Novel Sustainability Scoring Method for Soil Remediation Technologies

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Background/Objectives: The concept of sustainability is ever more pervasive in all aspects of today's society, and soil remediation should be no exception. Several of the goals set by the United Nations are particularly relevant to soil rehabilitation, such as resilient infrastructure development, safety, resiliency of land management and sustainable consumption.

Governments, including California EPA, are using scoring methods to determine which sites have priority in funding for remediation. Scoring methods have been used for years to determine the most sustainable remediation technologies.

Unfortunately, the sustainability of a remediation method is too often understood solely as its correspondent greenhouse gases emission. While being a key factor, it is only a limited part of the big picture. Furthermore, several of tools are available for the stakeholders to estimate CO2-equivalent emissions of different technologies but, depending on their scope and assumptions (which are not always disclosed), results can vary significantly.

Approach/Activities: In order to properly choose the most sustainable technologies depending on project- and pollutant- specific constraints, a sustainability scoring method is proposed. It is based on three main pillars, namely the economic (ECO), environmental (ENV) and socials (SOC) criteria.

The economic criterion is the most straightforward as it relates to the remediation cost. It includes the total cost, degree of uncertainty and change in land value. The social indicator, often the most neglected, relates to the impact of the remediation on society and individuals. It covers safety, education and employment, stakeholder involvement, land use, dust, odours, traffic, and noise generated. Finally, the environmental criterion evaluates the efficiency of remediation, risk of secondary contamination, gas emissions, impact on soil and water characteristics and generated waste.

Each sub-criterion is rated thanks to an evaluation grid, attributing a note ranging from 0 to 10 based on the performance of the given remediation method. When a numbers-based rating is not possible, which is typically the case for some social indicators, a clear description of different scenarios is used to make their objective assessment possible.

After each of the main three pillars have been attributed a score based on the mean score of the topics that they cover, a final scoring method is proposed such that:
Each of the main pillars (ECO, ENV, SOC) is given the same weight.
A poor score in one of the pillars is highly penalizing for the final overall score.
For those reasons, necessary to select truly sustainable technologies, the final sustainability score is the geometrical mean of the three main scores, written as $\sqrt[3]{\overline{ECO} \times \overline{SOC} \times \overline{ENV}}$.

Results/Lessons Learned: To highlight the method and conclude the paper, a small case study is used, where "remediation" using excavation (dig & dump) is compared against thermal desorption. While studies relying on CO2- equivalent emissions sometimes favour one method or the other based on their respective scopes and assumptions, the weaknesses of the excavation are properly highlighted using a full sustainability scope.

Fast Track to Closure – Remedy Selection

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Background/Objectives: The Site was the former Fashion Cleaners dry-cleaners facility that operated from approximately 1949 through 2014, and used tetrachloroethene (PCE) and trichloroethene (TCE) in the dry-cleaning process. In 2011, approximately 7,900 pounds of waste PCE and TCE sludge and filters were transported offsite for disposal. In 2019, during a Phase I and Phase II Environmental Site Assessments on an adjacent property, PCE and TCE were detected in three soil vapor samples above vapor intrusion screening levels. As a result, the Idaho Department of Environmental Quality (DEQ) requested an initial site characterization at the Former Fashion Cleaners Site. The 2019 site investigation included 3 soil borings and two soil vapor samples that detected PCE and TCE. In 2020, the EPA Environmental Response Team collected additional soil gas samples and subcontracted the installation and sampling of groundwater at and around the site. Five of the soil gas samples exceeded removal management levels for PCE. PCE also was detected in the groundwater samples, but at concentrations well below the maximum contaminant level (MCL).

Approach/Activities: In 2022, an underground storage tank (UST) was discovered during the removal of a heating oil tank by the owner. This UST had apparently been used to store dry cleaning fluid. Tetra Tech removed the tank and fifteen 55-gallon drums of contaminated soil. Tetra Tech collected additional groundwater, soil and vapor samples in February/March 2023. Groundwater exhibited detectable concentrations of PCE that were less than the MCL. However, as long as residual PCE and TCE remain in the soil column, transport to groundwater is possible via infiltration and/or vapor transport. In addition, the highest soil impacts were generally located 15 feet below ground surface on top of a clay layer. Below the clay layer, the soil is generally sandy, and the concentration decreases significantly with depth. As a result, remediation efforts were focused on how to target the removal or treatment of the soil below the former tank and adjoining area. An alternative analysis eliminated excavation due to the proximity to the building.

