Out of sight: Case studies of innovative *in situ* remediation under active industrial sites across Europe

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1 Introduction

In situ remediation on busy sites

Choosing the correct remedial approach for the treatment of a contaminant requires consideration of many different parameters. These may include the type of contaminant, the concentrations at which it is found in the ground, the required targets, the hydrogeological conditions etc. As well as these technical aspects, it should also be acknowledged that many of these contaminant issues occur on (and usually because of) busy industrial sites.

The requirement of the site owner to continue operations while the remediation occurs can have significant implications for 'traditional' methods of remediation, such as excavation or pump and treat. Excavations can be expensive and highly disruptive. Pump and treat systems can take up valuable space and often present an never-ending cost.

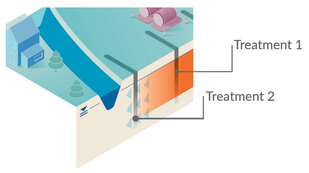
In situ remediation techniques offer the ability to target contamination on busy sites with minimal disruption to the ongoing operations. The actual site works are quick, typically injections are completed within days or weeks, with the remediation occurring in the subsurface for months or years afterward.

This poster shows some examples of how in situ remediation can provide cost effective treatment and end-point certainty, in some of the most difficult locations.

2 Volvo Manufacturing Plant, Belgium

Remediation of TPH, BTEX and CVOC at Volvo Car Ghent

Historic spillage of lubricant oils and cleaning solvents, used in the manufacturing process, resulted in two plumes contaminated with low but persistent levels of petroleum hydrocarbons (including BTEX) and chlorinated solvents underneath the Volvo manufacturing plant. REGENESIS completed a pilot test in the first out of two areas to confirm site investigation results by **Artemis Milieu** and increase efficiency of full-scale treatment.



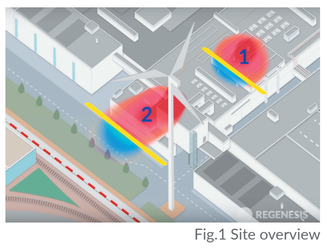


Fig.1 Site overview

Remediation goals:

Reduce risk of contaminant migration across the plant's site boundary.

Application:

Two PlumeStop® barriers have been designed to treat the plumes and prevent off-site migration:

1. The first was installed in an area located adjacent to the plant's paint mixing area to mitigate against the offsite migration of the BTEX Plume;
2. The second barrier was installed close to the site boundary to treat a mixed plume comprising of BTEX and chlorinated solvents.

Pilot test results:

Total BTEX concentrations have been reduced by more than 99% over a 6 month period (see figure 2).

Full-scale treatment:

The full-scale application finished in April 2019. The first two monitoring campaigns confirm the trends we have observed during the pilot test.

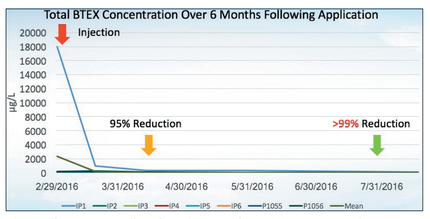


Fig.2 Pilot test results showing total BTEX concentration over a period of 6 months after injection

Highlights:

- Small, portable injection equipment, avoided disruption of ongoing operations
- Application completed <10 weeks (spread over different phases), followed by years/decades of treatment
- 99% reduction of total BTEX concentration in 6 month period

4 Train Care Depot, UK

Remediation of free product under an active train care depot, where trains have been stored, repaired, cleaned and refulled for over 50 years. Due to fuel spill incidents, a 2m thick layer of LNAPL (Light Non-Aqueous Phase Liquid) was located on top of the groundwater column in the source area and with the contaminanted plume migrating towards residential properties.

Remediation goals:

- Removal of LNAPL
- Reduction of adsorbed contaminant mass in the smear zone &
- Treatment of groundwater to enhance the degradation of the residual dissolved phase contamination

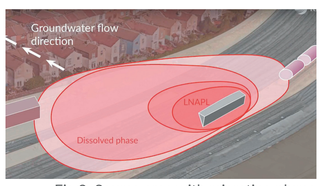


Fig.3 Source area with migrating plume

Application on site:

- 18 treatment wells and 10 monitoring wells were installed across the fuelling point, access road & four foot and six foot of the rail
- Treatment level: 2-6m below ground level
- Total treatment area: 1,000 m^2

Treatment Phase 1:

A pump & treat system was installed and operated to remove the easily-accessible LNAPL. Following this, four applications of PetroCleanze® were applied into the treatment wells. By using PetroCleanze, soil-bound contaminant mass moved from the smear zone into the groundwater, making it easily removable by the pump and treat system, thus avoiding any future rebound in concentrations, due to desorption, after the pump and treat system was switched off.

Treatment Phase 2:

Residual contamination was then addressed using RegenOx® to provide In Situ Chemical Oxidation (ISCO) and ORC Advanced to accelerate Enhanced aerobic Natural Attenuation (ENA).

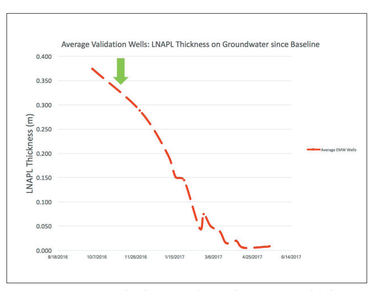


Fig. 4 Graph showing how the LNAPL thickness is reduced during pumping and increases due to enhanced desorption during PetroCleanze applications. It can be seen that the 'rebound' caused by each consecutive PetroCleanze injection is lower than the prior one, indicating a reduction in adsorbed contamination following each event

Highlights

- No disruption to site operations (ongoing train service, continued operation of fuelling point)
- Safe & cost-effective solution
- An integrated solution using enhanced extraction and in situ remediation
- Rapid removal of LNAPL
- Significant reduction in groundwater concentrations

3 Bologna Railway Station, Italy

In situ remediation of a widespread chlorinated solvent plume beneath the train station and surrounding urban area in Bologna.

