In Situ Sustainable CrVI Soil Remediation Implemented in Barranquilla, Colombia

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Background/Objectives. A former bronze smelting plant (Site) located in the city of Barranquilla, Colombia operated from the early 1960s to 2000. The plant is approximately 7,760 square meters (m^2) with approximately 3,800 m^2 of metals-impacted soil where slag and sediment had been previously deposited during Site operations. Site investigations conducted from 2010 to 2012 found elevated concentrations of hexavalent chromium (CrVI) and lead in soil above screening levels down to approximately 1 m below ground surface (bgs). Maximum concentrations detected were 229 and 9,220 mg/kg, respectively. The Site is bordered by other industrial manufacturing facilities to the north, residential housing to the east and an elementary school immediately adjacent to the western edge of the property. The Magdalena River, one of the main water courses in Colombia, is located approximately 700 m to the northeast. After reviewing several remedial strategies and engaging all stakeholders, a sustainable remediation strategy was developed that allowed for the beneficial reuse of the property with minimal impact to the adjacent residents and the elementary school.

Approach/Activities. Based on the data collected during the bench study completed in May 2016, a full-scale shallow soil treatment was designed to chemically reduce the CrVI to CrIII and stabilize the lead in the impacted area. The chemical reduction and stabilization soil treatment included a mixture of 3% Portland cement and a stoichiometric ratio of 6:1 calcium polysulfide (CPS) to Cr VI in soil. Soil surrounding the perimeter of the treatment area was mixed using 1m x 1m cells, in order to preserve the integrity of a surrounding boundary wall. 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. The soil mixing was conducted using a CAT 750 excavator. Approximately, 3,800 m^3 of soil were mixed and treated in January and February 2017. Following the treatment of soil, 71 composite samples were collected to assess remediation effectiveness. Cr VI and lead were analyzed in soil and in the leachate of a SPLP test. An average of 26 days passed between the collection of the samples and laboratory analysis. The reduced and stabilized soil was then compacted, graded and capped with 15 cm of subbase and 15 cm asphalt cap.

Results/Lessons Learned. The complete mixing of soil and cement was achieved as the average pH of the collected samples was greater than 11. Average detected concentration of Cr VI was 4 mg/kg, a reduction of 96%. Average SPLP for Cr VI was 0.06 mg/L. Average detected concentration of lead was 1,245 mg/kg. No significant concentrations of lead were detected in the SPLP analysis. The potential for future exposure and infiltration to groundwater was also mitigated through the installation of the 30 cm cap. The elevated pH catalyzes the reduction reaction of Cr VI that allowed the reaction to continue after the sampling event as the chemical reduction process typically continues for at least 90 days. The sustainable remedial strategy allowed for beneficial reuse of the property, with no impact to the surrounding community.