In-situ thermal remediation (ISTR) has been selected to remediate the remaining soil contamination and to achieve site closure. This method was selected over other remediation alternatives based on treatment time, cost, and space constraints at the site. Haemers Technologies, Inc. was selected as the technology provider and contracted in August 2023. Once the ISTR activities have been completed, contaminant concentrations will be reduced in site soils to below their respective RSLs. The ISTR remediation will begin in early 2024 and conclude late Spring 2024

Results/Lessons Learned: A draft Site Closure Plan has been developed by Tetra Tech and has been approved by the DEQ. It is currently under the mandatory public comment period. The closure schedule is anticipated to be completed in 180 days with the exception of waste removal and decontamination due to:

- Uncertainty in the time required for the in-situ thermal remediation to reduce soil contamination levels below RSLs.
- Co-location of the contaminated soil with site structures (buildings), which requires additional and more complex remediation set-up and controls.

Site investigation data, with the remediation selection evaluation and process, and all results of the ISTR remediation will be presented.

State of the Art for PFAS-impacted Soils. What are the Available Remediation Technologies?

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Background/Objectives: This presentation delves into the contemporary landscape of remediating soils contaminated with Per- and Polyfluoroalkyl Substances (PFAS). While PFAS contamination in water and waste streams has garnered substantial attention, this discussion centers on the specific challenges posed by PFAS-contaminated soils. The aim is to provide a comprehensive overview of the current status of remediation technologies for PFAS-impacted soils, highlighting the evolution of these methods and their effectiveness. By focusing exclusively on soil-based contamination, this presentation contributes a nuanced perspective, shedding light on the latest advancements, limitations, and promising approaches in addressing this pressing environmental concern.

Approach/Activities: The approach to addressing PFAS-impacted soils begins with a foundation in the known physical and chemical properties of PFAS, while acknowledging the significant gaps in our understanding regarding their complex interactions, degradation chemistry, and long-term behavior in soil. From this starting point, our activities focus on elucidating the feasibility and effectiveness of separating PFAS from the soil matrix and managing the resulting contaminants.

We meticulously evaluate various technologies, including Stabilization, Soil Washing, Thermal Desorption, and Incineration, with the overarching goal of gaining insight into their capacity to tackle PFAS-contaminated soils. These technologies serve as the cornerstones of our comparison, with an emphasis on their capabilities, limitations, and the nuances of their interactions with PFAS compounds present in the soil.

Stabilization, a method aimed at immobilizing contaminants in the soil, offers potential advantages in terms of reducing PFAS mobility. Soil Washing, utilizing a combination of mechanical and chemical means, effectively extracts PFAS from soil, albeit with cost and applicability considerations. Thermal Desorption, relying on heat-induced separation, presents promise for PFAS removal, while also raising questions about energy intensity and suitability for diverse soil types. Incineration, a high-temperature destruction method, provides an option for PFAS disposal but entails its own set of challenges.

It is crucial to underscore that the efficacy of these technologies hinges on several factors, including the specific PFAS compounds involved, soil characteristics, and environmental conditions. Recognizing the interplay between advantages and limitations, and considering the variations observed in different scenarios, is paramount when selecting an appropriate treatment strategy. Our endeavor acknowledges the intricacies of PFAS behavior in soil and strives to provide a comprehensive understanding of the available remediation technologies within this multifaceted context.

Results/Lessons Learned: This study provides a comprehensive overview of diverse technologies deployed to address soil contamination, particularly in the context of Per- and Polyfluoroalkyl Substances (PFAS). These technologies encompass Containment (landfilling or on-site containment), Stabilization (on-site or at landfill sites), Soil Washing, Thermal Desorption, and Incineration. Each of these approaches offers unique advantages and challenges. Containment effectively isolates contaminants but raises concerns about long-term sustainability. Stabilization presents prospects for immobilizing PFAS but requires vigilant oversight. Soil Washing physically extracts contaminants but may be cost-prohibitive in certain scenarios. Thermal Desorption shows promise but necessitates careful energy consumption evaluation, and Incineration offers disposal options but warrants comprehensive scrutiny. Combinations of these remediation technologies can offer flexible solutions for PFAS-impacted soils. While numerous unknowns persist in PFAS science, the lessons learned from these approaches and their combinations

play a pivotal role in addressing this pressing environmental concern, guiding practitioners toward more effective and sustainable soil remediation strategies.

