REGENESIS

Combined ISCR and *in situ* sorption of a PCE plume on school grounds in Northern Italy

CASE STUDY

Colloidal activated carbon and sulfidated ZVI co-applied for successful treatment and minimization of daughter products

Summary

An ongoing manufacturing facility located within a major Italian city created a widespread tetrachloroethene (PCE) contaminant plume in the underlying aquifer. The highly aerobic aquifer has inhibited natural attenuation, with no daughter products detected even after many years.

Environmental company TAUW is in charge of this site and has implemented hydraulic containment within the factory grounds, as required by law. However, there remained a need to target the plume beyond the site boundary. This external plume needed a considered approach, as it was spread across a large urban residential area with accessibility only in public parks, streets, municipal properties and on a school ground.

TAUW determined that a series of *in situ* barriers would be used, as they could be installed within the limited access locations and cause little disturbance at the surface. The barriers provide years of treatment from a single application and are entirely passive, requiring no operation or maintenance. A combination of **In Situ Chemical Reduction (ISCR)** and **In Situ Sorption** was selected for the barrier composition, with REGENESIS' products **S-MicroZVI®** and **PlumeStop®** to be injected into six barriers. The simultaneous use of these technologies would provide rapid removal of the contaminants from the groundwater, complete degradation and minimisation of daughter products. A Master Plan was agreed with the local Authorities, with the intention to complete a series of barriers across the city to deplete plume concentrations.

SITE TYPE

School grounds within and urban residential area

PROJECT DRIVER

External plume management for offsite liability reduction

TREATMENT

In Situ Chemical Reduction, *In Situ* Sorption

GEOLOGY

Partially cemented sandy gravel

CONTAMINANTS

Tetrachloroethene (PCE)

TECHNOLOGIES

PlumeStop®, S-MicroZVI®

Design Approach & Planning

The first barrier has been designed with **PlumeStop** colloidal activated carbon and **S-MicroZVI** colloidal sulphidated zero-valent iron.

Fig. 1

PLUME STOP
Liquid Activated Carbon

Both technologies are **colloidal liquids** with **low viscosities**, allowing them to be **co-applied at low pressure** into the sub-surface. This ensures that the substrates are emplaced within the flux zones through which the contamination advects. The products have unsurpassed distribution properties that create a wide radius of influence from each injection location. This means that the number of injection points can be minimised, **reducing cost**, **time** and **disturbance** to complete the installation.

The PlumeStop coats the aquifer in a **1-2µm layer** of **activated carbon**, turning it into a purifying filter. This provides both rapid and long-term removal of the contamination from the groundwater. Once sorbed the contamination is degraded through ISCR. Reduction along the β-elimination pathway results in minimisation of the daughter products.

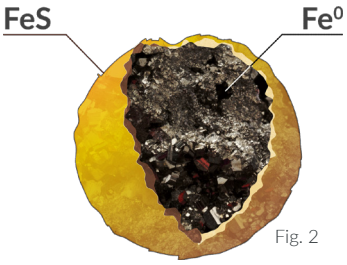

Fig. 2

S-Micro ZVI
Sulfidated Zero-Valent Iron

The chemical reduction of the sorbed contamination regenerates the sorption sites on the activated carbon filter, allowing further contamination to be sorbed and subsequently destroyed in an ongoing cycle. This self-regeneration ensures that the barrier will continue to be effective over a very long time, without the need for further injections.

The application was completed in a single mobilisation using direct-push injection technology. In order to reach the lowest sections in the target zone, pre-coring of the injection locations was completed prior to direct push injection.

Fig. 1 PlumeStop distribution | Fig. 2 Representation of a sulfidated zero valent iron particle

Direct Push Application

A **50m long *in situ* barrier** was applied at the edge of a park within school grounds, with minimal interference with the school activities. **20 direct push injection points** were completed with **2.5m spacing**, over a period of 5 weeks (including pre-drilling). PlumeStop and S-MicroZVI are designed to be completely compatible allowing efficient co-injection. The dosage for each point was tailored according to the baseline concentrations along the barrier, ranging from few µg/L to over 1000 µg/L PCE.

Design verification testing was used to determine optimal pressure and volume rates to be used. **Low pressure (<2 bar) injection** was then used for all injections, despite the challenging geology, suggesting that the formation readily accepted the colloidal substrates into the flux zones. Throughout the application, injection confirmation testing was completed to confirm interlocking radii of influence along the length of the barrier.

