TECHNOLOGY NEWS AND TRENDS

A newsletter about soil, sediment, and ground-water characterization and remediation technologies

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Environmental contamination by persistent organic pollutants (POPs) poses significant challenges due to their chemical stability, tendency to bioaccumulate, and ability to easily disperse. Of the 12 globally recognized POPs, nine are pesticides and the remaining three are industrial chemicals (PCBs) or industrial byproducts (dioxin and furans). As highlighted in this issue of Technology News and Trends, *degradation or destruction of POPs often relies on ex-situ technologies combining thermal, physical, and/or chemical processes, but increasing numbers of less costly bioremediation and thermal applications are successful in-situ.*

CLU-IN Resources

CLU-IN's "Contaminant Focus" on POPs provides assorted technical reports, background information, and links concerning remediation strategies. Users may download documents such as EPA's *Reference Guide to Non-Combustion Technologies for Remediation of Persistent Organic Pollutants in Stockpiles and Soil*, or the United Nations Environment Programme's *Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPS and the Identification of Promising Technologies for Use in Developing Countries*. Visit CLU-IN at http://www.cluin.org/POPs.

In-Situ Thermal Remediation Completed on Wood-Treatment Waste

After four years of operation, full-scale in-situ thermal remediation of soil at Southern California Edison's former wood treatment site in Alhambra, CA, concluded last spring. Subsurface soil containing PAHs, PCP, and dioxins/furans was treated by in-situ thermal desorption (ISTD), a technology employing the simultaneous application of thermal conduction heating and vacuum to treat soil without excavation. Treatment achieved cleanup goals for approximately 16,500 yd^3 of predominantly silty soil to a depth of 105 ft, and provided the opportunity for property reuse without restrictions.

The treatment area included the locations of four below-ground creosote "dip" tanks formerly used to preserve utility poles, an aboveground storage tank farm, a boiler house, and decommissioned pipelines that remained in place during ISTD treatment. The mean (and maximum) concentrations of contaminants targeted during soil treatment were 2,306 (35,000) mg/kg total PAH, 0.018 (0.194) mg/kg dioxins/furans (TEQ), and 2.94 (58) mg/kg PCP. Due to the large treatment area and associated electrical power constraints, remediation occurred in two phases. Phase 1 operated from 2002 through early 2004 and was immediately followed by phase 2 operations, which continued until September 2005. Site-specific risk assessment established cleanup goals for contaminants of concern: 0.065 mg/kg PAHs (based on benzo(a)pyrene equivalents [B(a)P-E]), 1 µg/kg dioxins/furans (based on TCDD TEQ), and 2.5 mg/kg PCP.

ISTD employs a network of horizontal or vertical heater-only and heater-vacuum wells containing electrically powered heating elements with maximum operating temperatures of 600-800°C. Silicon-controlled rectifiers are used to control output of the heating elements. Through direct surface contact and conductivity, heated wells raise the temperatures of surrounding soil. As soil is heated, organic contaminants are vaporized and drawn toward the heater-vacuum wells. The vapors pass through the superheated zone surrounding the heater-vacuum wells, where potentially 99% of contaminant destruction occurs. Mechanisms responsible for contaminant destruction and/or vaporization include evaporation, steam distillation, boiling, oxidation, and pyrolysis. Remaining trace contaminants are removed in an aboveground air quality control (AQC) system.

Treatability tests were conducted to determine optimal operating temperatures and residence times. Testing confirmed that successful treatment of high-boiling point PAHs occurs at temperatures significantly lower than their boiling points. Modeling indicated that exposure of this site’s PAH-contaminated soil to temperatures of 335°C over three days would reduce contaminant mass more than 99.9%. Limitations of the AQC system, however, prevented operation of all ISTD heaters at the full design temperature in areas of high contaminant mass. Based on earlier laboratory evaluation of PAH oxidation rates, it was determined that achieving a slightly lower temperature for a longer duration would achieve site-specific cleanup goals. A treatment paradigm was designed to sustain a 300°C operating temperature for thirty days. Overall treatment duration was driven by the last location of the treatment zone to achieve target temperature.

Field preparations began with installation of 654 heater-only and 131 heater-vacuum wells in a triangular pattern to average depths of 20 ft across the 31,430-ft^2 treatment zone. A light cement aggregate layer was constructed over the surface to prevent subsurface heat loss during phase 1. Based on phase 1 results, polystyrene insulating board was added to the phase 2 cover between a bottom layer of light aggregate material and a top layer of insulating cement. Two 2,500-kVA transformers were installed to provide power for the ISTD system, including the vacuum blowers, AQC system, and well heaters.

