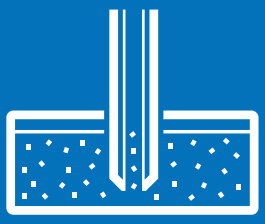
# FRAC-IN-OX TECHNOLOGY

Technology for the Combined Direct Push and Fracturing
of Contaminated Soil with Injection of Strong Oxidising Agents



# PRINCIPLE

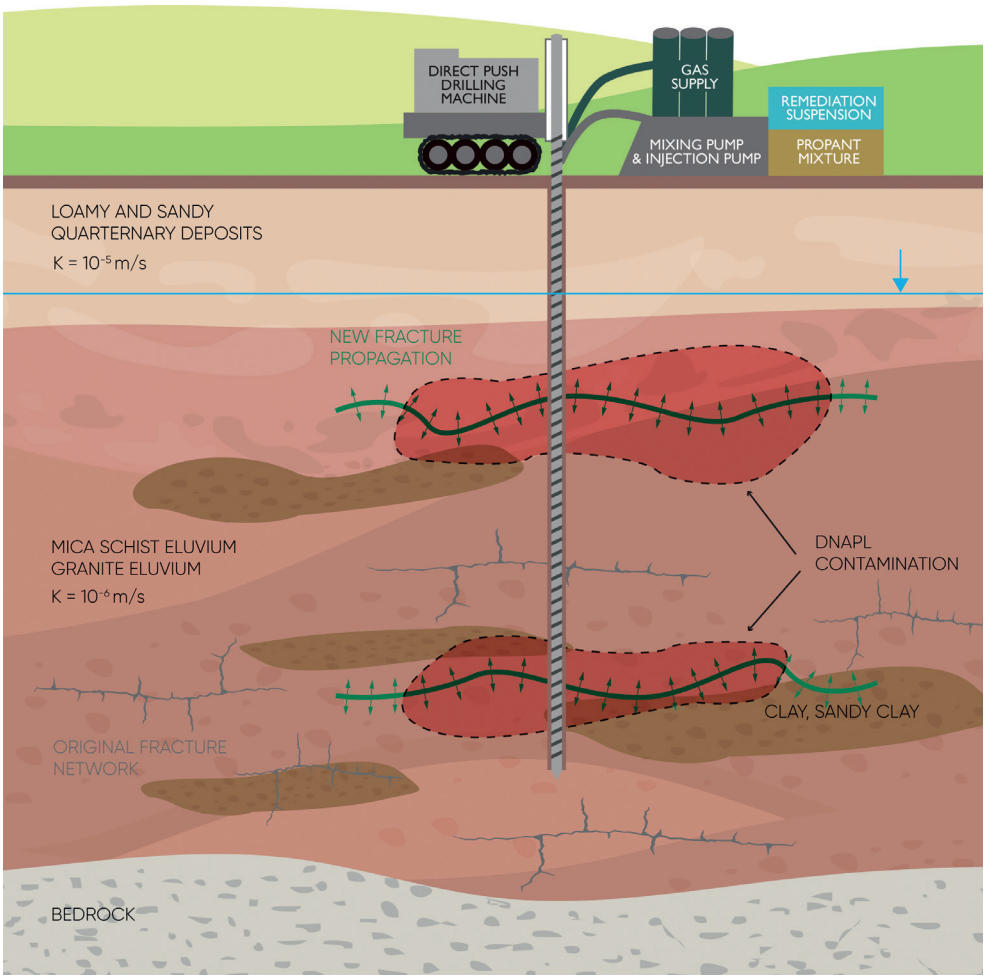
Frac-In-Ox technology combines direct-push drilling with pneumatic fracturing and the subsequent hydraulic emplacement of strong oxidation agents into the subsurface. The technology is suitable for treating poorly permeable or heterogeneous sites contaminated with organic contaminants that are treatable via *in-situ* chemical oxidation (ISCO). The technology enables the injection of highly-concentrated and, thus, highly-corrosive solutions of strong oxidation agents.

# DESCRIPTION

Direct Injection comprises the insertion of a hollow rod into the soil using the Direct-Push drilling unit. The end of the rod is equipped with injection nozzles, which are closed while inserting the rod so as to prevent clogging. Once the injection depth has been reached, the injection nozzles are opened and a predetermined volume of the fluid is injected into the surrounding soil. Once completed, the injection nozzles are closed and the rod is pushed into the deeper horizons. This approach allows for several injections at differing depths in one single push probe.

The Frac-In-Ox process involves the injection of air under high pressure and with a high flow rate into low-permeability soils that are generally considered inaccessible using standard injection techniques.  High pressure air injection results in the pneumatic fracturing of the soil thus forming a network of cracks into which a suspension containing sand is subsequently injected. The sand in the suspension acts as a proppant for the filling and stabilisation of the cracks. The suspension may also contain calcium peroxide that can act both as an oxidising agent and as a slow-release source of oxygen. The stabilised fractures are then flushed with solutions of strong oxidising agents based on sodium/potassium persulphate.

## Conception model of Frac-In-Ox applicability




# APPLICATIONS

Frac-In-Ox technology is recommended for the treatment of contaminated soil and groundwater in low-permeability environments such as clays, sandy clays and loam in cases where the target contaminants can be treated *in-situ*. Frac-In-Ox suspensions are compatible with *in-situ* treatment comprising chemical oxidation and/or enhanced aerobic bacterial treatment. This treatment approach works well for petroleum compounds, organic solvents, PAHs etc., which often pollute production plants, brownfields and industrial zones. The radius of influence (ROI) of the injections typically ranges from 4 to 6 m.

