Thermal In Situ Sustainable Remediation (TISR^{TM}): Linking Renewable Energy to Sustainable Site Restoration

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Background/Objectives. Within the mesophilic range (20-40°C), a three-fold increase in microbial kinetics and organic contaminant degradation can be achieved with each incremental 10°C step in temperature. Observation of this natural biodegradation enhancement has been documented as a side-benefit in numerous conventional high-temperature thermal remedies and has fostered interest in development of lower temperature applications to achieve similar results in the absence of aggressive heating. The TISR^{TM} process accomplishes similar objectives, but utilizes renewable energy (solar) to increase the ambient groundwater temperature to 20-30°C in order to enhance contaminant biodegradation rates by three times. TISR^{TM} requires minimal infrastructure, no contaminant treatment or disposal, and negligible utility cost. Therefore, faster clean-up times and significant life-cycle cost reduction compared to traditional remedial alternatives are predicted.

Approach. The TISR^{TM} process uses captured solar energy to promote subsurface groundwater heating without any fluid exchange between the aquifer and the heating system. Pilot testing to support full-scale TISR^{TM} (US Patent Pending) implementation for a 10-acre site (New York) has been implemented since 2015. A total baseline benzene, toluene, ethylbenzene and xylene (BTEX) concentration of 11 milligrams per liter was reported at the pilot test location. In less than two years over 90% reduction in BTEX has been recorded. Similar tests are currently being initiated on two sites impacted by petroleum hydrocarbons and chlorinated solvents, respectively. The TISR^{TM} system consists of a closed-loop system containing a working fluid, solar collectors and a network of borehole heat exchangers (BHEs). Each BHE consists of thermally conductive, high surface area BHE placed at the targeted treatment interval to ensure effective heat transfer to the reactive zone via soil-particle conduction and heated-groundwater advection. The length and spacing of the BHEs were determined based on the vertical thickness of the subsurface contaminant zone, thermal modelling, and empirical data.

Results. This paper will present results from three sites to highlight design details and pilot test findings including: achieved subsurface temperatures, observed contaminant reduction, estimated biodegradation rates, and geochemistry trends. Results to date indicate that even in New York state, with a BHE spacing of 10 feet groundwater temperatures can be increased to 20-30°C, a condition coupled with significant contaminant destruction.