-well vapor extraction has been applied to a wide range of soil types ranging from silty clay to sandy gravel.

What are the advantages of in-well vapor extraction?

- Does not require injection wells, discharge lines, discharge fees, etc., to recirculate/discharge groundwater.

- A single well can be used for extraction of vapors and groundwater cleanup.

- Can continuously remove VOCs from groundwater without pumping water to surface, avoiding the need to handle contaminated water above ground and/or to dispose of or store partially treated water.

- Contaminated vapors are more easily and inexpensively removed and treated aboveground than contaminated water.

- Low operation and maintenance costs.

- Involves no moving parts beneath ground surface.

- Designed to run continuously with only routine maintenance.

- Does not involve complicated components.

What are some limitations of in-well vapor extraction?

- Chemical precipitates may form during air stripping and may clog the well screens, limiting groundwater circulation.

- Shallow aquifers may limit system effectiveness due to limited space for reinfiltration/circulation.

- If air-stripping wells are not properly designed or constructed, the plume may be spread beyond the radius of influence of the stripping well.

Where is in-well vapor extraction being used?

At Edwards Air Force Base, CA, groundwater was contaminated with 300 ppb of TCE. The groundwater depth was 27 feet in a sandy silt/silty sand soil type. In seven months, TCE concentrations were reduced an average of 67%.

A number of other installations of in-well air stripping have operated for periods of two months to 20 months and resulted in contaminant reductions of 50% to over 99% for TCE and petroleum hydrocarbons.

References:

Miller, R.R., and D.S. Roote. In-well Vapor Stripping. Pittsburgh, PA: Ground-Water Remediation Technologies Analysis Center, February 1997.

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Figure 1. The In-Well Vapor Extraction Process