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Going

Photos provided by Savannah River Site

A PSVE well with a BaroBall valve

A growing trend in environmental remediation is the use of natural processes. As we increase our knowledge about the ways nature cleanses itself, we're developing more remedial approaches that take advantage of natural phenomena. These approaches, such as bioremediation and phytoremediation, are reducing the costs of cleanup and intruding less on the environment. Another example of such an approach is passive soil vapor extraction, which is based on natural venting cycles between the surface and subsurface. When atmospheric pressure is higher than the subsurface's pressure, air is induced to flow through wells into the subsurface. Conversely, when atmospheric pressure is lower then subsurface pressure, air flows out of wells into the atmosphere, taking with it chlorinated solvents in the gas phase.

Passive soil vapor extraction (PSVE, Tech ID 56), also known as barometric pumping, is part of the Subsurface Contaminants Focus Area inventory of technologies. PSVE wells function like active air injection or extraction wells but do not use mechanical pumps. At any given time, the atmospheric pressure at the surface and the soil gas pressure in the subsurface area are different. If these two zones are connected by a vadose zone well, the pressure differential results in flow either into or out of the well. If the subsurface contains volatile organic compounds in the gaseous phase, the flow out of the well will result in the removal of the contaminants without mechanical pumping.

Natural atmospheric pressure fluctuations are transmitted through the unsaturated subsurface and are controlled by the permeability of the soil. The majority of the PSVE flow is achieved in the coarser, more permeable zones of the soil. The mass transfer of the contaminant to the coarser zones of the soil limits removal of contaminants from fine-grained sediments.

PSVE systems at Savannah River and Hanford

PSVE has been used as an interim remediation strategy at DOE waste sites contaminated with chlorinated solvents. PSVE requires minimal operation and maintenance, making it a low-cost alternative to pump-and-treat systems or a cost-effective polishing technology. The Savannah River Site and the Hanford Site are currently using PSVE to remove chlorinated contaminants. SRS installed 24 PSVE wells at one site to remove trichloroethylene (TCE) and perchloroethylene (PCE). According to Joseph Rossabi, a researcher at SRS, "Since

September 1996, more than 240 pounds of chlorinated organic contaminants—180 pounds of TCE and 60 pounds of PCE—have been removed using PSVE. To date, close to 90 percent of the volatile contaminants have been removed from the system."

Rossabi adds that the barometric flow rates for a typical well at SRS are generally low (28 to 280 liters per minute). "However, if the concentration of the contaminant in the gas phase is high, mass removal by PSVE can be as much as 1–2 kilograms per day, per well."

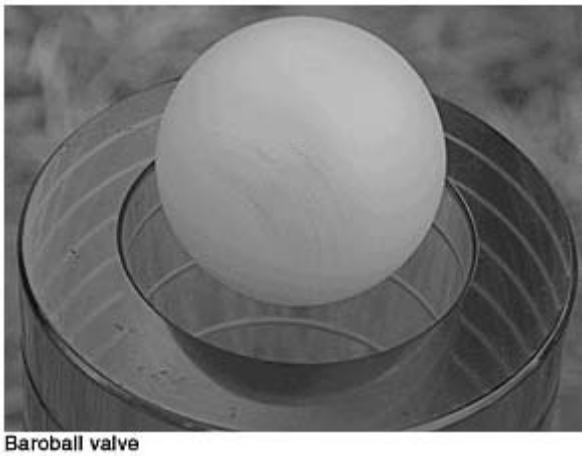
Low-cost techniques, again based on natural processes, can increase mass removal. Enhancements can include the addition of wind-powered turbine vacuum pumps, one-way mechanical valves, and solar heat injection.

The Hanford Site is using PSVE as a polishing technology. Hanford installed eight PSVE wells in 1999 to remove the remaining TCE and PCE after active (pump-enhanced) soil vapor extraction removed 167,551 pounds of the contaminants at a waste site. These PSVE wells began operating in 2000, and data is being collected to determine the effect the wells are having on contaminants.

PSVE requires installing extraction wells within the polluted area, using either conventional drilling methods or direct penetration equipment. When installed with a direct penetration rig, the wells are threaded with a steel push tip onto the well pipe. These pipes are pushed through the soil with steel rods and are designed to access the appropriate portion of the unsaturated zone to effectively remove contaminants. The PSVE wells are typically placed vertically, but horizontal wells can also be used.

BaroBall enhances contaminant removal

PSVE systems are more effective when airflow into wells is shut off. A simple one-way valve called the Baroball, (Tech ID 3117) developed by Westinghouse Savannah River Company, does just that. "One-way valves significantly increase the effectiveness of barometric pumping by preventing the inflow of air into the venting well when atmospheric pressures reverse, a condition that can reduce contaminant removal by diluting and dispersing the pollutant," Rossabi said.


Baroball valve

The BaroBall valve, commercially available through Durham Geo Enterprises, uses a ping-pong ball in a conical seat to permit gas flow in one direction with a minimal pressure requirement (approximately 1 millibar) and to effectively prevent gas flow in the reverse direction. The valve attaches directly to the well casing at the surface.

Depending on the configuration, the valve can also be used to inject air and/or nutrients into the subsurface to enhance bioremediation; to control or confine the movement of a subsurface gas-phase plume in the vadose zone; or to passively transfer solar-heated, water-saturated air into the subsurface to enhance volatilization in the subsurface.

Recent modifications to the BaroBall valve let field technicians measure the volume of

air passing through the valve without hindering the valve's operation. The new design consists of a tapered column that permits the ping-pong ball to rise in the column in proportion to the flow rate. By periodically recording these flows along with vapor concentrations, technicians can evaluate the overall performance of the passive remediation system. When accelerated remediation techniques are used in conjunction with barometric pumping, the use of the BaroBall valve with the flow measurement feature can provide evidence of increased flow, indicating the effectiveness of these combined techniques.

PSVE is very effective at removing contaminants from the unsaturated zone. The extracted vapors sometimes require treatment, but costs for treating extracted vapors are low compared to the costs of technologies requiring excavation. Vapors extracted by PSVE are typically treated using carbon adsorption, incineration, catalytic oxidation, or condensation. Carbon adsorption is the most commonly used treatment for contaminated vapors. The type of treatment chosen depends on which contaminants are present and their concentrations.

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