Thermal Desorption of VHOC Contaminated Soil and Vapor Management at Lucciana, France

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Background/Objectives As electricity consumption in Corsica experienced significant growth, the EDF group embarked on the renewal of its thermal power plants across the island to address escalating electricity demands. The demolition of the existing Lucciana power plant and the site remediation were pivotal steps in the construction of a modernized facility. Indeed, soil gas analysis have been conducted to assess the land quality and revealed the presence of Volatile Halogenated Organic Compounds (VHOC) contamination up to a depth of 11 meters at the aquifer’s roof. The contamination necessitated treatment before proceeding with new construction.

Approach/Activities: In response to the VHOC pollution challenge, EDF's Lucciana power plant issued a call for tenders in 2020/2021 to remediate the soil at the upcoming facility. In 2022, Haemers Technologies, in collaboration with Englobe, implemented an In Situ Thermal Desorption (ISTD) strategy to remediate the two affected areas to a depth of 13 meters. Two distinct batches of treatment have been carried out.

The first batch, covering an area of 250 square meters, underwent treatment employing 33 Smart Burners™. For the second batch, spanning 400 square meters and with a contaminated zone between 5 and 13 meters, 51 remote flame Smart Burners™ were used to concentrate energy precisely on the impacted area.

In addition to the heating system, a Vapor Treatment Unit (VTU) was integrated into the setup. This VTU included a heat exchanger, condensate tank, three pumps, a knock-out, an extractor, and two activated carbon tanks. To ensure optimal treatment conditions, a water table lowering system was installed, ensuring that the water level remained below the heating zone. The thermal desorption project was executed concurrently with a venting and sparging system, demonstrating the compatibility of both technologies.

Throughout the treatment process, rigorous monitoring encompassed gas emissions and consumption, ground temperature, and pressure to maintain precise control over the installation.

Results/Lessons Learned: The project culminated in the successful treatment of 6,500 cubic meters of contaminated soil. For batch 1, the average concentration in soil gases was 142,000 µg/m³ of VHOC, while batch 2 exhibited 708,520 µg/m³ of VHOC. Each batch underwent a 70-day treatment regimen, with a 5-day period at the target temperature of 85°C, effectively reducing gas soil concentration below 15,000 µg/m³. The project achieved its overarching objectives, with the cold point temperature reaching the desired 85°C and all remediation targets being met.

Enhanced Dynamic Skimming – A New and Highly Effective Approach to LNAPL Recovery

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Background/Objectives: The recovery of Light Non-Aqueous Phase Liquids (LNAPL) poses significant challenges in environmental remediation. These challenges include issues related to high viscosity, susceptibility to clogging in extraction systems, substantial energy consumption, fluctuations in groundwater levels, effluent generation, and the complexities of handling thin contaminant layers. Traditional methods often struggle to effectively address these multifaceted challenges.

Certain skimming solutions have been developed to address these limitations. These solutions involve dynamic vacuum suction of hydrocarbon-free phases at various depths, creating an imbalance between the free phase level within a well and the surrounding soil. This imbalance facilitates well recharge and immediate pollutant extraction. The frequency of pumping depends on factors such as the time required to recharge the well with the pollutant and the duration of suction per well, which is correlated with the quantity of free phase present. These solutions utilize proprietary floats connected to pumping units via flexible hoses, with pumped mixtures automatically transferred to settling tanks for storage and subsequent removal by specialized companies. Minor quantities of effluent are treated in coalescence separators.

However, the effectiveness of this technology is contingent upon soil permeability and LNAPL viscosity, with pumping times influenced by well recharge dynamics. In response, our approach seeks to enhance LNAPL recovery efficiency by harnessing the inverse relationship between temperature and viscosity.

