MOBILE INJECTION TREATMENT UNIT

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Abstract: CBA Environmental Services (CBA) has developed and patented an innovative environmental remediation technology known as the Mobile Injection Treatment Unit (MITU). The MITU was originally designed to remove volatile organic contaminants (VOCs) through the use of hot air injection and soil mixing. CBA has improved the process of in-situ enhanced thermal desorption and expanded the capabilities of the MITU to include chemical reagent mixing. The MITU has proved to be superior to other mechanical mixing applications due to its ability to function in all soil types. The capacity of the MITU varies depending on the model and the site conditions. Straight reagent mixing applications can achieve a production rate of over 1000 cubic yards per day, while enhanced thermal desorption production rates have ranged from 50 to 500 cubic yards per day. Developments to the technology are ongoing, and advancements to the heat generation and mechanical mixing system are currently under *beta* testing.

The concept of mobile incineration of VOC contaminated soils grew from the SUPERFUND program as an avenue to cut transportation costs associated with off-site disposal or treatment, which could approach or exceed the total combined cost for the other aspects of the cleanup (LaGrega, et al., 1994). Low temperature thermal treatment advanced as a cost effective alternative to incineration without the air quality standards that accompanied the incineration process. However, both of these processes are ex-situ; therefore requiring excavation, and most likely variances and/or permits under RCRA. Hence, in the late 1980s and early 1990s in-situ treatment processes were rapidly developed and explored. Soil Vapor Extraction (SVE) technology became widely popular across the U.S., but the use of this technology is limited to permeable, unsaturated soils (Chambers, et al., 1991). The MITU technology combines a very mobile piece of equipment with a cost effective thermal treatment process that is applicable in most soil types and conditions.

VOC contamination in vadose zone soils is distributed among three phases of the soil matrix. The distribution of the contamination depends on the soil characteristics as well as the specific contaminants of concern. 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 (LaGrega, et al., 1994). The MITU utilizes an intrusive trenching mechanism to decrease soil density and increase soil particle surface area. Forced hot air is injected into and across the soils being mixed with the trenching device. This process, mechanically enhanced thermal desorption, promotes contaminant movement by both advection and diffusion by increasing bulk air flow and reducing the diffusion path length. Contaminants are released to the atmosphere beneath a protective shroud where they are captured by a vacuum / vapor recovery system and conveyed for treatment via carbon adsorption or catalytic oxidation.

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Soil heating technologies have proved to remove over 98% of volatile and semivolatile aliphatic and aromatic compounds by achieving soil temperatures of 150° C (Chambers, et al., 1991). The MITU heat generation system operates at continuous temperatures in excess of 400° C. The technology has had very favorable results in the field displaying consistency with the 98% removal efficiency accomplished by soil heating technologies. The process has also been demonstrated to be equally successful at removing chlorinated solvents, specifically PCE and its daughter products.

The MITU technology has been utilized successfully on a State Superfund project in Wisconsin. The project included the remediation of soils containing very high concentrations of PCE and TCE. The treatment process involved mass reduction by thermal treatment and a secondary, polishing step by chemical oxidation with potassium permanganate. The MITU was utilized for both treatment steps and was able to achieve a 98% reduction in PCE mass via thermal treatment and an additional 0.5% total reduction or 80% relative reduction via chemical oxidation.

The treatment approach was first pilot tested on the project in an area defined as the "worst" contaminated on the site. The volume of the treatment area for purposes of the test was 103.7 cubic yards (20 ft L x 20 ft W x 7 ft D). The soil is described as a lean clay that is in a medium dense to very dense state of relative density. High blow counts, on the order of 21 blows to 79 blows per foot, were encountered during split spoon sampling. The average moisture content is 17.7%, and the wet density of the lean clay is 133.7 lbs/ft^3. The thermal treatment began in December 1999, and achieved approximately 99% mass reduction through 60+ hours of treatment (Figure 1). Thermal treatment continued to cumulative total of 90 hours; however the reduction curve achieved through thermal treatment became asymptotic. A polishing treatment step using potassium permanganate was then introduced.

