CASE STUDY | KLOZUR® CR

APPLICATION OF KLOZUR® CR ACHIEVES TREATMENT GOALS FOR HYDROCARBONS, BTEX AND MTBE AT A FORMER PETROLEUM STATION IN ITALY

SITE OVERVIEW

KLOZUR® CR is a combined remedy treatment technology consisting of KLOZUR® SP (sodium persulfate) and PERMEOX® Ultra (extended release calcium peroxide). This technology was successfully applied at a site in a densely populated urban area in Bologna, Italy and which was contaminated with various toxic contaminants. The site, a dismantled former petroleum station, was impacted by the storage of fuels which resulted in groundwater contamination including hydrocarbons (C<12 ~ 2000 µg/L), benzene (~ 500 µg/L), ethylbenzene (~ 380 µg/L) and methyl tert-butyl ether (MTBE) (~ 13000 µg/L).

Two injection events were carried out fifteen (15) months apart with a total of 4800 kg of KLOZUR® CR (25% by weight aqueous slurry) applied at the site. Eighteen (18) months following the first application, the concentrations of contaminants had decreased below the remedial goals in all monitoring piezometers in the treatment area. Total petroleum hydrocarbons were reduced by greater than 80 percent while MTBE was reduced by greater than 90 percent. Monitoring data confirmed that elevated oxidation-reduction potential (ORP) and dissolved oxygen (DO) levels were sustained to support continued enhanced aerobic bioremediation.

KLOZUR® CR

SIDE DETAILS

Site Type
Confidential Former Petroleum Station

Location
Bologna City Center, Italy

Contaminants
Total Petroleum Hydrocarbons (TPH) ~2000 µg/L
Benzene ~500 µg/L
Ethylbenzene ~380 µg/L
MTBE 13000 µg/L

Soils
Silty sands to silty clays

Application
Solid slurry Injection

Results
Remedial goals obtained for all contaminants
TPH > 80% Reduction
MTBE > 90% Reduction

THE APPROACH

Monitoring data from 2017 suggested that the total contaminated area of the site was approximately 350 m2 (Figure 1). The groundwater at the site was initially observed at a depth of approximately 3.8 m below ground surface (bgs), flowing in a northerly direction at a low rate of approximately 4 meters / year. Treatment with KLOZUR® CR targeted a 5 m vertical interval of saturated contaminated soil, between depths of 4 m and 9 m bgs. The soil consisted of backfill (gravel in a sandy matrix) up to a depth of 3.5 m bgs, below which were found silty sands, sandy loam, and silty clay lenses, at an effective porosity in the saturated zone of 15% and a hydraulic conductivity of about 10-4 cm/second.

The KLOZUR® CR technology was selected by the design engineers for groundwater remediation to sequentially promote:

- ISCO, In Situ Chemical Oxidation, via alkaline activated sodium persulfate,
- Enhanced aerobic bioremediation, due to slow-release oxygen in bio-available form (PERMEOX® Ultra),
- Enhanced anaerobic bioremediation (anaerobic oxidation), due to the interaction of sulphate and residual hydrocarbons in groundwater.

The remediation goals were calculated through industry standard risk analysis (AdR) corresponding to the sitespecific risk threshold concentrations (CSR) (Table 1).

Figure 1. Site location

Table 1. Site-specific risk threshold concentration remediation goals

Contaminant of Concern	Remediation Goals (CSR) (µg/L)
Benzene	18.24
Toluene	6.85
Ethylbenzene	53.04
p-Xylene	2.31
Total Hydrocarbons	350 (*)
MTBE	74.66

*CSR=CSC (Contamination threshold Concentration D.Lgs.152/06)

FIELD APPLICATION

Two injection events were carried out in February 2018 and April 2019, with 2380 kg and 2400 kg of KLOZUR® CR used, respectively. The KLOZUR® CR was injected, as a 25% slurry, through 18 injection points (Figure 2) which were distributed with a regular triangular mesh of about 5 m side (sphere of influence ~ 2.5 m) in the region of the source area. The thickness of saturated treatment area was 5 m, between depths of 9 m and 4 m bgs (bottomup application with injective step approximately every 30 cm).

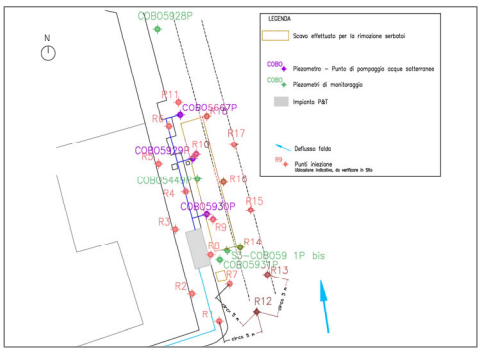


Figure 2. Grid of the 18 injection points (in red) and 4 monitoring points (in green) together with the direction of flap SN