Approach/Activities: Advanced dynamic skimming enhancement: Our innovative approach seamlessly integrates into a comprehensive remediation strategy for contaminated sites, complementing techniques such as soil excavation, thermal desorption, bioremediation, and chemical oxidation. Our method leverages the temperature-viscosity relationship by increasing temperature through In Situ Thermal Desorption, thereby reducing product viscosity. This expedited well filling process enables faster dynamic skimming.

Our approach ensures the complete removal of even the thinnest free phase layers and viscous layers when combined with heating, surpassing the performance of traditional methods. Observations from multiple In Situ Thermal Desorption sites, where LNAPL pumping was conducted alongside soil heating, have demonstrated substantial improvements in product recovery. The combination of In Situ Thermal Desorption and dynamic skimming significantly reduces project timelines.

Results/Lessons Learned: This abstract highlights technological advancements and the potential for enhancing the efficiency of LNAPL recovery through the application of heat. The presentation will include results comparing the amount of product recovered with and without aquifer heating, offering valuable insights into the effectiveness of this innovative approach.

Innovative Underground Skimming Technology for Efficient LNAPL Recovery: A Case Study from Northern France

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Background/Objectives: The efficient recovery of Light Non-Aqueous Phase Liquids (LNAPL) from groundwater presents significant challenges due to diverse soil characteristics, groundwater conditions, and pollutant characteristics. Many conventional recovery methods struggle to address these complexities effectively. However, underground skimming technology has emerged as a promising solution, offering a unique approach to overcome these challenges.

Approach/Activities: This technology's key advantage is the use of skimmers, with a central float being a crucial component. The float, specifically designed for prolonged exposure to hydrocarbons, consistently keeps the skimmer positioned atop the LNAPL layer, even in varying conditions. Remarkably, the float can adapt to groundwater fluctuations of up to 2.5 meters. The skimming process, combined with vacuum pumping, prevents clogging and enables the recovery of LNAPL with differing viscosities. Vacuum pumping in wells creates an imbalance that induces the pollutant to migrate toward it under the influence of gravity, facilitating the comprehensive recovery of the floating layer.

A notable application of this technology is an ongoing project located in Northern France since 2012. This project operates within an industrially restricted site within an ATEX zone. The targeted pollution consists of a complex blend of heavy garage oils, exhibiting a honey-like texture that poses significant recovery challenges with a viscosity of 0.5 Pa.s at 288K. The groundwater depth varies from 17 to 22 meters, experiencing fluctuations of up to 1.5 meters annually. The installation includes two containers and eight strategically positioned wells across the site. The pollutant is routed to the first container, housing the pumping unit, and subsequently stored in the second container with two 2500L IBCs. Impressively, over the course of ten years, a total of 22,124 litres of LNAPL have been successfully recovered using this technology.

Results/Lessons Learned: This abstract presents a compelling case study demonstrating the effectiveness of underground skimming technology in addressing the challenges associated with LNAPL recovery in complex groundwater environments.

Thermal Desorption of TPH Contaminated Dehydrated Sludges and Vapor Management at Kalina, Poland

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Background/Objectives: The five-hectare Kalina Pond, situated in Świętochłowice, very close to Katowice, Poland, had its origins in the early 20th century as a result of coal mining activities in the region prior to World War I. Initially, it served as a fishing pond and later transformed into a leisure center with the addition of a swimming pool. For many years, the reservoir remained relatively intact. However, a significant shift occurred in the early 1950s when a nearby chemical plant, specializing in paint and varnish production, began disposing of its waste upstream from the reservoir. Consequently, the site became rapidly contaminated with BTEX, phenol, and aromatic hydrocarbons due to runoff from the waste pile.

Approach/Activities: In response to this environmental challenge, Remea Poland/Menard, a Polish environmental remediation company, engaged Haemers Technologies to spearhead the decontamination efforts. The primary objective was to rejuvenate the site, transforming it into a recreational area for local residents while fostering biodiversity in the region. Haemers Technologies designed an ex-situ thermal treatment plant, comprising two main units:

- A heating pile containing dehydrated sludges (with humidity 9levels of up to 50%) collected from the pond's bottom.
- A Vapor Treatment Unit (VTU), responsible for recondensing the vapors and reintroducing them into the pile for oxidation via a burner flame (reburn principle).