Application Design Summary:

Injection points: 20
Spacing: 2.5m
Target depth: 20-25m BGL
Barrier length: 50m

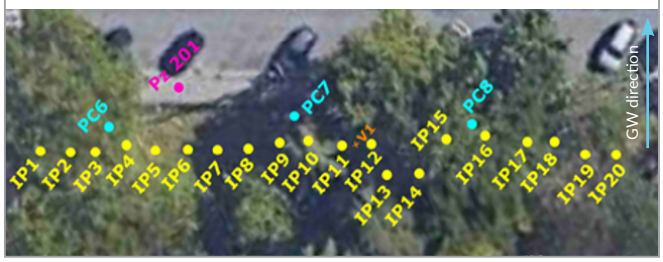

Fig. 3 Injection points and groundwater flow

Results

Performance is being monitored through 4 monitoring wells (3 wells 2m downgradient and 1 well 5m downgradient of the barrier). Validation is ongoing, with data now at 5 months post-injection. The results show a **significant** and **rapid decrease of PCE concentrations** in all 3 monitoring wells immediately downgradient. PCE reduction was observed immediately in the first monitoring round and remains low, with over 2 orders of magnitude reduction observed in some cases. Reductive dechlorination daughter products are either absent or observed in very low concentrations confirming the synergistic effect of sorption and chemical reduction.

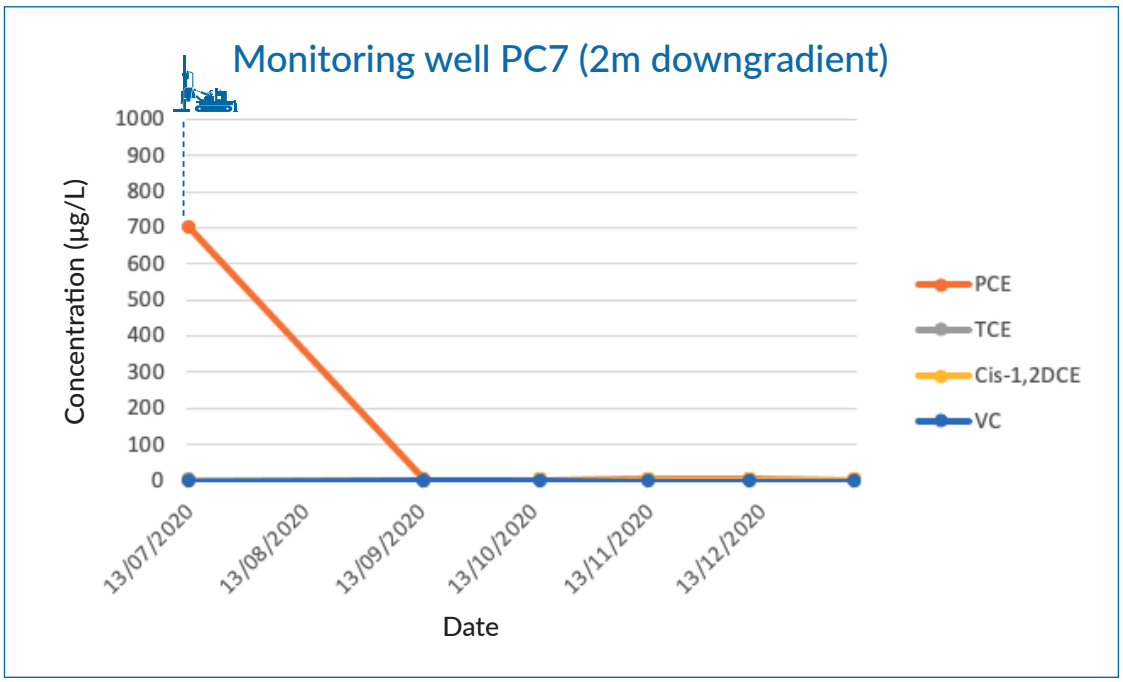

Fig. 4 Chlorinated solvents trend after injection, central portion of the barrier

