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LSPA 2026 Environmental Symposium

Renaissance Framingham Hotel & Conference Center, Framingham, MA

Remediation Roundtable: Modern Remediation in Practice—Tools and Technologies Shaping Cleanup Approaches

April 9, 2026, 8:00 AM–12:00 PM, Track 1
4.0 Technical LSP Credits (#1932); 2.0 CT LEP Credits (CTLEP-644)
NY PE/PG Credits - PENDING

<u>PRESENTATION DESCRIPTIONS</u>

Modified Fenton's Reagent: Still a Powerful and Dynamic Remediation Tool

Paul Dombrowski, PE, Senior Remediation Engineer, ISOTEC Remediation Technologies, Inc.

The earliest in-situ chemical oxidation (ISCO) treatments in the mid-1980s utilized hydrogen peroxide. Hydrogen peroxide is often applied with an iron catalyst (catalyzed hydrogen peroxide or CHP) in order to generate a wide variety of free radicals and reactive species. Modified Fenton's reagent (MFR) using chelated iron complex catalysts and stabilizers is one of the safest forms of implementing hydrogen peroxide with minimal off-gassing and/or temperature increase. Stabilizers allow for a controlled and more gradual decomposition of hydrogen peroxide facilitating injection and improved ISCO distribution into the subsurface. Chelated iron allows the Fenton's reactions to occur under natural pH conditions of the subsurface (i.e., pH 5 to 8), thus eliminating the need for pH adjustment required by traditional Fenton's reagent. The MFR process generates powerful free radicals when the catalyst reacts with hydrogen peroxide, including both strong oxidants (hydroxyl and hydroperoxide radicals) and strong reductants (superoxide radical and hydroperoxide anion).

Incorporating MFR into remediation offers many benefits, notably surfactant-like effects that significantly enhances desorption of organic contaminants from soil and mechanical perturbation from peroxide derived bubbles that open historically blind pore spaces allowing treatment of previously inaccessible contamination. Additionally, the reaction product of MFR is dissolved oxygen that can enhance aerobic biodegradation of many organic contaminants.

The presentation will feature remediation case studies incorporating MFR, including MFR as a standalone ISCO method and where MFR was included as part of a combined remedy. Examples of combined remediation using MFR include combination oxidant application with MFR and activated sodium persulfate, sequential treatment with ISCO and enhanced reductive dechlorination, surfactant-ISCO (S-ISCO), or ISCO after surfactant enhanced fluid recovery. MFR can be applied via injection or soil blending, and MFR has been used to treat vadose zone soils, saturated overburden, and bedrock. Four decades into ISCO remediation, hundreds of remediation sites have been addressed using MFR and attained cleanup objectives. Considerations for remedial design, implementation, and safety when handling MFR will be highlighted.

Combining Microbiological, Chemical, and Abiotic Processes for Simultaneous Treatment of cVOCs and Heavy Metals

Fayaz Lakhwala, PhD, Key Accounts Manager, Soil & Groundwater Remediation, Evonik Corporation

For over two decades, biologically-mediated enhanced reductive dechlorination (ERD) and abiotic in situ chemical reduction (ISCR) processes have been applied to degrade chlorinated volatile organic compounds (cVOCs) in situ. Recently, biogeochemical reduction (BGCR), a process which combines natural microbiological, chemical, and abiotic processes, has been combined with ERD and ISCR to provide an additional mechanism to enhance cVOC degradation and sequester toxic metals.

During ERD and ISCR, highly reducing conditions are established which promote the reduction of ferric iron (Fe[III]) to ferrous (Fe[II]) and sulfate (SO4) to sulfide (HS-). These reduced forms are highly soluble and rapidly combine to produce reactive iron-sulfide minerals such as mackinawite (FeS), and pyrite (FeS2). The newly formed minerals precipitate throughout the aquifer in various forms. These biologically generated iron-sulfide minerals have been demonstrated to abiotically degrade cVOCs via the β elimination pathway. This additional biogeochemical degradation pathway minimizes the generation of toxic degradation products such as vinyl chloride, thereby minimizing risk and substantially reducing the time to achieve remedial goals. Furthermore, if ZVI is distributed with the biogeochemical reagents, the ZVI particles are sulfidized making them more reactive to the abiotic degradation of chlorinated organics. Sulfidation of ZVI is also known to extend its longevity.

In addition to degrading cVOCs, when soluble iron and free sulfide concentrations are increased by the BGCR approach, heavy metals will be removed by a variety of precipitation, coprecipitation, and adsorption reactions. For example, arsenic is removed from solution as arsenopyrite (FeAsS2) whereas other metals such as zinc are precipitated as sulfides such as sphalerite (ZnS). These minerals have very low solubility and have been demonstrated to be very stable following formation.