At the outset of 2022, Haemers Technologies initiated a on-site pilot-demonstration pile on to demonstrate the efficacy of its ex-situ Smart Burner technology in addressing the specific contaminants. Subsequently, two additional piles were constructed adjacent to the pond to actively treat the sludges.

Results/Lessons Learned: The project encompassed the treatment of 2800m³ of contaminated sludges, with maximum average pollutant concentrations of up to 12,500 mg/kg d.m for PAHs, 720 mg/kg d.m for BTEX, and 1049 mg/kg d.m for phenols. The treatment spanned a duration of 10 months and resulted in a remarkable pollutant mass reduction exceeding 99.5%.
The successful completion of the project has led to the restoration of the site, allowing residents to enjoy the recreational features of the pond and newly developed facilities once again. Moreover, the revitalization efforts have facilitated the return of wildlife, rejuvenating this small piece of land.

Thermal Desorption of Heavy Oils Contaminated Soils in an Oil Field in South Sudan

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Background/Objectives: More than 12.000 m^3 of soil are contaminated with heavy oils coming from an oil field exploitation for more than 20 years in one of the different oil fields in South Sudan. Soil contamination in that area has a massive negative impact on nature and health of the neighboring resident due to potable water and fertile soil contamination. Consequently, the site is contaminated with C10-C40, mainly heavier fractions (C30-C40).

Approach/Activities: In response to this environmental challenge, an English environmental remediation company, engaged Haemers Technologies to spearhead the decontamination efforts. In 2022, the first phase began with a small ex-situ pilot of 200m^3.

Due to the remoted place of the site, several changes in design were necessary for the good operation of the contaminated soil ex-situ treatment. The main change is linked to the impossibility to have concrete on site to cover the soil pile. Pilot phase was to test different design to optimize the treatment counting with the challenges of this remoted site. One more pilot pile is planned to resolve the difficulties encountered during the first pilot pile. Afterwards, six (6) full-scale piles of 2000m^3 are planned.

Contaminated vapors are treated using the reburn technology which consists of using the flame created to heat the soil in order to burn the contaminated vapors which are hydrocarbons. Throughout the treatment process, rigorous monitoring encompassed gas emissions and consumption, ground temperature, and pressure to maintain precise control over the installation.

Results/Lessons Learned: The project encompassed the treatment of 12.000m^3 of contaminated soils, with maximum average pollutant concentrations of up to 56.000 mg/kg d.m for C10-C40 and 25.000 on average. The pilot treatment spanned a duration of 50 days and resulted in a remarkable pollutant mass reduction exceeding 99.9%.
Numerous obstacles were faced while conducting operations in South Sudan. The rainy season rendered certain roads to the site impassable, resulting in delays due to the unavailability of materials or equipment. Additionally, communication was challenging in this remote location, making it difficult to make quick decisions in response to issues. Consequently, there was a need for adaptability in both the design and schedule to effectively address the highly contaminated soils. The accomplishment of this initial remediation pilot has paved the way for the project's ongoing progress. The commencement of full-scale operations is scheduled for January 2024, with subsequent results to be shared.

Harnessing Solar Energy for Sustainable In Situ Thermal Desorption of Contaminants with Parabolic Trough Concentrators

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Background/Objectives: Solar energy, an abundant and cost-free form of thermal energy depending on regional availability, holds promise as a solution to reduce dependence on fossil fuels. Solar thermal technology, or solar thermal energy, utilizes the sun's heat to generate thermal energy. It employs solar collectors, such as flat-plate or concentrating systems, to capture sunlight and convert it into heat. The utilization of this technology offers an environmentally friendly approach, devoid of greenhouse gas emissions, contributing to the fight against climate change.

Approach/Activities: In Situ Thermal Desorption (ISTD) is an effective technology for treating organic contaminants in soil. The primary principle involves heating the soil through a network of steel pipes functioning as heat exchangers. This process elevates the soil's temperature and pressure to the volatilization point of pollutants. This paper explores the novel concept of using solar energy to power the soil heating process in ISTD.

Of the various solar thermal technologies, parabolic trough concentrators emerge as particularly well-suited for achieving high-temperature soil heating. These concentrators operate based on the geometry of a large, curved parabolic mirror with an absorber tube along its focal line. All parallel light rays reflect to this line, heating a heat-transfer fluid within the receiver tube. Temperature levels of up to 1000°C can be attained depending on solar intensity, geographic location, fluid flow rate, and collector dimensions.