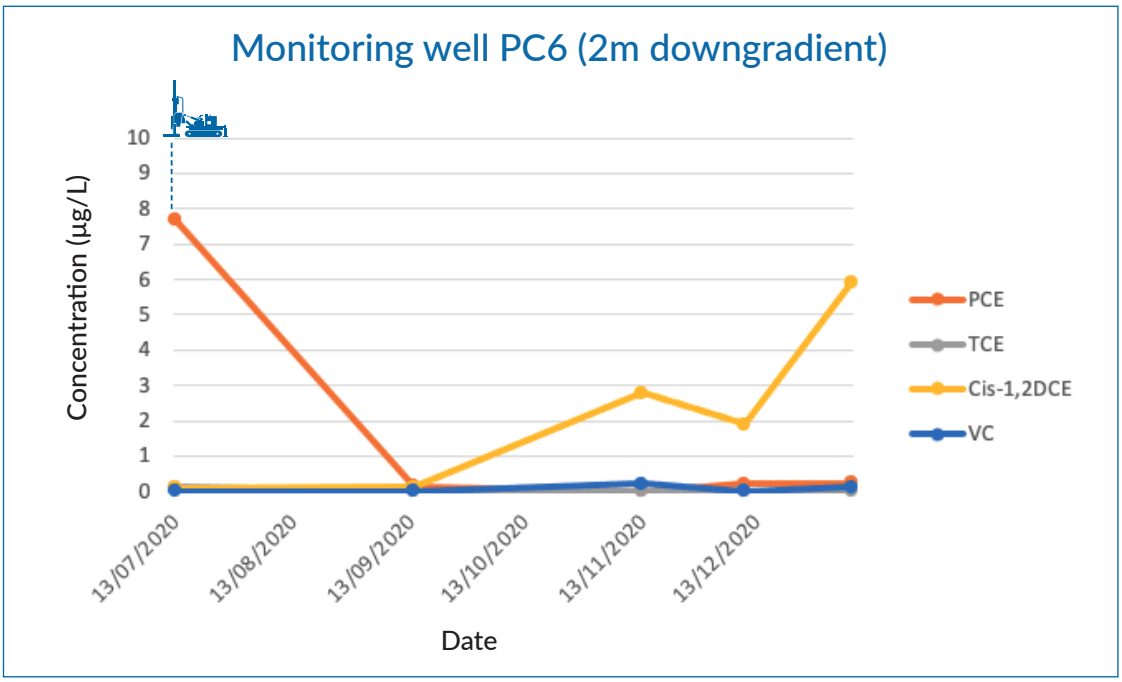

Fig. 5 Chlorinated solvents trend after injection, left portion of the barrier

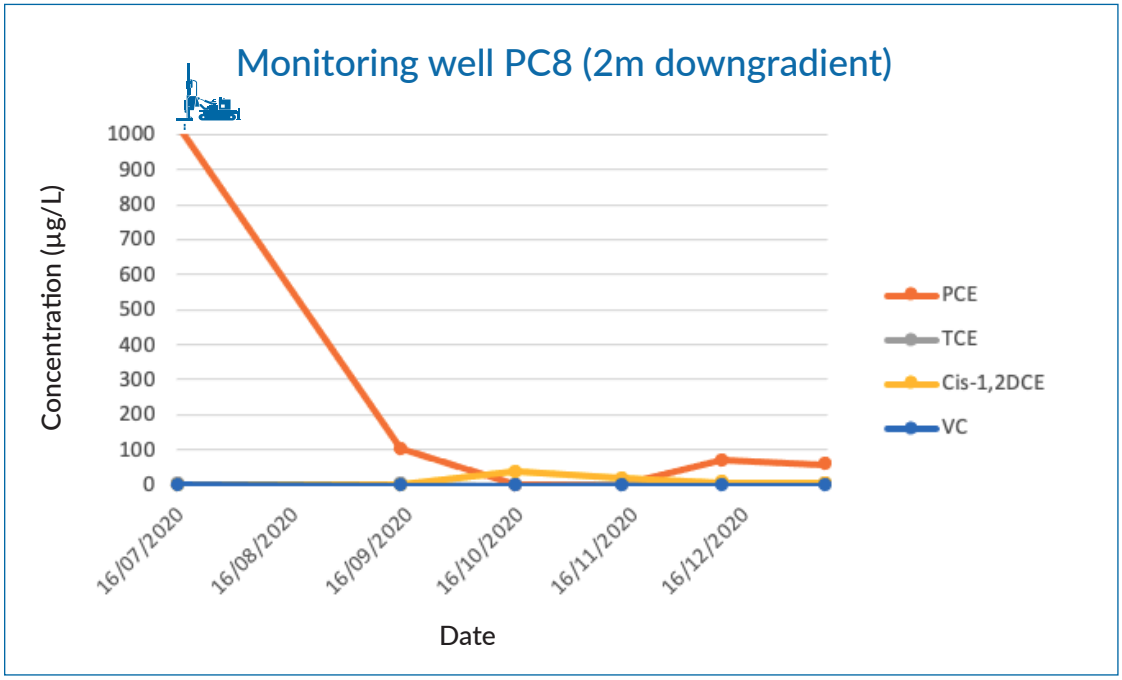

Fig. 6 Chlorinated solvents trend after injection, right portion of the barrier

The monitoring well further downgradient shows a later reduction of the PCE concentrations as would be expected. Some cis1,2-DCE is created by with no evidence of TCE and VC. Biological degradation may be more pronounced here due to the reducing conditions created by the S-MicroZVI. As the upgradient parent compound is removed, the levels of daughter products are expected to decrease in line with the other validation wells.

