In Situ Sustainable CrVI Soil Remediation Implemented in Barranquilla, Colombia

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Summary

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- Results
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Site Overview

- Former plant located in mixed use area (industrial and residential) in the city of Barranquilla, Colombia.
- Operated as a bronze smelting plant with pipe and valve chrome and nickel plating.
- Plant operated from the 1960's to the early 2000's.
- Back lot was used as slag and residue disposal area.

Background Investigations

- Client completed a due diligence assessment in 2006. Assessment identified various heavy metal impacts in the soils of the former disposal area.

- Further investigations completed in 2013, including a Human Health Risk Assessment, identified Cr VI and lead as the main compounds of concern.

Background Investigation Cont'd

- Cr VI concentration in soil detected up to 229 mg/kg. Reference limit for direct contact: 97 mg/kg
- lead concentration in soil detected up to 9220 mg/kg. Reference limit for direct contact: 750 mg/kg
- Heavy metal impacts delineated to an area of 3,885 m2 (96 acres) and to a depth of ~1.0m below the ground surface.

Remedial Action Objectives

- Chemical reduction of toxic Cr VI to non-toxic Cr III;
- Stabilizing/solidifying impacted soil exceeding reference limits to reduce permeability and mitigate potential leaching of COCs to groundwater;
- Homogenize soils to facilitate and accelerate treatment by increasing direct contact of the constituents of concern with the amendments;
- Create a physical barrier to eliminate the potential direct contact and inhalation exposure to impacted soil;
- Direct meteoric stormwater flow away from Site;
- Least intrusive to local community; and,
- Coordination of any remedy with off-school time.

Treatability Test

- Soil from the boreholes with the highest concentration of Cr VI and Pb was collected and was mixed with reagents in different proportions. Soil was collected from two boreholes. Reagents included Portland cement, fly ash, bentonite and calcium polysulfide solution (CPS) to reduce Cr VI to Cr III. 19 mixing aliquots were prepared, including one aliquot as control.
- After the preparation, aliquots were evaluated after one, seven, 15, 21 and 28 days for hardness and structural integrity using a portable penetrometer. All samples were submitted for laboratory analysis after 28 days. Cr VI and Pb concentrations were analyzed in SPLP test.

Treatability Test Cont'd

Treatability Test

- Based on the results, a mixing of soil with 3% of cement with CPS at a rate of five times the stoichiometry was the recommended treatment approach.
- Given the variability of Pb and Cr VI concentrations and distribution at the Site, a confirmation test was conducted. The test included blending soil from each boreholes (equal parts), 3% of cement and five-times the stoichiometry of reductant. Mix was conducted in triplicate.
- Only by mixing the soil, with no addition of reagents, the concentrations of hexavalent chromium decreased by one order of magnitude. Lead concentrations remain in the same order of magnitude.
- The use of 3% cement and calcium polysulfide at 5 times stoichiometry stabilized lead and chromium in the soil. The SPLP concentrations for hexavalent chromium and lead were below the Method Detection Limits (MDL).

Remediation Approach

- Prior to implementing the full-scale mixing, a smaller scale "bucket test" was conducted to develop and optimize the mixing protocols and sequencing and was an adjustment from the original work plan.

- Protocol adjustment included mixing dry ingredients then adding wet solution followed by thorough mixing.

Remediation Approach

- The remediation area was divided into three different treatment areas with a Cr VI load of 58 mg/kg, 62 mg/kg and 229 mg/kg. A different concentration of reductant agent (CPS) was applied to the soil, according to the Cr VI load, based on the conclusions of the treatability test.
- Remediation area was divided into perimeter and interior treatment cells, in order to protect the integrity of a perimeter wall. Soil from the perimeter cells were gathered into 24m3 piles, in order to ease the mixing. Interior cells were subdivided into six 24 m3-subcells and mixed with no extraction of soil (*in situ* mixing).
- A mixing central station was built in order to complete the mixing of water an CPS.
- Mixing of soil and reagents was conducted mechanically using an excavator. Cement was first applied and mixed with soil, and the wet reagents were added and thoroughly mixed.

Remediation approach

LEGEND

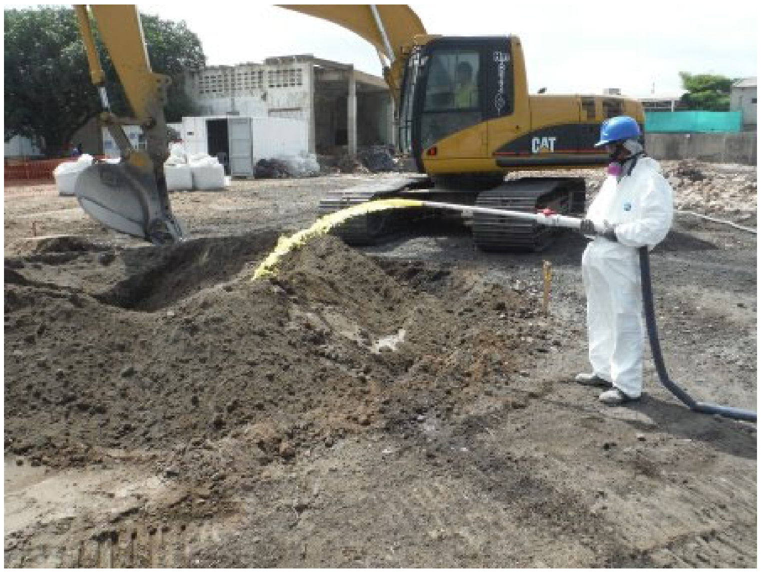
- Area to be treated with cement down to a depth of 0.8 m
- Area to be treated with cement and reductant down to a depth of 1.0 m
- Area to be treated with cement down to a depth of 1.0 m

Notes:
Total area of treament: 3884m²
Total volume of treatment: 3765 m³

Remediation Approach

Remediation Approach

Remediation Approach



Confirmatory sampling

- Before the installation of the asphalt cap, 71 composite confirmatory samples, including 3 soil blank duplicates as quality assurance/quality control (QA/QC) were collected: 14 samples were collected from the perimeter cells and 54 samples were collected from the interior cells.

- Samples allowed to ‘set” for 30 days prior to analysis to allow for chemical reduction process and stabilization.

Civil Work – Asphalt Cap

- A 30cm-thick cap with an extension of 4,806 m2 was installed in order to eliminate the potential direct contact and inhalation exposure to treated soil;

- 143 linear meters of perimeter drainage channels was constructed in order to direct meteoric stormwater flow away from Site.

Capping and Drainage

Results

- Post-mixing soil data showed 96% reduction of CrVI
- The average pH of samples was 11.8 – Good indication of even distribution of cement
- No significant concentrations of Pb and ND for CrVI detected in the SPLP leachate analysis of the samples
- Meteoric water infiltration was mitigated via installation of the 30cm asphalt cap.

Lessons learned

- Mixing cutter head could have reduced mixing time with additional 3 to 4 months needed to allow for import/export issues.
- Coordination with all stakeholders including adjacent elementary school, current property owner, state agency, subcontractor and RP critical to implementing sustainable remedy on time and under budget.
- The sustainable remedial strategy allowed for beneficial reuse of the property as a parking lot, with no impact to the surrounding community.

Thank you

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