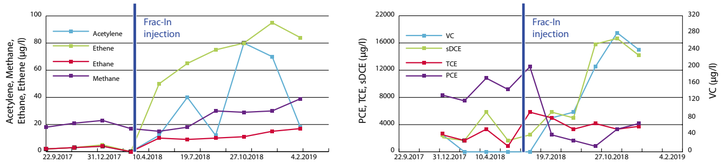
Parameters monitored during the tests in the Czech Republic



Part of the material was injected in the unsaturated zone and later excavated in order to observe the actual spatial distribution of the Frac-In injections. The fractures filled with the mixture of milled iron and sand can be readily identified in the photograph below.

Occurrence of the injected suspension in the fractured soil

The development of Frac-In technology was supported by Eurostars-2 program, with the support of the Ministry of Education, Youth and Sports.

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02. Tailored remediation design

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04. Monitoring & analytical services

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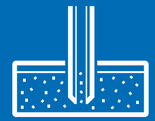
FRAC-IN TECHNOLOGY

Technology for Combined Direct Push and Fracturing of Contaminated Soil



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PRINCIPLE

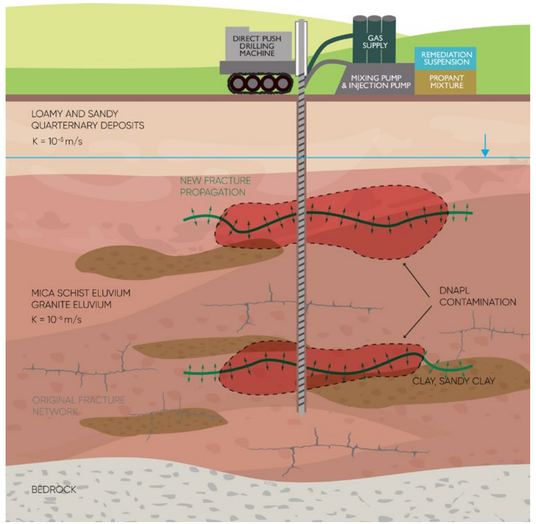
Frac-In technology combines Direct-Push drilling with pneumatic and hydraulic fracturing to inject remediation agents in low-permeability contaminated soils. The injected suspension consists of a mixture of water, sand and thickening agent, containing tailor-made remediation agents such as coarse iron materials or other chemical reductants, and carbon sources to enhance bacterial activity.

DESCRIPTION

Traditional Direct Injection is performed by inserting a hollow rod into the soil using a Direct-Push drilling unit. The end of the rod is equipped with injection nozzles, which are closed while inserting the rod to prevent clogging. When the injection depth is reached, the injection nozzles are opened and a predetermined volume of a fluid is injected into the surrounding soil. When finished, the injection nozzles are closed again, and the rod is pushed into deeper horizons. In this way, a number of injections at different depths may be carried out in one push.

During the Frac-In process, it is also possible to carry out fracturing of low-permeability soils, which are generally considered inaccessible by standard injection techniques. The fracturing creates permeable pathways for the active agents to reach the contamination in the soil. Fracturing is accomplished by a combination of pneumatic and hydraulic pressures, forming a network of cracks in which the suspension is injected. The sand in the suspension acts as a proppant, filling up and stabilizing the cracks. The remediation agents in the injected suspension come into close contact with the contaminated soil, and start treating the contamination.

Conception model of Frac-In applicability



APPLICATIONS

The Frac-In technology is recommended for treating contaminated soil and groundwater in low-permeability environments, such as clays, sandy clays and loam, when target contaminants can be treated in-situ. The current Frac-In suspensions are compatible with in-situ treatments consisting of chemical reduction and/or enhanced anaerobic bacterial treatment. This treatment works well for chlorinated solvents or heavy metals, often encountered at production plants, brownfields and industrial zones. Further development regarding reagents for ISCO and enhanced aerobic biodegradation is ongoing. The radius of influence (ROI) of the injections typically ranges from 4 to 6 m.

Main advantages of the technology

- Frac-In technology makes it possible to inject remediation suspensions into soils where classic remediation techniques are difficult or impossible.
- Frac-In technology reduces the total cost and time of the remediation by combining several remediation steps in one action: drilling, fracturing and application of remediation agents.
- Tailored design of remediation agents ensuring optimal treatment of the contamination.

Frac-In good practices

- Reduce preferential flow paths and short-circuiting of the injected material towards the soil surface.
- Avoid clogging of the injections rods.
- Assure the stability of underground and aboveground infrastructure.

REFERENCE PROJECTS

The Frac-In technology was verified by multiple tests at contaminated sites in the Czech Republic and Belgium.

SELECTED REFERENCE SITE: This site in Czech Republic is characterized by a heterogeneous geology with low permeable sandy clays, contaminated with chlorinated ethenes. During the Frac-in application 5550 L of suspension containing 1700 kg of solid particles (mixture of iron and sand), as well as 5500 L of hydraulic/rinsing fluid was injected. Monitoring of the groundwater quality after the Frac-In injection demonstrated a significant decrease in parent contaminant concentrations and the development of breakdown products. The tests clearly evidenced the effective degradation of the contaminants by the Frac-In technique.