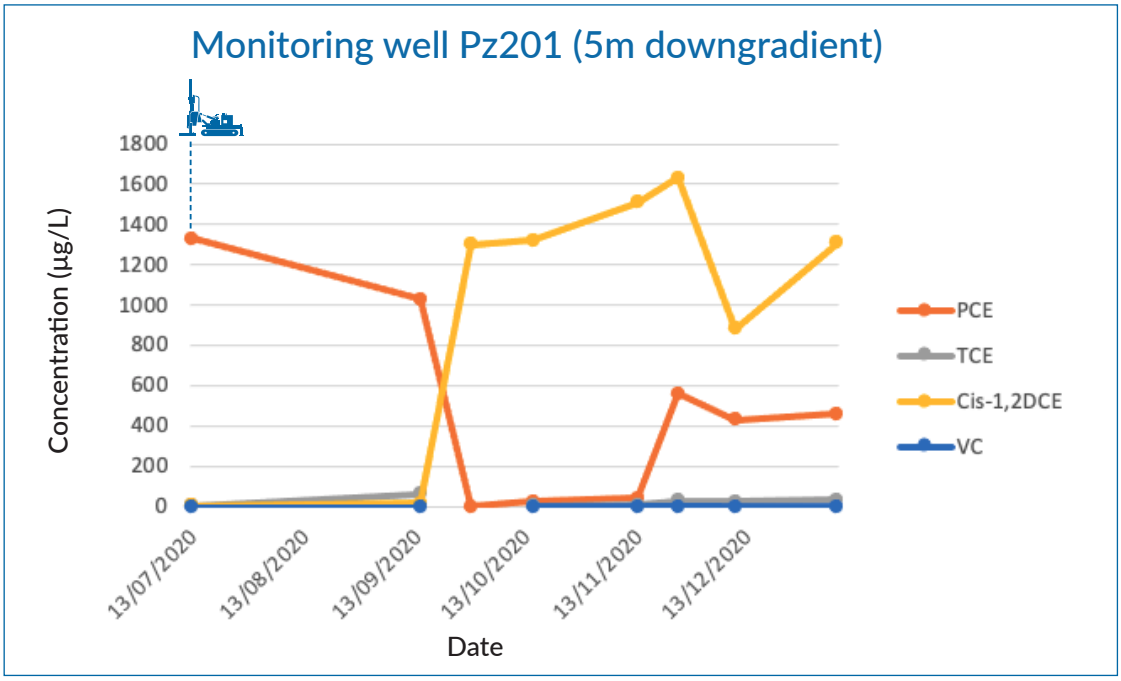

Fig. 7 Chlorinated solvents trend after injection, 5 meters down-gradient of the barrier

Long term monitoring of the barrier is planned and will allow the verification of the longevity of the barrier and the maintenance of excellent treatment conditions.

Conclusion

A combination of PlumeStop and S-MicroZVI were co-injected safely and easily, with minimal disturbance to the school grounds and urban setting of the site. The treatment carried out by TAUW and REGENESIS has been immediately **effective** providing **dramatic reductions** in contaminant concentrations.

The ***in situ* barrier** requires **no power or maintenance** and through **self-regeneration**, may be expected to continue to **treat the contaminant plume** for **years** from a **single application**. The information gathered during the site application and the validation monitoring are currently being used to refine the design of the other *in situ* barriers which will be installed across the city as part of the Master Plan.

About Tauw

TAUW is a European consultancy and engineering firm with a strong position in environmental advice and the sustainable development of the living environment. From offices in the Netherlands, Belgium, Germany, France, Spain and Italy, more than 1,200 dedicated employees work on a beautiful, clean, safe and sustainable living environment.

TAUW Italia has been active since 1990 acting as reference point for industrial clients, real estate developers and investment funds. With 2 offices, in Milan and Pisa, TAUW Italia is specialized in the design and operation management of remediation projects and site redevelopment, permitting, auditing and compliance management.

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