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In Situ Enhanced Soil Mixing

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The Need

Soils contaminated with volatile organic compounds (VOC), especially those of a fine-grained nature, are difficult to treat with conventional remediation technologies. Meanwhile, there has been a need to implement in situ or "in place" soil treatments that are considered as an effective cleanup alternative that does not require extensive excavation of soils and the associated worker exposure, storage, treatment, and disposal issues.

The Technology

In Situ Enhanced Soil Mixing (ISESM) is a remediation technology that has been used to remediate soils contaminated with volatile organic compounds (VOCs). The technology was developed by industry with the assistance of the U.S. Department of Energy's Office of Science and Technology and the Office of Environmental Restoration.

ISESM includes a number of in situ soil treatment technologies that can treat contaminated soils, especially those with a fine-grained nature. Contaminants can either be removed from the soils or stabilized in place. The process of mixing allows good access for reagent delivery to all soil particles and the interstices between particles.

A single-blade auger or with a combination of augers ranging in diameter from 3 to 12 feet is used to mix the soils. Effective depth of mixing is likely to be 40 feet, although commercial vendors have worked at depths as great as 100 feet with the smaller diameter augers. Enhancements such as injection of heated air in combination with vapor extraction, injection of oxidants, or injection of grout can be utilized for a particular site.

ISESM technologies include:

- **Soil mixing with vapor extraction combined with ambient air injection** [Contaminated soil is mixed with ambient air to vaporize volatile organic compounds (VOCs). The mixing auger is moved up and down to assist in removal of contaminated vapors. The vapors are collected in a shroud covering the treatment area and run through a treatment unit containing a carbon filter or a catalytic oxidation unit with a wet scrubber system and a high efficiency particulate air (HEPA) filter.]

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- **Soil mixing with vapor extraction combined with hot air injection** [This process is the same as the ambient air injection except that hot air or steam is injected.]
- **Soil mixing with hydrogen peroxide injection** [Contaminated soil is mixed with ambient air that contains a mist of diluted hydrogen peroxide (H2O2) solution. The H2O2 solution chemically oxidizes the VOCs to carbon dioxide (CO2) and water.]
- **Soil mixing with grout injection for solidification/stabilization** [Contaminated soil is mixed as a cement grout is injected under pressure to solidify and immobilize the contaminated soil in a concrete-like form.

The Benefits

- In situ treatment of VOCs in clay soils was effectively (>85% reduction) and rapidly accomplished at acceptable costs.
- Vapor stripping processes-ambient air and hot air injection:
    - Treatment performance improved with longer mixing times. 50% of the target VOCs were removed in approximately 90 minutes, whereas 92 to 98% of the contaminants could be removed in the top fifteen feet of soil if mixing were continued for 225 minutes.
    - Extension of the zone of treatment to 22-ft. depth exhibited only a moderately reduced removal efficiency (i.e. average of approximately 88%).
    - Soil bacteria levels were increased by several orders of magnitude following ambient air stripping.
- In situ peroxidation was found to treat soil more rapidly than vapor stripping. VOC treatment efficiency was approximately 72% mass removal in 75 minutes to a depth of fifteen feet.
- In situ solidification. VOC treatment efficiency was over 90%. Limited VOCs were removed in the off-gas during grout injection and mixing.
- In situ treatment of VOCs in clay-rich soils was rapidly accomplished (e.g., >15 cubic yards per hour [yd[3]/h]).
- Treatment costs for each of the four technologies was comparable, ranging from $150 to $200 per cubic yard for the demonstration. Further experience has brought treatment costs down.
- Use of a hydraulic probe for soil sampling with on-site VOC analyses, followed by three-dimensional visualization, provided enhanced information compared with conventional sampling, off-site analyses, and routine data treatment.

Status

In situ soil mixing, also known as soil mixing wall, auger mixing, etc., has been used for years in the construction industry.

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The four ISESM treatment technologies were selected for evaluation during a full-scale field demonstration at the Department of Energy (DOE) Portsmouth Gaseous Diffusion Plant (PGDP), near Piketon Ohio. The field demonstration was conducted at the X-231B Unit in June 1992. Replicated tests of in situ vapor stripping, peroxidation, and solidification were made in soil columns measuring 10 ft in diameter and 15-22 ft deep.

The technology demonstration was a public/private partnership effort between Oak Ridge National Laboratory (six divisions), DOE-Portsmouth Field Office, Lockheed Martin Energy Systems at Portsmouth, University of Tennessee, Michigan Technological University, Chemical Waste Management, Millgard Environmental Corporation, Envirosurv, and NovaTerra.

Millgard Corporation named their technology as MecTool Remediation System which received 1993 Nova Award from Construction Innovation Forum.

BARRIERS

ISESM is attractive for relatively small sites and requires surface access at all locations where soils are contaminated. The technology is suited to shallow applications and above the water table. Improvement in equipments, such as more mobile and scaled down mixing equipment, and experience will be needed to reduce cost further.

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REVIEWERS

Peer reviewed as an emerging construction technology

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