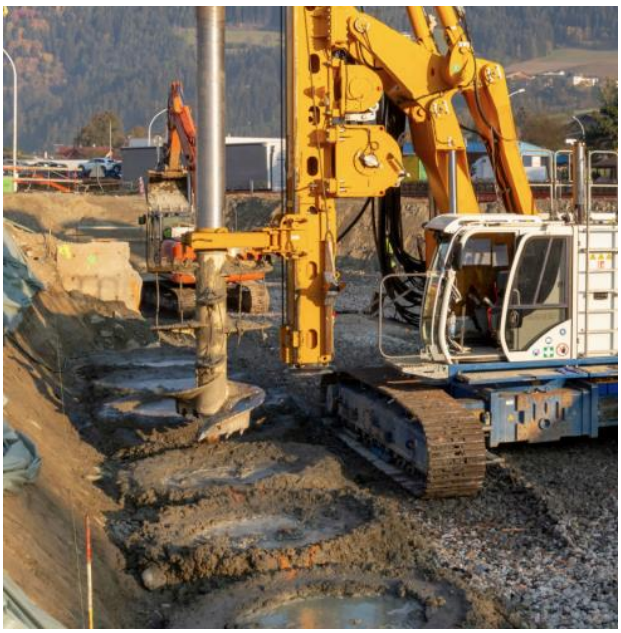
CASE STUDY | KLOZUR® SP

ISCO-ISS SUCCESSFULLY REMEDIATES PETROLEUM HYDROCARBON CONTAMINATED SOILS WHILE ACHIEVING COMPRESSIVE SOIL STRENGTH GOALS FOR SITE REDEVELOPMENT



SITE OVERVIEW

Petroleum hydrocarbon contamination at a confidential gasoline station in Bolzano, Italy was first identified in 2002. The primary contaminants identified were BTEX (benzene, toluene, ethylbenzene, and xylenes), lighter petroleum hydrocarbons (C_4-C_{12}), and heavier petroleum hydrocarbons (C_{13}-C_{40}).

The aqueous contamination was originally controlled with a pump and treat type system installed in 2003 and the vapors in the vadose zone were controlled by a soil vapor extraction (SVE) system installed in 2005. It was decided to treat the more elevated contamination throughout the site using a process of combining in situ chemical oxidation (ISCO) and in situ solidification and stabilization (ISS).

SITE INFORMATION

Site:	Confidential
Site Location:	Bolzano, Italy
Lead Consultant:	Ladurner Bonifiche S.r.l.
Regulatory Agency:	Province of Bolzano, Italy

CONTAMINANTS OF CONCERN

Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) Total Petroleum Hydrocarbons (C_4-C_{12}) Total Petroleum Hydrocarbons (C_{13}-C_{40}).

SOIL TYPE

Sandy silt with some gravel and cobbles.

REMEDIAL APPROACH

Soil mixing using in situ chemical oxidation (ISCO) combined with in situ solidification and stabilization (ISS).

Reagent dose rates added by soil mass:

- 4 to 8 percent Portland cement
- 0.7 to 1.0 percent KLOZUR® SP

RESULTS

Remedial activities successfully allowed for site development

- Benzene and TPH (C_4-C_{12}) were treated to below remedial goals
- TPH (C_{13}-C_{40}) mass was reduced with residuals solidified within low permeability matrix

Post Application geotechnical characteristics were achieved allowing for access during remediation and site redevelopment Soil bulking and waste generalization was minimized.

SITE REMEDIAL GOALS

The site had remedial goals based on contaminant reduction, future use, and soil bulking minimization during soil mixing. The remedial goals for contaminants included reducing concentrations in soil to below 2 mg/Kg for benzene, 250 mg/Kg for TPH (C_4 to C_{12}) and 750 mg/Kg TPH (C_{13}-C_{40}). Since the site was going to be redeveloped, the soils needed to have sufficient long-term bearing capacity. Site design objectives during the remediation activities included having sufficiently stable soils to handle construction traffic and to minimize the bulking during soil mixing and subsequent waste generation. To accomplish these goals the combined remedy of ISCO-ISS was selected using activated KLOZUR® SP, sodium persulfate.

TECHNOLOGY OVERVIEW

ISCO and ISS are two separate well established remedial technologies. Alkaline activated KLOZUR® persulfate is an ISCO technology used to remediate a site through contaminant destruction. ISS is a remedial technology that solidifies the soils increasing the compressive soil strength and decreasing the soil's hydraulic conductivity and contaminant mobility. These two technologies can be applied as a combined remedy in a single application. The alkalinity from Portland cement is used to create alkaline conditions that activates the persulfate forming various radicals to react with and treat the contamination while stabilizing the soils.

BENCH SCALE TESTS

A series of bench scale tests were conducted where site soils were mixed with different blends of KLOZUR® SP, binders (Portland cement and calcium oxide), and water. In addition, potential mixing sequences were also evaluated including sequential treatment with calcium oxide and KLOZUR® SP followed by Portland cement, calcium oxide and KLOZUR® SP only, and a combination of the Portland cement and KLOZUR® SP in a single application. The bench tests identified an optimized reagent blend that supported up to 91 percent reduction of contaminant concentrations while also meeting remedial targets.

FIELD APPLICATION

The targeted treatment area was approximately 735 m2 with a target interval of approximately 3 to 8 meters below ground surface (bgs). A 1.6m diameter mixing auger was used with a 17 percent overlap between 556 columns in the target area. The field application lasted approximately 1 month and treated approximately 37 metric tons of contaminated soil per hour.
The selected reagent blend varied the KLOZUR® SP concentration from 0.7 to 1.0 percent and the Portland cement from 4 to 8 percent, by weight to the total soil volume. The reagents were blended together into a slurry above ground and applied into the subsurface using a 30 kW screw pump.

RESULTS

The contaminant reduction goals were primarily achieved with: • 100 percent of the sample locations below 2 mg/Kg Benzene goal • 100 percent of the sample locations below the 250 mg/Kg TPH treatment standard for (C_4 to C_{12}) • Over 50 percent of the sampled locations at the site were below 750 mg/Kg TPH (C_{13} to C_{40}) treatment goal The C13 to C40 fraction of TPH that was not treated in by ISCO occurred in areas of NAPL identified during treatment. The residual contamination was solidified by the ISS treatment, resulting in reduced risk due to the very low post application hydraulic conductivity. The regulatory authorities ruled there was no need to further remediate and authorized redevelopment of the site. The geotechnical goals for the site were also achieved: • Unconfined compressive strength (UCS): 215 to 470 kPa (~30 to ~70 psi) • Hydraulic conductivity: 2.8 x 10-6 cm/sec to 7.3 x 10-7 cm/sec The ISCO-ISS remedy also resulted in less than 15 percent bulking of soils minimizing the amount of material requiring off-site disposal.

SUMMARY

ISCO was successfully combined with ISS at this site achieving all of the remedial goals common for redevelopment sites. Benzene and TPH (C_4 to C_{12}) were reduced to below the remedial goals. TPH (C_{13} to C_{40}) were reduced and the residual contamination was then solidified into a matrix with a significantly lower permeability compared to the surrounding geology. Finally, the soils had targeted compressive strengths shortly after the application allowing for site activities during the application and rapid site redevelopment.

REFERENCES

Schifano, V., and San Nicolò, L (2019) "Integrated Remediation – Redevelopment of Contaminated Sites: the ISCOSS Soil Mixing Technology," AquaConSoil 2019, Antwerp, Belgium
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