Klozur® One Application Destroys over 99% of Trichloroethylene in Five Weeks at a Former Manufacturing Facility in The Netherlands

Background

The soil and groundwater at a manufacturing facility near the city center of Uden had been impacted with chlorinated hydrocarbons as the result of former business activities. Following demolition of the buildings in 2005, site investigations revealed high levels of contamination. In the groundwater aquifer, concentrations of more than 16 µg/l of trichloroethylene (TCE) were measured, indicating the presence of a source zone (SZ). The impacted SZ was 270 square meters and contamination ranged from 3 to 7 meters below ground level. For the planned redevelopment of the site into a residential area, local regulatory authorities mandated remediation of the contaminations to stringent clean-up target levels.

Site Information:

Site Type: Former Manufacturing Facility

Location: Uden City Center, The Netherlands

Lead Contractor: Heijmans Infra B.V.

Engineering Consultant: TTE Consultants

Remedial Approach: Injection through Fixed Wells

Results: 99.6% Reduction of TCE

Challenge

Following detailed Site Investigations (SI), as per standard operating procedures, the first step was excavation of contaminated soils to the top of the groundwater level, and then backfilling the area with certificated clean soils. The end-use for the site was construction of residential housing, therefore rapid remedial results were required. As result of the Remedial Options Appraisal (ROA) process, selection of a technological solution required high reliability, cost-effective implementation and quick results. The engineering consultants conducted the SI and were involved with results verification, whereas the lead contractor was responsible for overall project management including technology selection.

Solution

The *in situ* chemical oxidation (ISCO) technology Klozur® One was selected primarily because it met all ROA objectives. As a blend of sodium persulfate with built-in activation chemistry, Klozur One provided powerful oxidation capacity as a "ready to use" product suitable for this highly contaminated treatment area. A total of 9,225 kgs was required, delivered in 25 kg bags from a nearby warehouse, helping to keep the logistics carbon footprint low. As persulfate requires careful handling, the contractor took all necessary safety measures for storage and handling. At the on-site mixing facility the bags were opened under controlled conditions, ensuring little physical contact between field technicians and the sodium persulfate. Special attention was focused on reducing the production of any dust particles.

The injections were made per batch (Table 1), and in the injection plan there are several different concentration batches provided. A typical batch contained 4 m^3 of clean water into which a specified amount of Klozur One was added. From the mixing unit, the proper solution of Klozur One is transferred into the injection tank.

Table 1. Klozur One Batching (Displayed in US Customary Units)

Batch Number	Batch Volume (Liter)	Klozur One (Kg/batch)	Number of 25kg Bags	Batch Concentration (g/l)	Volume per Well (Liter)
1	3,700	350	14	94.6	2,775
2	4,500	200	8	44.4	3,600
3	4,500	200	8	44.4	3,600
4	4,500	200	8	44.4	4,500
5	4,500	200	8	44.4	4,500
6	3,600	350	14	97.2	3,600
7	4,500	425	17	94.4	4,500
8	4,000	200	8	50.0	3,600

Each batch of injectable solution was mixed together and then subsequently applied to the subsurface through existing injection wells. In total, the contractor used 40 injection points at three different subsurface levels, in a grid pattern with a center-to-center distance of 2 meters (Figure 1).

With this grid, it was possible to engineer contact across the entire source area. At spots with higher concentrations of contaminant, more solution was applied with a higher concentration of persulfate. At each injection point between 2,775 and 4,500 liters of solution were applied. Through use of a manifold system (Figure 2), 4 to 6 wells were worked simultaneously, using a little overpressure to prevent blow-out at the surface. In total, the field work lasted nine days injecting 155 m^3 of Klozur One injection fluid.

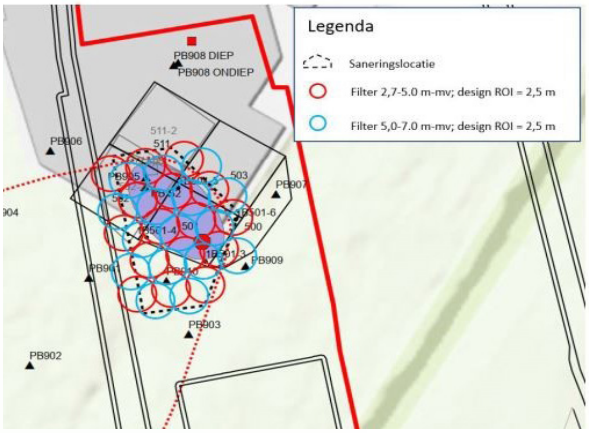

Figure 1. Injection Grid Layout

Figure 2. Injection Well Manifold

Results

Before start of the injections there was an investigation of the TCE concentrations on-site. Monitoring activities during and after the injections included measurements of pH, oxygen, redox, and electrical conductivity. Following the injections with sodium persulfate, there was a notable decrease in pH and increase in electrical conductivity visible. The contractor used PeroxyChem's Klozur Field Test Kits to determine an indication of the amount of active sodium persulfate still available.

The parameters were monitored weekly. After four weeks most of the sodium persulfate was consumed, allowing the monitoring wells to be used for groundwater quality. In total, 10 wells were monitored and in all of them the TCE concentration was decreased to below remediation targets. Four weeks later, an independent verification by the engineering consultants confirmed the positive results. The consultant also concluded that there was no active sodium persulfate left and that the trichloroethylene was sufficiently removed (Table 2).

In total, the chemical oxidation process removed 99.6% of the TCE. With these results, the client and regulator accepted closure of the site, with no further remediation requirements.

Table 2. Monitoring Well 2 Data Over time (Displayed in US Customary Units)

Monitoring Well 2	Parameter	6-Sept 2019	24-Sept 2019	21-Oct 2019	21-Nov 2019
depth: 4.5 meters below ground level	PCE (µg/l)	<50	<1	<1	<1
	TCE (µg/l)	14,000	2.4	<1	<1
	DCE (µg/l)	<50	1.4	1.4	1.4
	VC (µg/l)	<100	<2	<2	<2
	Sodium (mg/l)	13	n.a.	3,900	2,600
	Sulfate (mg/l)	30	n.a.	1,300	1,400