Challenge:

- Low chlorinated solvents concentrations (100µg/l or less)
- Main contaminants: TCE and cis-1,2-DCE
- Stringent remediation targets
- Widespread plume beneath train station, extending out under the surrounding urban area
- Two aquifers with different geological characteristics

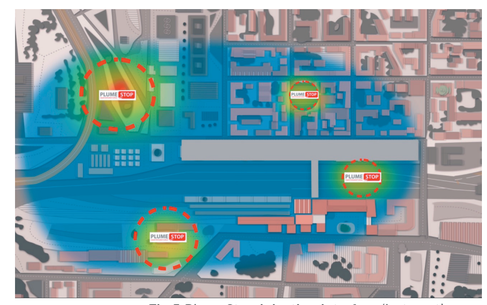


Fig.5 PlumeStop injection into four 'hot spot' areas

Geology:

- Superfical aquifer (6m-8m thickness) consisting of fine sands and silts
- Deep aquifer (2m-4m thickness) consisting of higher permeable sand

Pilot test:

REGENESIS installed six multi-level injection wells at a single location and applied specific doses of PlumeStop at the target depths.

Full-scale application:

PlumeStop was injected into the four identified 'hot spots' areas illustrated in fig 5. In all treatment areas, PlumeStop has been co-injected with REGENESIS electron donors HRC® and HRC Primer®, which provide initial biostimulation and promote continual in situ bio-regeneration of the Liquid Activated Carbon.

Results:

Results available (fig. 6) show a rapid reduction in chlorinated solvent concentrations inside the treatment areas. In the majority of monitoring wells concentrations of all chlorinated compounds are below stringent regulatory standards and in many cases also below detection limit. It is expected that the concentrations will be maintained at low levels without any rebound effect, due to the continuous regeneration of the activated carbon provided by the biodegradation process.

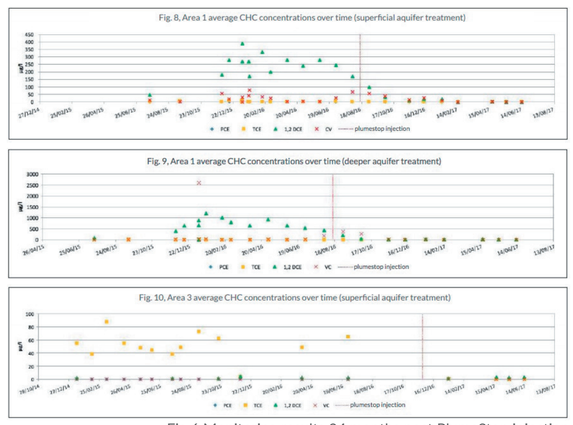


Fig.6 Monitoring results 24 months post PlumeStop injection

Highlights:

- Successful remediation with a single application in two porous media aquifers at the same time
- Rapid reduction in chlorinated solvent concentrations
- No re-application of PlumeStop required, due to the self-regenerating capability of the biomatrix

5 Active Dry Cleaning Facility, UK

A spill during delivery of dry cleaning fluid, caused the ground beneath an industrial dry cleaning facility to be contaminated with up to 2 tonnes of Tetrachloroethene (PCE). Groundwater and soil up to 10m below ground levels were significantly polluted.

Challenges:

- Chlorinated solvent contamination was found in shallow permeable soils and deep in low permeable clays beneath the site
- There was evidence of DNAPL in more sandy layers within the clay
- Treatment was required in the busy outside yard and inside under the active machinery of the facility
- The contamination was moving offsite in an aerobic aquifer, showing no natural signs of biological degradation

Application:

In the deep, low permeability clays, REGENESIS applied a combination of Hydrogen Release Compound (HRC) products (HRC Primer®, HRC® and HRC-X®). HRC is an engineered, hydrogen release compound designed specifically for enhanced, in situ anaerobic bioremediation of chlorinated compounds. The HRC product mix was injected with a direct push injection rig on a grid pattern across the target area. In the shallow, permeable made ground, the high-volume version of HRC, called 3-D Microemulsion (3DMe) was injected to enhance the anaerobic biodegradation of the chlorinated hydrocarbons. The injection was completed within two weeks, with no impact on the dry cleaning operations.

Cost:

- The total cost of the in situ treatment was € 200.000
- Project savings of in situ remediation over pollutant mass reduction via excavation was considered to be € 567.000 (this does not include the cost of disturbance to the operation while an 11m deep excavation would be completed onsite)

Highlights

- Up to 2 tonnes of Tetrachloroethene (PCE) contaminated soil and groundwater
- No disruption to ongoing operation of the facility
- Injection completed in two weeks
- Tailored treatment to suit areas with different contamination concentrations and permeabilities
- In situ approach saved up to € 567.000 compared to excavation
- Winner of the UK Brownfield Briefing awards in the categories 'Best In Situ Remedial Treatment' and 'Best Project Closure/Verification Process'

For more information, please contact Gareth Leonard (gleonard@regenesis.com) or visit our website www.regenesis.com.

REGENESIS is the world's leading provider of environmental solutions for in situ groundwater remediation. Our multi award-winning technologies have been used on more than 26,000 sites to date, in 29 countries worldwide. They are currently being used every working day in Europe.