Once the heat-transfer fluid reaches high temperatures, it is injected into the soil via an exchanger tube, elevating the soil to a target temperature and vaporizing any contaminants. The fluid then returns to the parabolic concentrator, where it is reheated, and the process continues.

Results/Lessons Learned: Parabolic trough concentrators exhibit high efficiency and the capacity to store heat, enabling soil heating even in cloudy or nighttime conditions, making them suitable for thermal desorption applications. Thermal insulation tanks play a crucial role by storing some of the warm heat transfer fluids, ensuring continuous and stable soil heating, regardless of weather conditions. During periods when the sun isn't shining, the stored heat is redirected to maintain high soil temperatures, enhancing the technology's sustainability and operational reliability.

Assessing the Energy Consumption of In Situ Thermal Desorption for Soil Remediation

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Background/Objective: The energy consumption of In Situ Thermal Desorption has raised concerns, with variability stemming from factors like application method, contaminant type, moisture content, and energy source. Over the last 30 years, the overall energy efficiency of ISTD has increased substantially to reach less than 200KWh/ton of soil, which is comparable to dig and haul options without any soil treatment. This study seeks to comprehensively assess these factors to understand what drives energy consumption and how it can be optimized by design. Real-world projects, like ENI's Gela (Italy) refinery clean-up, where ISTD was applied to clean-up more than 100,000 m³ of heavily contaminated soil provide valuable reference points for this assessment.

Approach/Activities: The research employs a methodology utilizing a proprietary UDF adaptation of Ansys-Fluent© modeling on porous multi-phase media. It conducts a detailed simulation of Thermal Desorption's energy consumption, focusing on primary parameters including energy density, type of heating, and energy source. The secondary parameter, heating time, is considered contingent on energy density and power input. Modeling results are then compared to site data to further validate the model and run the different scenarios for understanding the design parameters influencing total energy consumption.

Results/Lessons Learned: Comparative analysis against conventional remediation methods, such as excavation and disposal (typically requiring up to 200 kWh/ton of soil), reveals that optimized energy consumption through careful parameter selection positions In Situ Thermal Desorption (ISTD) as a more energy-efficient and environmentally responsible alternative. The insights gained from our modeling and real-world experiences contribute significantly to our understanding of the factors influencing energy consumption.

The analysis highlights several key parameters crucial for optimizing energy consumption in ISTD. One of the most critical factors is energy density, representing the interdistance between heating elements. It is evident that higher energy density leads to lower energy consumption. However, it is important to note that there are limitations on energy density, often dictated by the available power supply, particularly when grid electricity serves as the energy source. In such cases, the available power becomes a decisive parameter, and careful consideration is needed to balance energy density with available resources. Another important parameter is the geometry of the target treatment zone. The surface/volume ratio is directly related to total energy consumption. Shallow, extended treatment areas are suboptimal for ISTD, as they lead to a high thermal loss ratio over the duration of the treatment. Therefore, optimizing the treatment area's geometry is essential for energy efficiency.

Furthermore, ISTD offers the potential for a significantly reduced carbon footprint compared to several alternative soil remediation methods. This reduced environmental impact is primarily due to the efficient energy consumption and the avoidance of extensive excavation and transportation activities associated with traditional soil disposal. By employing ISTD and optimizing its parameters, we can contribute to a more sustainable approach to soil remediation while simultaneously lowering the carbon footprint associated with these critical environmental projects. These findings underline the importance of ISTD in the context of sustainable remediation practices and its potential as a significant contributor to reducing the environmental impact of soil cleanup efforts.

This research contributes to the advancement of In Situ Thermal Desorption as an environmentally sustainable solution, paving the way for broader adoption all over the world.

Scaling up of Mercury Contaminated Soil Thermal Desorption Treatment: Laboratory, Pilot and Full-Scale in Israel

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Background/Objectives: Many nations have recognized the environmental and health hazards associated with mercury and have taken steps to minimize or eliminate its use in various industrial applications. The Minamata Convention on Mercury, established in 2013, is a global treaty with the goal of safeguarding human health and the environment from the detrimental effects of mercury. It advocates for the phase-out of specific mercury-based processes, including mercury electrolysis, in favor of safer and more environmentally friendly alternatives. Mercury, in its various forms - elemental, inorganic, and organic compounds - can pose risks to human health, affecting the nervous system, respiratory system, gastrointestinal tract, and skin. This results in symptoms such as tremors, muscle weakness, memory impairment, and developmental issues, particularly in foetuses and young children.

