Evaluating Energy Efficiency and Carbon Footprint in Soil Treatment Technologies: the case of In Situ Thermal Desorption

Aline Jordens (aline.jordens@haemers-tech.com), Ysaline Depasse, Hatem Saadaoui, Jan Haemers
(Haemers Technologies, Brussels, Belgium)

Purpose of Study

In Situ and On-Site Thermal Desorption is increasingly applied worldwide due to its performance and reliability in soil remediation. However, its energy consumption and overall sustainability have been questioned. This study aims to provide concrete data on the carbon footprint and energy consumption of In Situ Thermal Desorption projects compared to alternative methods. Specifically, it focuses on evaluating direct heating technologies (fueled by fossil or biofuels) versus indirect heating technologies (using electricity generated from renewable or fossil fuels). The goal is to identify the most sustainable and efficient approaches within thermal remediation technologies.

Methodology

The study begins by evaluating energy consumption across a broad range of soil remediation technologies, including biological, chemical, physical and thermal methods, to establish a baseline for their relative energy demands. It then focuses on thermal remediation, which, despite its effectiveness, varies significantly in energy use and carbon footprint depending on site-specific and regional factors.

Key variables such as contaminant type, soil composition, target temperature, and local energy grid characteristics are analyzed to compare direct heating systems (fossil fuels or biofuels) with indirect heating systems (electricity - renewable or fossil-based). Quantitative data on energy efficiency, lifecycle losses, and CO2 emissions are evaluated, alongside the inefficiencies of electricity supply chains and the combustion efficiency of gas-fired systems. The potential of biofuels to mitigate environmental impact is also assessed, emphasizing their integration into existing systems and carbon savings compared to fossil fuels.

Summary of Findings/Results

Thermal remediation technologies, often criticized for their energy intensity, perform better than expected compared to other soil treatment methods. Their efficiency and reliability, particularly in challenging conditions, make them competitive when efficient systems are used. While biological or chemical methods may use less direct energy, total carbon footprints must also consider external energy use, such as chemical production.

Within thermal remediation, gas-fired systems generally consume less primary energy than electric systems due to inefficiencies in electricity generation and transmission. However, the choice between gas and electric depends on the local energy grid. In regions with high renewable energy use, electric systems may have a lower carbon footprint, while gas systems are more sustainable in fossil fuel-dominated grids.

The key to sustainability lies in reducing energy consumption overall. Both gas and electric systems benefit from renewable energy sources like biofuels or renewable electricity, enabling significant carbon footprint reductions. Tailoring solutions to regional contexts ensures optimal environmental and operational performance.

Conclusion/Take-Home Message

Thermal remediation is more sustainable than often perceived, provided efficient systems and renewable energy sources are utilized. The choice between gas-fired and electric systems depends on local energy grid composition and project specifics. Prioritizing energy efficiency and sourcing renewable energy—whether through biofuels for gas systems or renewable electricity—are key to reducing the carbon footprint.

Significance/Contributions of Study

This study emphasizes the need for lifecycle analysis when evaluating energy systems, challenging the traditional focus on point-of-use efficiency. It contributes to the broader discourse on sustainable soil remediation by advocating for practical, cost-efficient, and environmentally responsible heating technologies. Additionally, it highlights the potential of biofuels to reduce the carbon footprint in industrial applications.