Soil, Sediment, Bedrock and Sludge

Bioventing

Introduction:

Oxygen is transported to impacted unsaturated soils by forced air movement (either extraction or the injection of air) in order to increase the soils oxygen concentrations and stimulate the biodegradation process.

Description:

Bioventing is a promising technology that encourages the natural in situ biodegradation of any aerobically degradable compounds in soil through providing oxygen to indigenous soil microorganisms. The process of bioventing utilises low airflow rates to ensure just enough oxygen is present to sustain the activity of microbes. Oxygen is most commonly supplied by direct air injection into residual contamination in soil. Degradation of adsorbed fuel residuals, and volatile compounds are degraded as vapours move through biologically active soils. Bioventing is a medium to long-term technology, with cleanup duration times ranging from a few months up to several years.

Applicability:

The technique of bioventing has been successfully utilised to remediate soils impacted by petroleum hydrocarbons, non-chlorinated solvents, pesticides, and other organic contaminants. Whilst bioremediation cannot degrade inorganic contaminants, it can be used to alter the valence state of inorganics and cause adsorption, uptake, accumulation, and concentration of inorganics in micro or macroorganisms. Such techniques, while still experimental, demonstrate great promise of stabilising or removing inorganics from contaminated soils.

Limitations:

- Water table within several feet of the surface, saturated soil lenses, or low permeability soils will reduce the effectiveness of bioventing.
- Low soil moisture content could limit the biodegradation process.
- Monitoring of off-gases at the soil surface on occasion may be needed.
- Aerobic biodegradation of chlorinated compounds may not be effective unless there is a co-metabolite present.
- Low temperatures can slow remediation.

Data Needs:

It is essential that air must be able to pass through the soil in sufficient quantities to maintain aerobic conditions. Natural hydrocarbon-degrading microorganisms must also be present in quantities great enough to sustain active biodegradation rates. Initial testing is designed to determine both air permeability of soil and in situ respiration rates.
Numerous soil characteristics known to impact the activity of microbes are pH, moisture, nutrients such as nitrogen and phosphorus, and temperature. Soil pH measurements should show the optimal pH range to be 6 to 8 for microbial activity; however, microbial respiration has been demonstrated in soils that fall outside this range. The soil moisture is very soil-specific. Air Force bioventing test sites have maintained biodegradation rates with moisture levels as low as 2 to 5% by weight. However, in extremely arid climates, it may be possible to increase the rate of biodegradation through irrigation.
In Alaska biological activity has been measured in soil temperatures as low as 0° C, although during summer months, bioventing will more effectively degrade contaminants. When used with other indicators of increased microbial activity or biodegradation, respiration tests can provide one of a number of lines of independent evidence to qualitatively document that biodegradation is occurring.

Performance Data:

Bioventing is becoming increasingly more common, with hardware components readily available. As with most biologically based technologies, the time duration needed to remediate a site is greatly dependent upon the soil and the chemical properties of the contaminated media.

Cost:

Surface area is the main driver in costs, impacting the number of injection/extraction wells that are installed at a site.

Soil type due to the fact soils that contain sand and gravel produce significantly lower costs by reducing the number of injection/extraction wells that are required to be installed.

Other cost implications can include contaminant type and its concentration, soil permeability, pumping rate, and whether off-gas treatment is required. The process does not need expensive equipment and typically only a few personnel are involved in the operation and maintenance of the system.