4.0 THE CBA SOLUTION

CBA's patented MITU technology, in conjunction with various treatment reagents, has revolutionized the rapid remediation of sites that have been contaminated with chlorinated solvents. The MITU technology is designed to aggressively increase the surface area of soils to optimize treatment conditions that will facilitate maximum removal of contaminants.

CBA has developed and patented a treatment train approach for CVOC contaminated soils that involves thermal desorption followed by chemical oxidation with potassium permanganate. This approach has enabled CBA to achieve substantial mass removal rates, as high as 99% in some instances.

CBA's MITU technology combined with various treatment approaches has proven its effectiveness time and time again. Whether it be thermal treatment of a small site with only one contaminant or thermal and chemical treatment of large sites with multiple contaminants, CBA has the experience and ability to achieve site closures in a very timely, cost efficient manner.

4.1 MITU Technology

4.1.1 MITU-LVR

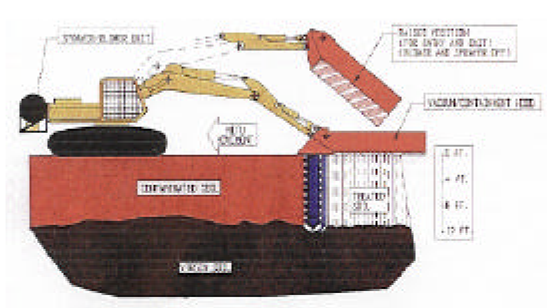
This model consists of a large track trencher outfitted with a specialized rotating drum attachment. This model has the capability of cutting to a depth of 4 feet with a trench width of 11 feet. The unit is fairly compact when the trenching boom is in the ground; it is approximately 20 feet long at this point. The MITU-LVR is typically equipped with a vapor collection hood and auxiliary heat system when performing Thermal treatment.

The MITU-LVR can be utilized for thermal desorption (pictured left) or for admixing various reagents. This model has completed several projects involving thermal, chemical oxidation, and enhanced bioremediation treatment of soils contaminated with organic compounds. The unit is capable of treating soils in-place or ex-situ in a constructed treatment cell.

The MITU Rotating Drum is fairly easy to mobilize to most site locations. The unit is compact enough to allow for excellent maneuverability on projects which have very little operating space. This unit is ideal for soils requiring extensively high heat (up to 800 ^{o}F) and aggressive soil breakdown (i.e. hard clay). The unit also performs extremely well mixing soils with or without chemical additives. The MITU Rotating Drum can achieve production rates well in excess of 1000 cubic yards per day.

4.1.2 MITU-12

On this model, the modified trenching head is mounted on a track excavator. This is the most widely used MITU unit, as it is capable of treating both in-situ, to a depth of 12 feet below grade, or ex-situ (stockpiles) as high as 8 feet (see photos and schematics below). The MITU 12 is extremely versatile and can maneuver fairly easily given various site constraints.



4.2 Treatment Approaches

The USEPA has identified several Presumptive Remedies for halogenated volatile organic compounds at Superfund sites; they include: soil vapor extraction (SVE), low temperature thermal desorption (LTTD), and incineration. Other commonly used technologies include bioventing and as of late, chemical oxidation has become increasingly popular. CBA's MITU technology is capable of providing and delivering several of these treatment approaches either simultaneously or sequentially.

The following subsections provide descriptions of some of the treatment processes that CBA has successfully utilized on sites contaminated with CVOCs.

4.2.1 Thermal Treatment

Thermal treatment utilizing the MITU is very similar to Low Temperature Thermal Desorption (LTTD) technologies; however, the MITU offers some distinct advantages over LTTD and other volatilization technologies that will be discussed later. The MITU's thermal treatment process is designed to operate on the same principles as LTTD; that is to heat the soils to a sufficient temperature to cause CVOCs to volatilize and desorb from the soil particles and other organic matter.

CVOC contamination in vadose zone soils is distributed among three phases of the soil matrix. The partitioning and distribution of the contamination depends on the soil characteristics as well as the concentrations and characteristics of the specific contaminants. The movement of contaminants through the soil media is either by advection, movement with bulk air flow, or by diffusion, movement via concentration gradient. Volatile compounds desorb from the soil particle surface, transfer to the soil water, and volatilize to the soil gas. In low to medium permeable soils (sand and gravel), diffusion is the limiting factor in the movement and re-movement of contaminants.

Thermal Treatment with MITU 12 Protective/Vapor Recovery Hood

Typically, there is no combustion involved in either the primary or secondary treatment of organics with the MITU; therefore, air quality permitting is of minor significance. However, for contaminants with low adsorption isotherms, secondary catalytic or thermal oxidation of the vapor stream may be required. If necessary, CBA has experience in obtaining the proper air quality permits for utilization of the MITU.

