IN-SITU THERMAL DESORPTION PILOT STUDY TO TREAT CHLORINATED COMPOUNDS FROM A FORMER CHEMICAL MANUFACTURING FACILITY: THE USE OF PILOT STUDY DATA TO OPTIMIZE FULL SCALE DESIGN

Lowell Kessel[1], Grant Geckeler[1], Jan Haemers[1], Cavis Carpenter[1]

[1]TPS TECH, 6 Airport Road, Belfast, ME 04915, USA
lkessel@envirologek.com

1. Abstract

Thermal Conduction Heating (TCH), Steam Enhanced Extraction and Electrical Resistance Heating form the most common In Situ Thermal Remediation (ISTR) techniques. Such ISTR techniques have been successfully demonstrated at >100 sites to worldwide, and have proven especially effective for addressing source zones with high concentrations of chlorinated and organic chemicals. Many of these projects are in urban environs, where rapid and certain redevelopment is desired without excavation.

In Winter of 2012, TPS TECH completed a pilot-scale application of In-Situ Thermal Desorption (ISTD) – a combination of TCH and vacuum – to treat of chlorinated volatile organic compounds (chlorobenzenes) in low to moderate permeability clays

A small group of 14 thermal wells heated the 120 m3, 5 m deep target treatment zone, to an average temperature of 200°C in 30 days. Despite the low permeability of the treated volume, soil vapour extraction exaggerated by steam stripping was the dominant removal mechanism of the chlorinated compounds. Superheated temperatures above the boiling point of water resulted in additional mass being recovered as the vapour pressure of the chlorinated compounds continued to increase with temperature, resulting in a >98% reduction in chlorinated VOCs. Based on the successful pilot study results, the full scale treatment of chlorinated compounds is currently being constructed onsite to treat 2,100 cubic meters of source zone soils via ISTD.

2. Pilot Study Design

A pilot study application of ISTD treatment of nitrochlorobenzene in low permeability soils vadose and saturated soils was recently completed at a former chemical manufacturing facility in France. The site operated chemical transfer pipeline to deliver nitrochlorobenzene to an adjacent rail spur from about 1958 to 2005.

The owner of the property, a confidential Fortune 500 client, desired to expedite cleanup of the affected soils in order to expedite its plant decommissioning activities. Concerns about the potential for human exposure to chlorinated vapors necessitated the remediation, and a remedial goal of 2.0 mg/kg for nitrochlorobenzene was set as a risk-based remedial goal by the regulatory oversight agency.

The pilot study remedial design specified 14 vertical heater wells at 1.5 m spacing. The aggressive well spacing was designed pursuant to the client's desire to finish the pilot study in a very short amount of time. Generally, the heater wells are placed between 2.5 and 3.5 m from one another. Each heater well contained a PLC-based unit to automatically maintain the desired heater well operating temperature. To ensure substantial removal of the high boiling point chlorinated compounds, TPS TECH selected 200°C as the target treatment temperature. An aggregate surface cover of 0.3 m thick non-structural concrete was installed atop the surface to act as an insulator for energy conservation purposes.

Fig. 1. ISTD Pilot Study Area.

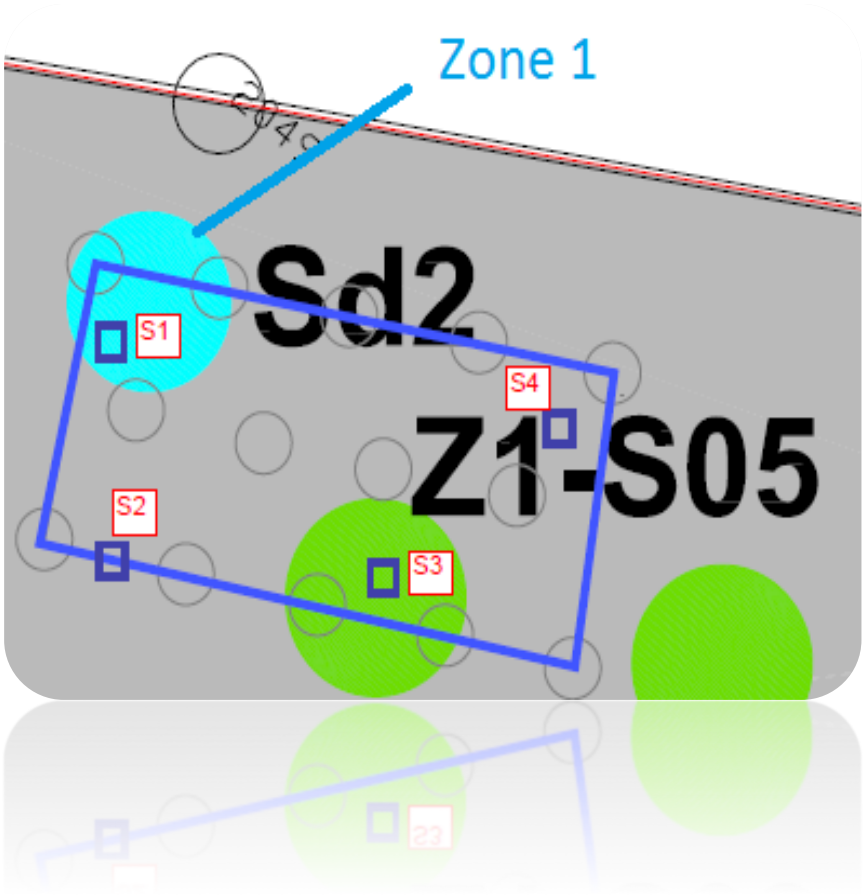

Fig. 2. Overview of Treatment Layout

3. Vapor Extraction and Treatment

Vapors were extracted via co-located off-gas extraction points and then cooled, condensing the steam fraction of the extracted vapor. This condensate was separated from the non-condensable vapor and collected onsite, where it was later treated with liquid-phase granular activated carbon prior to discharge in an adjacent sewer network. The non-condensable vapors were directed to primary and secondary vessels of vapour-phase activated carbon prior to discharge of the atmosphere.

4. Pilot Study Performance

During the 30 days of active heating, the target temperature of 200°C was reached throughout the vadoze section of the TTZ; although some sections of the saturated

zone did not exceed the boiling point of water. A total power consumption equivalent of approximately 190 kWh per ton of soil was used during the pilot study, with about 50% of the injected energy used to raise the temperature of the treated volume, and the remaining balance used to create steam from the pore water.

Four confirmatory soil samples were taken while the soil was still hot, using “hot sampling” techniques. The mean reduction of nitrochlorobenzene soil concentrations was >98% by mass.

Sample No	Depth	Starting Concentration	Ending Concentration
1	2 m	244 mg/kg	3.53 mg/kg
2	3 m	231 mg/kg	2.08 mg/kg
3	4 m	505 mg/kg	14.39 mg/kg
4	5 m	220 mg/kg	2.88 mg/kg

Table 1. Pilot Test Confirmation Data.

5. Application of Pilot Study Information on Full Scale Design

The pilot study provided three important functions for the full scale design of the in-situ thermal remediation project. First, it validated the efficacy of the target treatment temperature to remove the overwhelming amount of mass from within the treatment zone. Second, it provided valuable data for the optimization of the full-scale system’s vapour and liquid treatment modules. Thirdly, it provided kinetic data that allowed for the reduction of thermal wells needed for the full scale application, resulting in a cost savings of approximately $35,000.