The vacuum blower system included magnehelic gauges for monitoring well-field vacuum and ensuring that field boundaries remained under negative pressure. Thermocouples encased in steel pipe were placed at 164 temperature-monitoring points;

some thermocouples were installed adjacent to the heating elements, while others were installed in cooler centroid locations in order to track heat migration through the subsurface. Air monitoring activities included monthly compliance tests, continuous tracking of AQC system emissions, and four source-test events. The source tests involved analysis of air samples at the AQC influent and effluent as well as locations between the thermal oxidizer and each granular activated carbon (GAC) vessel. Well-field vacuum data were collected at 18 monitoring points three times daily, and vacuums were adjusted if needed.

Post-treatment analysis of soil samples (60 for PAHs, 18 for dioxins/furans) taken from shallow, mid-depth, and deep soil cores at 25 treatment-zone centroid locations showed contaminant reductions exceeding 99% (Figure 4). The average post-treatment concentration for PCP was 1.25 mg/kg, and sitewide means for dioxins/furans (TCDD TEQ) and PAHs (B(a)P-E) were 0.11 µg/kg and 0.059 mg/kg, respectively, all below remediation goals.

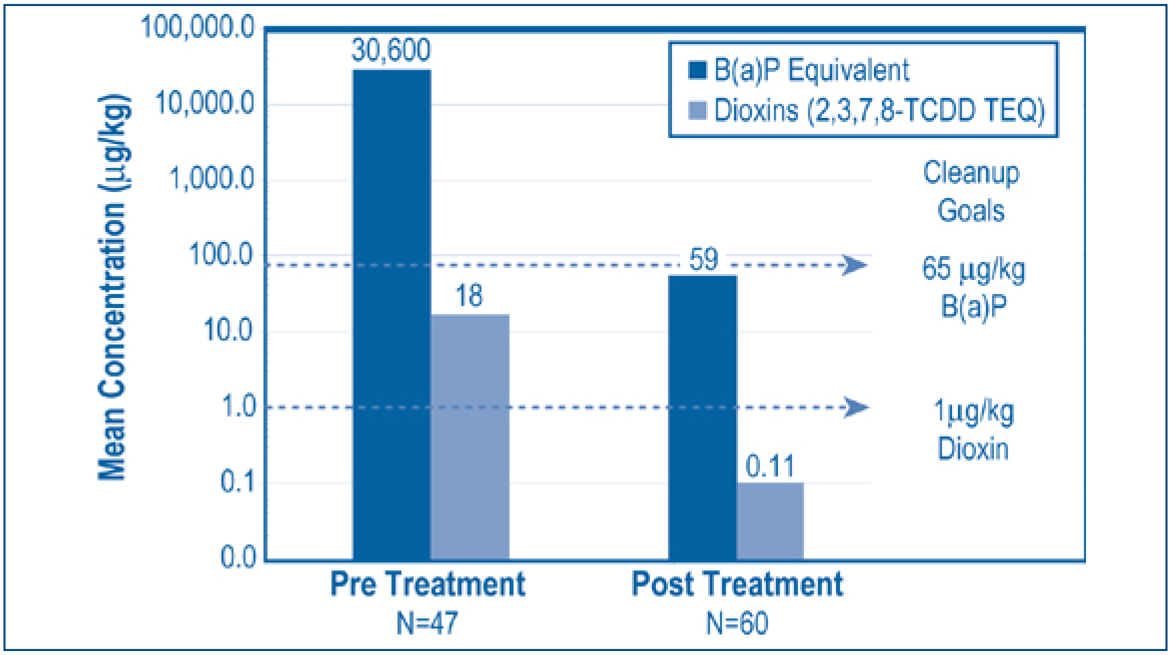

Figure 4. Mean concentrations of post-treatment soil samples showed nearly complete removal or destruction of PAH concentrations (based on B(a)P-E) and dioxins (based on 2,3,7,8-tetrachlorodibenzodioxin equivalents).

Daily measurements of carbon dioxide concentrations in stack gas indicate that a total hydrocarbon mass of 870,000 lbs (expressed as naphthalene) was removed from soil during the entire project. Additional but unmeasured contaminant mass likely was destroyed as a result of in-situ pyrolysis and oxidation. Pre- and post-treatment measurements of soil hydraulic conductivity and porosity indicated that ISTD did not significantly impact soil properties.

Factors to be considered in future ISTD applications include: (1) Additional characterization of a facility's former infrastructure (obscuring high contaminant mass) may lead to the use of a higher-capacity vapor-treatment system over a shorter treatment time. (2) Enhanced surface covers are needed to maximize vapor seal, minimize heat loss, and prevent surface-water infiltration; rigid polystyrene insulation is susceptible to degradation and should be avoided. (3) Horizontal collectors or shallower heater-vacuum well screens, connected into a coarse-textured fill layer above the treatment zone, would accelerate removal of contaminated vapors and steam. (4) ISTD efficiency at sites with non-aqueous phase liquids or high contaminant mass may be maximized through a phased approach such as thermally enhanced free-product recovery followed by high-temperature treatment.

The total project cost was $13 million, estimated to be 40% lower than soil excavation. Costs for ISTD implementation at sites with similar settings could potentially be reduced 47% by applying lessons learned during the Alhambra application.

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