Unlike incineration or even LTTD, thermal treatment with the MITU does not require excavation of contaminated soils; the thermal treatment can be performed in-place or on excavated soils. The underlying feature of successful thermal treatment with the MITU is its ability to break down soil density. The shearing action of the trencher pulverizes the soil into very fine particles, effectively increasing the surface area to volume ratio. In turn, CVOCs are more readily volatilized by virtue of increased contact with air flow and heat. The MITU utilizes an electrically powered heat generation system to heat forced air to temperatures in excess of 800°F (425°C). The forced air is then conveyed into the trench and across the soil particles. The final soil temperature depends on the soil characteristics and on retention time.

The vaporized constituents are captured beneath an enclosed shroud that is subjected to negative pressure, and are treated in a secondary treatment unit prior to discharge to the atmosphere. Secondary treatment of the vaporized constituents may consist of condenser units, catalytic or thermal oxidation, or carbon adsorption units.

The trenching head, heat generation system, and vapor collection system are all operated through an integrated control panel mounted in the equipment's cab. Several of the system's parameters can be monitored during operation to maintain operational control and optimize treatment effectiveness.

SVE and LTTD technologies have been able to achieve an average of 90% and 95% CVOC removal efficiencies respectively. The MITU technology has had very favorable results in the field displaying consistency with the 90% to 95% average removal efficiencies accomplished by the other technologies. Some typical contaminant removal results achieved through thermal treatment with the MITU are displayed in Table 2.1.

Table 2.1 Typical Thermal Treatment Remediation Results

Contaminant	Pre-Treatment (mg/kg)	Post Treatment (mg/kg)	% Reduction
Benzene	5.6	0.005	99.9%
Toluene	270	0.05	99.9%
Ethyl Benzene	54.5	0.97	98.2%
Xylene	324	4.5	98.6%
PCE	**369**	**18.1**	**95%**
TCE	**25**	**.5**	**98%**

4.2.2 Chemical Oxidation

In-situ chemical oxidation is a relatively new technology being used to treat CVOCs in soil and groundwater. There are three viable oxidants that are currently commercially available – Permanganate (Potassium and Sodium forms – $KMnO_4$, $NaMnO_4$), Hydrogen Peroxide (H_2O_2), Ozone (O_3), and Persulfate.

MITU-12 mixing $KMnO_4$ with CVOC contaminated soil in Milwaukee, WI

The attractiveness of in-situ chemical oxidation is that it is a relatively fast process. Most CVOCs are amenable to oxidation, and treatment can be completed in relatively short order. Generally the oxidation products are CO_2, water and chloride ion. The end products for the oxidants are generally innocuous. Ozone and peroxide generate oxygen and water; permanganate generates Manganese Dioxide (MnO_2), an insoluble mineral. The permanganate also will leave the corresponding cation – potassium or sodium.

CBA has had tremendous success using potassium permanganate for oxidation of CVOCs, particularly trichloroethylene (TCE) and tetrachloroethylene (PCE).

Permanganate has been preferred as an oxidant over ozone and peroxide due to its resistance to auto decomposition and its effectiveness over a larger pH range. The stoichiometric reactions for the complete destruction of PCE and TCE utilizing potassium permanganate are as follows:

PCE: $4KMnO_4^- + 3C_2Cl_4 + 4H_2O \longrightarrow 6CO_2 + 4MnO_2 + 12Cl^- + 4K^+ + 8H^+$

TCE: $2KMnO_4^- + C_2Cl_3 \longrightarrow 2CO_2 + 2MnO_2 + 3Cl^- + 2K^+ + H^+$

The stoichiometry indicates that approximately 1.3 pounds of permanganate is required to completely oxidize one pound of PCE. The equation, however, ignores oxygen demand inherent in the site soils due to natural organic material (NOM) and other reductants. Therefore, using a factor of three to ten times the weight ratio noted above is not uncommon.

Although the reaction mechanisms involved with oxidizing organic compounds sorbed to soils are not fully understood, the key to successful application is ensuring the contact between the oxidant and the contaminant. Typically the rate of contaminant degradation in heterogeneous matrices is controlled by the concentration of the oxidant, and any surface or subsurface structures as well as lithological changes can impede the success of in-situ chemical oxidation. However, CBA's patented MITU process is ideal for ensuring contaminant/reagent contact within vadose zone soils equating to appreciable contaminant degradation rates at lower than expected oxidant dosage rates. At a Wisconsin Hazardous Waste Site containing soils contaminated with chlorinated solvents, CBA used a combination of thermal treatment and chemical oxidation with potassium permanganate to achieve the required treatment objectives.

Typically, permanganate is applied to contaminated media as a solution or as a slurry; however, CBA applied potassium permanganate in its dry crystalline form (see photo, right). This method has proven to be successful in vadose zone soils having an adequate moisture content (>17%) and also in saturated soil conditions. In this application, the MITU is utilized to mix the $KMnO_4$ directly into the soils. A water spray is typically used for dust control and to aid in the kinetics of the chemical oxidation.

Applying $KMnO_4$ in dry crystalline form
Milwaukee, WI