This presentation will describe the synergistic effect of these processes and provide representative site data from a field-scale application to removal of chlorinated ethenes, cadmium, nickel, and zinc.

Two Case Studies Demonstrating 10-Year Longevity of Fracture-Emplaced Microscale ZVI
Chapman Ross, PE, Director of Technology, FRx, Inc.

Zero-valent iron (ZVI) is a proven amendment for in-situ chemical reduction of numerous compounds. Its effectiveness is closely linked to its longevity, which has been leveraged since the mid-1990s in the construction of trenched permeable reactive barriers (PRBs). Over the last ten years ZVI has more commonly been delivered via injection and, in its granular form, must be delivered via fracturing. Hydraulic fracturing is an established technology for delivery of granular amendments into low-permeability and heterogeneous formations. This injection technique can readily deliver high mass loadings of microscale ZVI (mZVI) to precise locations in the subsurface and is commonly used for both source treatment and injected PRB applications. Here we present performance monitoring results for two full-scale projects where ZVI-filled fractures facilitated treatment of target compounds for at least 10 years.

At a glacial clay till site in Denmark, a source zone treatment was completed using a grid approach to address TCE impacts in soil and groundwater. Dissolved oxygen and oxidation-reduction potential (ORP) measurements showed persistent reducing geochemical conditions within and downgradient of the treatment zone over a 6-year monitoring period, and the total contaminant mass in soil decreased by approximately 85% over this same period. More recently, mass flux calculations indicate a 96% decrease in the mass discharge of total volatile organic compounds (VOCs) in groundwater exiting the treatment zone and continued production of the complete degradation products ethene and ethane within and downgradient of the treatment zone.

At a second site in South Carolina, ZVI reactivity also persists ten years after remedy implementation. At this site, a 17-acre TCE plume was treated using injected PRBs in saprolite, weathered bedrock, and fractured crystalline bedrock. After ten years, TCE concentrations in offsite wells decreased by 98% from an average of 5,300 ug/L to 90 ug/L, and the 100 ug/L plume has decreased in areal extent from 11 acres at baseline to 0.9 acres.

Thermal Remediation of VOCs, SVOCs, and PFAS
Lauren Soós, Director of Market Solutions, TRS Group

As most volatile organic compound (VOC) source zones are created by spills or leaks from within buildings, in situ thermal remediation (ISTR) is often used to treat shallow soil and groundwater under or adjacent to buildings. The safety of ISTR vendor site workers and all who work on these projects is the ISTR vendor’s most important responsibility and is a critical factor when designing, constructing, and operating an ISTR system.
Common challenges when working in close contact with people may include access refusal, interruptions, trespassing, utilities, odor complaints, chemical handling hazards, indoor air intrusions, insufficient vapor recovery, shallow groundwater, health and safety incidents, etc.

Several mitigation measures are implemented by ISTR vendors and project personnel and may include early stakeholder engagement, relocation, off hour construction, angled and horizontal subsurface heating infrastructure, below grade heating element connections, trenching, indoor air monitoring, safety interlocks, security features, privacy fencing and noise mitigation, etc.

The presentation will focus on the technical complexities of ISTR design, construction, and operations around the public and that comes from experience working on 200 ISTRs with over 60 under buildings and in close vicinity to workers, residents, or the public. Additionally, the presentation will review the various tools available to manage these complexities. Lessons learned and results will also be discussed.

Groundwater Remediation Barrier Design and Construction: CVOC Plume Containment in Fractured Bedrock

Ernest Ashley, LSP, LEP, PG, Vice President, Discipline Leader – Remedial Investigations, CDM Smith

Characterization and remediation of DNAPL in fractured crystalline bedrock can be the most challenging and expensive of remediation efforts. At a site in central Massachusetts, migration of CVOC impacted bedrock groundwater within hydraulically active fractures has resulted in off-site overburden and bedrock groundwater contamination. The off-site groundwater impacts resulted in vapor intrusion issues requiring plume containment at the property line.

Pre-design well installation activities including borehole geophysics, packer testing and injection testing were used to develop a design basis for a groundwater remediation barrier at the property line. Bench scale treatability testing established the optimum amendments for the groundwater barrier including chemical and biological reduction. Injection pilot testing evaluated amendment delivery performance in terms of volume emplaced, radius of influence achieved, and ease/feasibility of injection into overburden and the fracturing process for bedrock. The comprehensive pre-design investigations, bench scale and pilot scale testing lead to a robust final remedial design for full scale plume containment.

This presentation will provide an overview of design and construction considerations for groundwater remediation barriers, the data collection efforts required, significant findings, details of the final remediation construction, post-remediation groundwater monitoring results, and lessons learned.