## Main advantages of the technology

- Frac-In-Ox technology allows for the injection of remediation suspensions into soils in cases where the application of classic remediation techniques is difficult or impossible.
- Frac-In-Ox technology reduces the total cost and duration of the remediation process by combining several remediation stages in one operation, i.e. drilling, fracturing and the application of the remediation agents.
- The tailored design of the remediation agents ensures the optimal treatment of the contamination.

## Frac-In-Ox good practices

- Reduce the occurrence of preferential flow paths and the short-circuiting of the injected material towards the soil surface.
- Avoid the clogging of the injection hose.
- Ensure the stability of the underground and aboveground infrastructure.

# REFERENCE PROJECTS

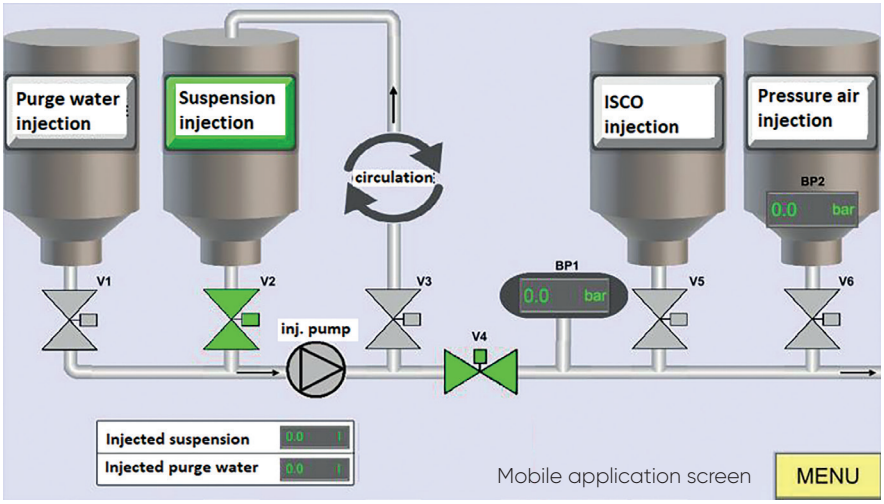
Frac-In-Ox technology was verified via pilot testing at a contaminated site in the Czech Republic.

SELECTED REFERENCE SITE: The site in the Czech Republic is characterised by a heterogeneous geology with low permeable sandy clays that have been contaminated with a mixture of solvents with the predominance of 1,2-DCA, chloroform and dichlormethane. The pilot test involved the injection of two differing mixtures of remediation agents into 16 injection probes at the site. One of the mixtures of remediation agents was based on the use of guar gum as the thickening agent for transporting sand into the created fractures, while the second was based on hydrophilic fumed silica and calcium peroxide. A total of 1.4 t of sand, 1.4 t of sodium persulphate, 0.95 t of potassium persulphate and 0.56 t of calcium peroxide was injected. Surveys of the pilot site using the so-called Hydraulic Profiling Tool (HPT) performed at the site prior to and following the Frac-In-Ox injections provided information on the changes in the hydraulic properties. The results indicated a significant increase in the hydraulic permeability of the aquifer. The monitoring of the groundwater quality both before and after the pilot testing served to prove the good distribution of the injected remediation agents and their long-lasting presence in the groundwater. A mean decrease of 62% in the sum of the volatile organic compound concentration was observed via the monitoring of boreholes 4 months following the injection campaign.

## Wireless-operated distribution component with pneumatically-powered valves, manometers and connections used for the controlled injection of the various materials


A - Inlet of suspension from the pump  B - Outlet of the suspension into the injected well  C - Depressurisation valve

The core of the injection set-up comprises the distribution component with wireless-operated pneumatically-powered valves, manometers and connections to all the input and output points. The valves are operated via the cMT Viewer mobile application, which allows for the remote operation of the system, thus significantly enhancing the safety of the procedure. After clicking on the selected injection vessel, the relevant valves are opened and closed automatically, thus preventing any human error issues. The application displays the injection pressure and volumes of the injected suspension and the flushing (purge) water.




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

DEKONTA is one of leading waste management, consulting and engineering companies offering environmental services. It has also its own research and development department, serving mainly to company purposes. The company is well established with international competence and more than 20 years of experience in the field. DEKONTA operates in many countries in Central / East Europe, Balkan, former Soviet Union states and selected Asian states (e.g. China, Vietnam, India, Mongolia, Kuwait).

ABO is part of the ABO-Group, an international holding comprising of company engineering, consulting and testing companies active in the environmental sector. The group has offices in Belgium, the Netherlands, France and the UK and provides services in soil and environmental consultancy, geotechnical investigations, technical inspections, safety control, energy, archaeology, etc. ABO is supported by its sister company Geosonda, a testing and monitoring company from the ABO-Group that is specialized in *in-situ* injection techniques.

NANO IRON is Czech company engaged in large-scale production of zero-valent iron nanoparticles (nZVI) mainly for *in-situ* groundwater remediation. NANO IRON provides also full technical support for any application. The company is the largest producer of nZVI in the world operating more than 7 years. The company is also engaged in the development and production of a new iron-based products.

This project has received funding from the Eurostars-2 joint programme with co-funding from the European Union Horizon 2020 research and innovation programme