

GROUNDWATER & ENVIRONMENT NEWSLETTER

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Vacuum Enhanced Recovery

Vacuum-enhanced Non-Aqueous Phase Liquid (NAPL) recovery (VER) is also referred to as dual- or multi-phase extraction (D/MPE), bioslurping and/or bioventing. It utilises vacuum pumps to remove contaminated groundwater, phase separated hydrocarbons (PSH) and/or hydrocarbon vapour from the subsurface soils (i.e. vadose/ unsaturated zone) & groundwater (saturated zone).

Principles of VER

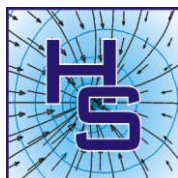
A vacuum is applied to the recovery bore using an aboveground vacuum pump to create negative pressure gradients, causing flow of subsurface fluid (vapour/ water/ PSH) towards the recovery bore.

The hydraulic gradient & relative aquifer permeability are the two main factors influencing the movement of fluids into the recovery bore. The end of the vacuum tube within the bore is positioned near the water-table. The effective capture zone around the bore depends on the transmissivity of the aquifer & the pressure gradient created within the vapour & liquid phases, which are directly proportional to the rate of vacuum applied. Higher applied vacuums create larger effective capture zones & greater recovery rates. However, the practical extraction rate is limited by the maximum allowable drawdown in the bore which cannot exceed the saturated thickness of the aquifer. Therefore, the hydraulic gradient cannot be increased by increasing the pumping rate if drawdown has reached its limit.

The increase in supply of oxygen/air enhances biodegradation of petroleum constituents within the vadose zone. Lowering the water table also increases air-phase permeabilities in the vadose zone, thereby increasing effective soil vapour extraction (SVE).

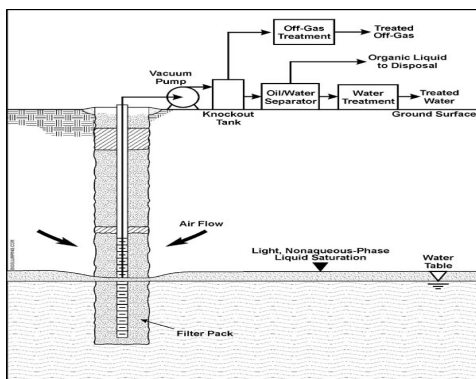
Main Components of the System

- Recovery bore;
- Vacuum pump capable of extracting liquids and vapours (usually a liquid ring pump);
- Liquid/vapour & oil/water separation;
- Water & vapour treatment units, if needed



Types of VER

- **Single Pump Extraction Systems** rely on high-velocity airflow to lift suspended liquids upwards by frictional drag through an extraction tube to the surface & may be used to extract groundwater &/or PSH.
- **Dual and Multi Pump Systems** use one pump to extract liquids from the bore & a second pump to extract soil vapour. A third DPE configuration uses three pumps, including the surface blower, a 2nd a pump to extract PSH & a 3rd to extract groundwater. DPE systems are a combination of traditional soil vapour extraction (SVE) & groundwater &/or PSH recovery systems.
- **Bioslurping** where aerobic biological degradation of the hydrocarbons is enhanced by introducing air into the unsaturated zone. 'Slurping' refers to the aerodynamic dragging action that lifts fluids up the slurping tube. The method involves the simultaneous application of vacuum enhanced extraction/recovery, vapour extraction, and bioventing



Source: <https://portal.navy.mil/portal/page/portal/navfac/>

- **Bioventing** uses indigenous microorganisms to biodegrade organic constituents adsorbed to soils in the unsaturated zone, the activity of which are enhanced by inducing air/ oxygen flow into the unsaturated zone (using extraction or injection bores) &, if necessary, by adding nutrients.

Advantages of VER

- More effective at recovering hydrocarbons in low permeability formations than traditional pump and treat methods including skimmer pumps.
- Can achieve high extraction rates.
- The increased air/oxygen circulation in the subsurface enhances potential indigenous biodegradation & therefore accelerates remediation.

- The remediation process occurs in-situ & hence minimises disturbance to regular site operations
- Capital, operation & maintenance costs are comparable to other applicable technologies.

Disadvantages

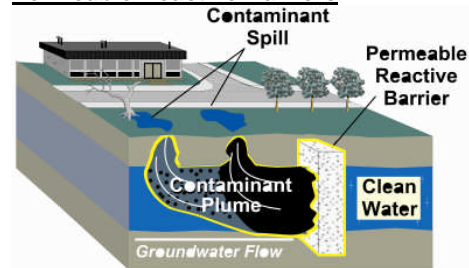
- Excess wastewater may be generated resulting in higher capital & maintenance costs.
- Excess waste generated may result in additional disposal requirements, discharge permits etc
- Single-pump systems may be expensive to implement at sites with medium to high-permeability soils, while dual-pump systems may not be effective in low permeability soils.
- Difficult to apply where water table fluctuations are high unless water table depression pumps are used.
- During bioslurping, 'channelling' may occur, when contamination is recovered from preferential migration pathways (e.g. high permeability fractures) in the subsurface, resulting in only partial recovery of soil vapours & groundwater, thus minimising the effectiveness of the remediation. However the effects of channelling may be reduced by cycling or pulsing the extraction system instead of continuous operation.)

Indicative Costs

Bioslurping - Aus \$0.26/litre LNAPL recovered (USEPA, FRTR V04).

Next issue -

Permeable Reactive Barriers



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