

Using Chemical Reduction and Biostimulation to Treat Pentachlorophenol Contamination in Brazil

Matheus Naves, Samuel Agena and Sander Eskes, *ERM, São Paulo, BR*; George Skladany, *ERM, Ewing, NJ*; Josephine Moulin, *ADVENTUS, Freeport, IL*

Five treatment options for pentachlorophenol (PCP) were evaluated during treatability tests in the laboratory: (1) biodegradation (4 treatment options were evaluated: supplemental oxygen and nutrients only (aerobic pathway), organic carbon with nutrients supplemented either oxygen (aerobic treatment pathway), zero-valent iron (anaerobic treatment pathway) or zero-valent iron plus sulfur (anaerobic treatment pathway and simultaneous metals immobilization); (2) chemical oxidation with potassium permanganate; (3) ozonation; (4) persulfate oxidation at alkaline pH; and (5) chemical reduction using zero valent iron or ferrous iron. The batch study showed that the PCP could successfully be degraded biologically under either aerobic or anaerobic conditions by adding a mixture of organic carbon supplemented with either oxygen or ZVI. Based on these results, it was decided to apply a reductive treatment approach to the groundwater phase and an aerobic approach to the soil treatment phase. Treatment activities were subdivided into 3 different modules:

Module I – Hydraulic containment and groundwater treatment along the river bank through an in situ recirculation system (injection, extraction and recirculation of the remedial substrate EHC-A through 3 pairs of injection and extraction wells);
Module II - Injection of EHC through direct push within the source area; and
Module III – Soil excavation and on site (ex situ) treatment using aerobic DARAMEND.

For Module II, an adaptive injection program will be implemented, using direct push at 48 injection locations, to treat the entire source area located below a building.

The objective is to: 1) provide hydraulic containment; 2) reduce the PCP mass in the groundwater within the hot spot area; and 3) improve the groundwater quality via enhanced natural attenuation induced by the EHC in situ bioremediation technology.

Percent reduction of Chlorinated Phenols at the treatability study at the soil and groundwater has ranged from 85 percent to 97 percent after sixty days.

The Problem

- > Source of contamination from a former PCP manufacturing plant, abandoned at the 60's.
- > Primary source under one current active building
- > Presence of area of discharge nearby the source of the contamination



Background

- The groundwater flow from the facility discharges to an adjacent river, and no containment system has been used to mitigate migration of contaminants.
- Treatability Test:**
 - On December 20th, 2005 Adventus received one soil sample from ERM (Site Brazil Composite). On January 31st, 2005 Adventus received approximately one gallon of Site groundwater. All samples were placed into cold room storage upon receipt.
 - The different characteristics of the technologies selected allowed the evaluation of both aerobic and anaerobic degradation pathways for the removal of PCP from soil and saturated zone.

Results:
 The treatability study showed that the PCP could successfully be degraded biologically under either aerobic or anaerobic conditions by adding a mixture of organic carbon supplemented with either oxygen or ZVI (supported a total of 97 and 96% removal respectively in 60 days). The batches amended with oxygen only did not show any removal within 30 days, but caught up after 60 days supporting 85% removal. The treatability test allowed the choice of the aerobic pathway to treat the contaminated soil using DARAMEND, with a 91% mass removal rate compared to the control system. For the groundwater, an anaerobic approach was selected based on existing geochemical conditions, ease of implementation and cost. For the recirculation module an aqueous carbon substrate supplemented with ferrous iron will be used (EHC-A) and for the direct injection module a granular organic carbon substrate with ZVI will be used (EHC). EHC supported a removal rate of about 89% compared to the control system.

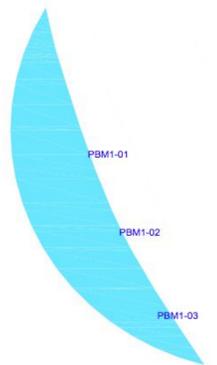
	Control		Carbon + Oxygen (Aerobic DARAMEND)		Oxygen only (EHC-O)		Organic Carbon + ZVI (EHC)	
Soil:								
Soil PCP Concentration (ug/g)	1.955	2.28	0.235	0.15	1.11	0.69	0.185	0.31
Mass of soil (g)	290	290	290	290	290	290	290	290
Mass of PCP (ug)	567.0	661.2	68.2	43.5	321.9	200.1	53.65	89.9
Water:								
Water PCP Concentration (ug/L)	19	11	0	0	8.6	5.7	0	0
Mass of water (L)	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Mass of PCP (ug)	14.25	8.25	0	0	6.45	4.275	0	0
Total:								
Total Mass of PCP (ug)	581.2	669.5	68.2	43.5	328.4	204.4	53.7	89.9
Average of duplicates		625.3		55.8		266.4		71.8
Mass of PCP removed (ug)		0.0		569.5		359.0		553.6
% removal		0%		91%		57%		89%

Remedial Approach:

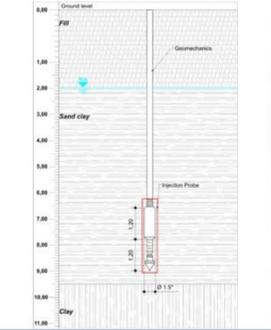
- Objective:**
- Reduce residual PCP mass in site soils/shallow aquifer beneath the existing building and in groundwater
 - Protect the ESA and the river nearby
 - Shorten the time to site closure
- Three treatment Modules:**
- Module I** – At this area of concern, located near the adjacent river, a recirculation system will be installed to both achieve hydraulic containment of contaminants at the property limits and to inject the nutrient/reductive solution to treat the area.
 - Module II** - Located inside the maintenance building, the nutrient/reductive solution will be injected in 48 points surrounding this building using a Direct Push GeoProbe 6600. Mass requirements were based on the values calculated from the treatability study results and the soil capacity of absorption.
 - Module III** - Approximately 1,000 cubic meters of soil will be excavated and treated above-ground in a bioremediation cell using an amendment with organic carbon and nutrients. Oxygen will be introduced via tilling.
- After the active remediation steps, the contamination will be followed by MNA.

	Module I	Module II	Module III
Matrix	Groundwater (saturated soil)	Groundwater (saturated soil)	Soil
Area	30 x 20 m	55 x 20 m	50 x 10 m
Depth	3 to 8 m bgs	2 to 9 m bgs	0 to 2 m bgs
Average PCP conc.	30 mg/L	300 mg/L	40 mg/kg
Amendment	19,200 kg EHC-A	78,475 kg EHC	8,000 kg DARAMEND

Module I – Injection and Recirculation of 19,200 Kg of EHC-A Using 1,000 m³ of Solution.



Module II – Direct Push Injection of 78,475 Kg in a 30% concentration slurry through 10 meters depth, starting from the top to the bottom.



Module III – Soil Excavation and On-Site Treatment (Ex-Situ) Using a Landfarming

