STAR Sustainability Analysis

New Jersey, USA

IMAGE 1: PDE test area and equipment setup on Site

Overview

STAR/STARx ranks highly with respect to sustainability due to the net positive energy generated by the process. This means that the energy generated by smoldering exceeds the sum of the heat sinks and losses: igniting the reaction, heating the contaminated materials up to smoldering temperatures, boiling off water and some volatiles, and radial heat losses. The net energy surplus increases with increasing scale of the STAR/STARx application. In other words, full field applications are more energy efficient than laboratory experiments and small pilot tests. This occurs for two main reasons. First, larger systems result in a larger thickness of contaminated materials along the treatment path, which generates more energy. Second, larger systems have a larger distance perpendicular to the smoldering travel path, which reduces heat losses.

Conclusions

As a result of this energy efficiency, STAR/STARx has a small carbon footprint relative to other active remediation techniques:

- STARx is applied on-site; this means no off-site transport of materials for landfilling or incineration, with the associated carbon footprint and hazards of transport.
- STARx destroys contaminants close to the source (i.e., in situ or on-site ex situ), reducing the handling, storage, and off-site destruction or disposal with the associated risks and costs.
- Since the reaction is self-sustaining, the contaminant-destroying smoldering reaction will continue for days without external energy input. This contrasts with incineration or endothermic thermal techniques (e.g., thermal desorption, electrical resistive heating, etc.), which requires continuous and copious fuel addition (such as diesel for incinerators) or energy use.
- STAR continuously generates net gains in energy and stores it in the soil, meaning that the taller and wider the scale of the system, the more excess energy that is available for recovery and reuse.
- The only amendment required for STARx is air, which is inexpensive and innocuous.

Case Study

These advantages have led to STAR/STARx ranking highly on sustainability assessments against a wide range of alternative treatments. As an example, a sustainability analysis was completed for the application for smoldering combustion at a site in New Jersey, USA. The analysis followed the United States Sustainable Remediation Forum's (SURF) nine-step process for evaluating remediation sustainability (Favara et al., 2011).

The remedy alternatives considered in addition to STAR were:

- In Situ Thermal Desorption (ISTD)/In Situ Thermal Stabilization (ISTS)
- In Situ Stabilization (ISS)
- Combination of Hydraulic (Pump and Treat, P&T) and Physical (Impermeable Barrier Wall)
- Containment (P&T / Wall)
- Surfactant In Situ Chemical Oxidation (S-ISCO)
- Bio-Venting and Air Sparging
- Excavation and Off-Site Treatment (Dig and Haul)
- Low-Temperature Thermal Desorption (LTTD).

The carbon footprint of each remedy was evaluated using SimaPro, a Life Cycle Assessment (LCA) software platform. The LCAs attempt to capture all outputs to the environment (e.g., kilograms of carbon dioxide) considering all materials and activities for the remedy application. For example, the STAR LCA included transportation of personnel to the site, manufacture of well points and thermocouples, energy usage for the heaters during ignition, energy usage for air delivery, vapor collection and treatment, and direct CO_2 emissions from the combustion process.

The results of the analyses showed that STAR was ranked as the most sustainable remedy out of the nine alternatives and was determined to have approximately 10 times lower carbon footprint than either LTTD or Excavation.

The STAR footprint is dominated by the gases produced by contaminant combustion (primarily CO_2 and CO), the energy required to run the heaters and blowers, and the activated carbon required to scrub the emissions. While the electricity associated with the extraction system for LTTD is on the same order as STAR, the energy required to heat the subsurface is an order of magnitude larger than any aspect of the STAR process. The Excavation remedy footprint is shown to be dominated by machinery operation, transportation of soil, and the off-site thermal treatment of the soil, which is an order of magnitude larger than any aspect of STAR. Moreover, the distribution of uncertainty in the STAR carbon footprint did not overlap with those of these other remedies. In other words, STAR was the most sustainable remedy regardless of variability in on site implementation.