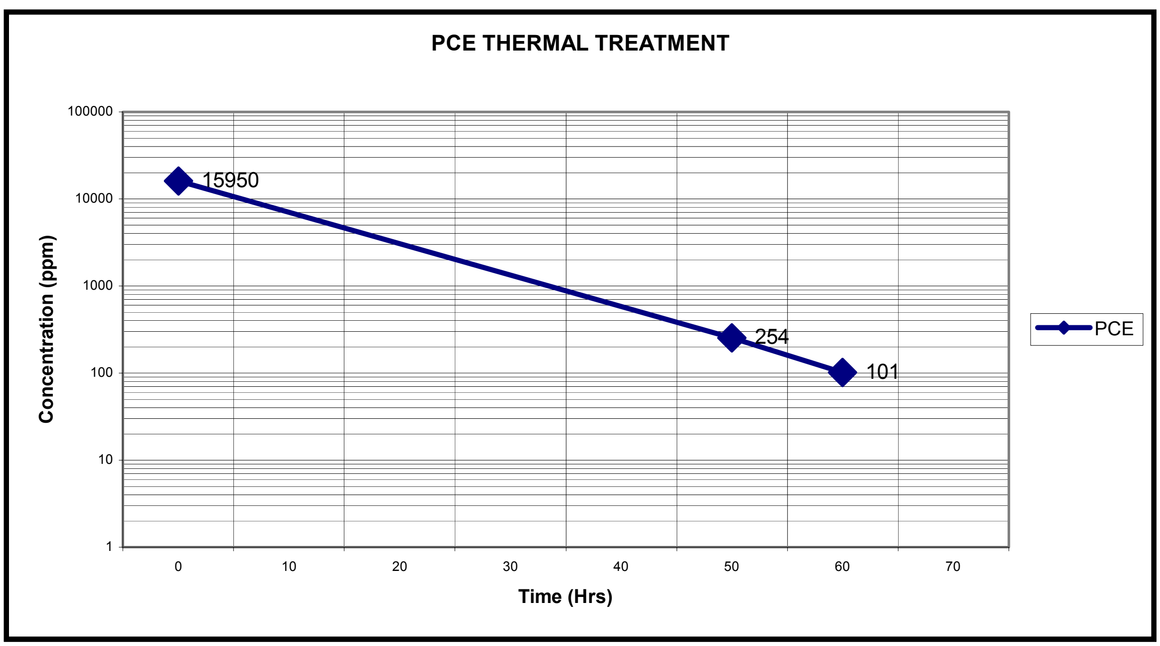

Figure 1: Reduction of PCE through mechanically enhanced thermal desorption over time on a semi-log relationship

A "bench-scale" treatability study indicated that potassium permanganate was the best suited oxidizer for reducing the residual PCE concentration remaining in the soils. The end products formed by the use of potassium permanganate are innocuous, and primarily consist of Manganese Dioxide (MnO_2), an insoluble mineral, and water. The cation with the associated form of permanganate will remain in solution. The theoretical oxidation of PCE with permanganate is as follows:

PCE: $4MnO_4^- + 3C_2Cl_4 + 4H_2O \quad = \quad 6CO_2 + 4MnO_2 + 12Cl^- + 8H^+$

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 content and other contaminants. Therefore, using a factor of three to ten times the weight ratio noted above is not uncommon. Free flowing, crystalline potassium permanganate was added at slightly increasing dosages over 7 mixing events. The permanganate was added in its dry form; a water spray was used to prevent fugitive dust emissions. The trend of PCE concentration decreased linearly with the permanganate additions, indicating that permanganate would be successful at oxidizing PCE to meet the required standards (Figure 2). Further bench scale and field testing showed that a significant amount of permanganate would be required to attain the final reduction necessary to meet the cleanup standards.

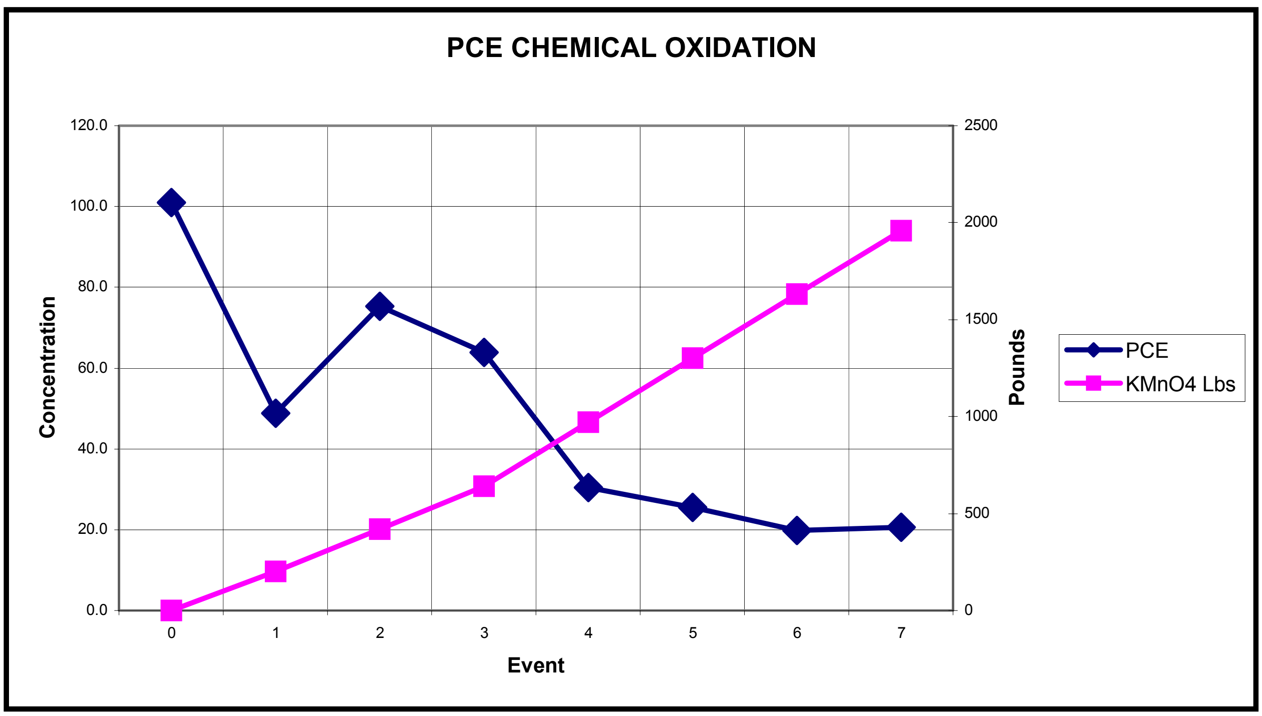

Figure 2: Chemical oxidation of PCE by direct mixing of potassium permanganate with the MITU

References:

LaGrega, Michael, D., Phillip L. Buckingham, and Jeffrey C. Evans: *Hazardous Waste Management*, McGraw-Hill, Inc., New York, NY, 1994.

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