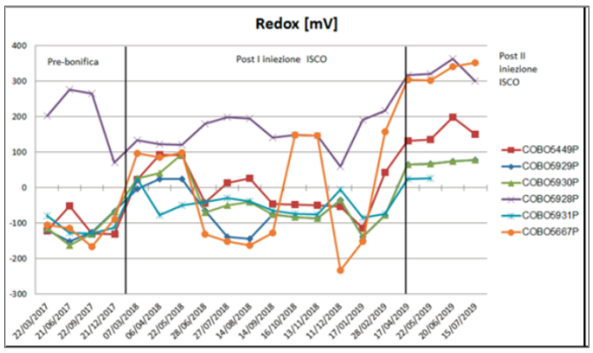


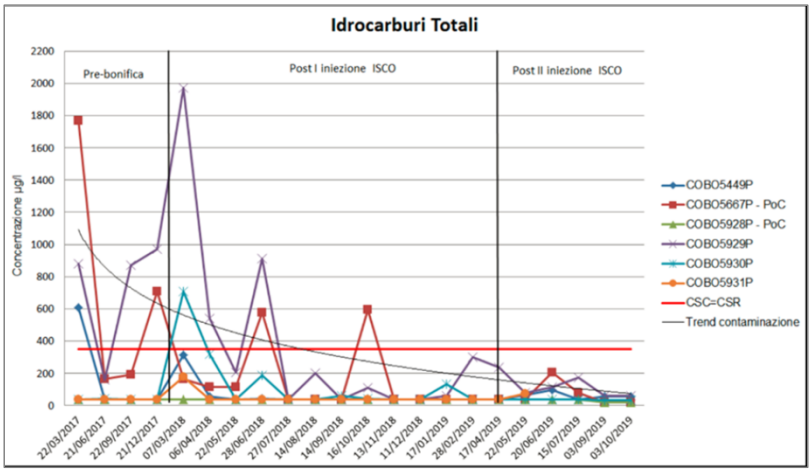
Figure 3. Redox potential and dissolved oxygen values in monitoring points before and after KLOZUR® CR treatment

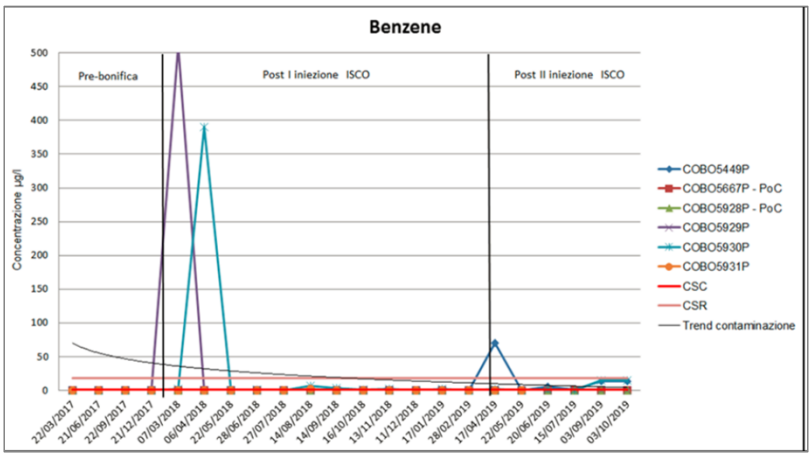
RESULTS

KLOZUR® CR generated oxidative conditions by alkaline activation of the sodium persulfate in the product and sustained conditions supporting aerobic bioremediation. An increase in oxidative reductive potential (ORP) was observed at all monitoring points in the treatment area, as well as higher dissolved oxygen (DO) concentrations (Figure 3). Most of the pre-appliction ORP values were about -100 mV and increased up to ~ +100 mV after the first application. Two locations showed an increase in ORP volume of greater than +300 mV after the second application of KLOZUR® CR . Similarly, dissolved oxygen concentrations increased from less than 5 mg/L up to 45 mg/L after the first application, and three locations exceeded a DO of 30 mg/L after the second application of KLOZUR® CR . This data confirmed that Klozur CR was effective in creating and maintaining the parameters necessary to remediate the contaminants found at this site.

Less than 12 months after the initial injections of KLOZUR® CR the site remediation goals were achieved in all monitoring locations present in the treatment area except for benzene levels at one location (piezometer COBO5449), and a second application of KLOZUR® CR occurred in April 2019. Six months after the second application, benzene concentrations were below the risk threshold concentrations at all monitoring points present in the treatment area.

Figure 4 shows that less than 18 months after the first injection of KLOZUR® CR , the remediations goals were achieved in all principal monitoring piezometers present in the treatment area without any subsequent rebound of the contamination levels, demonstrating the effective and complete degradation of contaminant mass.





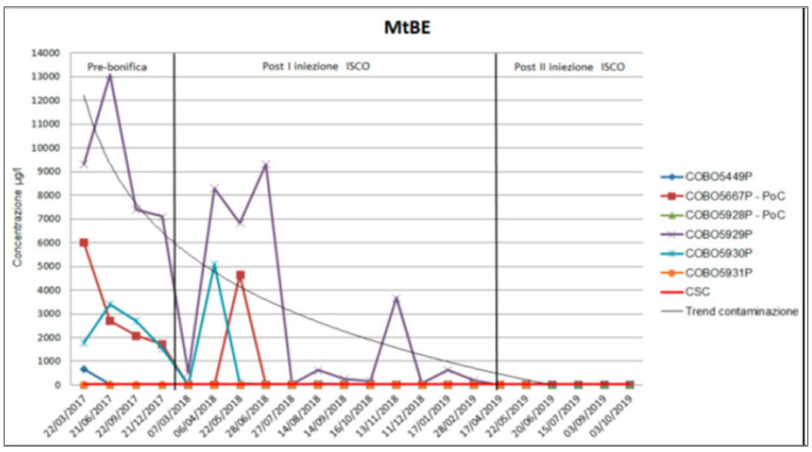


Figure 4. Total hydrocarbon, benzene and MTBE concentrations in groundwater before and after KLOZUR® CR treatment

Evonik Operations GmbH
Smart Materials
Active Oxygens Business Line
Soil & Groundwater Remediation

remediation@evonik.com
www.evonik.com/remediation