Approach/Activities: In a collaborative effort, Haemers Technologies, LDD Advanced Technologies, and Tidhar joined forces to remediate the former plant of the Electrical Industries Company, situated on a 60-acre site in Acre Bay, Israel. This facility operated from 1956 to 2003, primarily involved in chlorine and polyvinyl chloride (PVC) production. The chosen approach for land remediation involves the application of thermal treatment, among other techniques.

In early 2022, the initial laboratory phase was conducted to evaluate the kinetics of thermal treatment specific to mercury contamination. The results demonstrated a substantial reduction in overall mercury content, with a degradation/elimination rate of 92% observed after 24 hours at 200°C, increasing to 96% after 168 hours at 260°C.

Results/Lessons Learned: Following the kinetic study phase, Haemers Technologies conducted an on-site Pilot of Ex Situ Thermal Desorption (ESTD), targeting approximately 275m3 of extensively contaminated soil. The soil was heated to a target temperature of 350°C over 35 days, effectively remediating significant contamination with volatile organic compounds (VOCs), semi-volatile organic compounds (S-VOCs), and mercury. The consolidation of these soils into a treatment pile validated the treatment's efficacy and ensured compliance with air emission standards.

After the successful Pilot Phase, the project transitioned to its Full-Scale phase, with the first thermopile containing 4000 tons of contaminated soil scheduled for treatment by the end of 2023. A vapor treatment unit has been installed to manage extracted vapors, undergoing collection and condensation. The non-condensable fraction is subjected to further treatment before release into the atmosphere.

This project represents a significant collective achievement, showcasing the potential for broad application in addressing mercury contamination at similar brownfield sites in need of an effective technical solution.

An Innovative Remediation approach for In Situ Neutralization of Halogens and Sulphur during Thermal Desorption

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Background/Objectives: In the context of In Situ Thermal Desorption, contaminated soil containing pollutants like TPH, PAH, Mercury, chlorinated solvents, and others undergoes heating to induce vaporization of these contaminants. The resulting vapors are then drawn through perforated steel tubes, referred to as vapor tubes, which are surrounded by gravel serving as a drainage medium to prevent clogging. These recovered vapors can be either treated in a vapor treatment unit or reintroduced into the flame, particularly for hydrocarbon pollution when using burners.

Approach/Activities: In many instances, the contaminated soil contains various process-disturbing elements, such as phosphorus, sulfur, or halogenated compounds like chlorine. The heat applied during the process vaporizes many chemical compounds, including those that could contribute to equipment corrosion when carried through the porous medium to the extraction wells. The issue arises when these agents become highly corrosive, potentially undermining the effectiveness of the remediation technology. Left untreated, they can also lead to non-compliant air emissions.

Thermoreact® is an innovative product designed to replace traditional gravel around vapor tubes. This product facilitates in-situ neutralization of vapors before they exit the soil pack, reducing treatment requirements and yielding significant cost savings. Its composition can be customized according to the nature and concentration of pollutants in the soil, ensuring optimal neutralization reactions while maintaining the required permeability for effective vapor extraction. The resulting neutralization by-products consist of inert minerals that can be safely retained in the soil, offering a genuinely zero-waste treatment solution for a wide range of contaminants.

Results/Lessons Learned: This paper presents performance results from in-situ thermal desorption treatment utilizing Thermoreact® as a sulfur neutralization filter media around vapor tubes. This study demonstrates the following key findings:

- The technology effectively neutralizes sulfur-containing vapors.
- The effectiveness in sulfur neutralization remains consistent even in the presence of other pollutants.
- The visual appearance of the soil remains unchanged after treatment, allowing for the retention of inert neutralization products in the soil without affecting the site's visual aspect.
- The composition can be tailored to specific site parameters, including moisture levels, sulfur, hydrocarbon, halogen concentrations, and other soil chemical characteristics.