

E-REDOX® (O)

TECHNICAL FACT SHEET

ISOTEC
REMEDIAL
TECHNOLOGIES



Technology Overview

E-Redox® (O) is a “passive” bio-electro-chemical treatment system that accelerates in-situ biodegradation of petroleum hydrocarbons and other organics in groundwater and soil. By leveraging native microbial activity and ambient oxygen as a terminal electron acceptor, E-Redox® (O) can achieve rapid contaminant degradation without requiring external energy input or injected chemical amendment.

Key Benefits

- Zero energy input or chemical amendment needed.
- Promotes sustained biological oxidation in anoxic matrices, including in low-permeability formations like clay and fractured bedrock.
- Can be deployed in both source zones and plume areas using existing or newly installed wells.
- Operates continuously with minimal maintenance.
- Does not require the use of surface infrastructure.
- Enhances natural attenuation by a factor of 5-10x when applied in an MNA remedial strategy.

Best Suited For

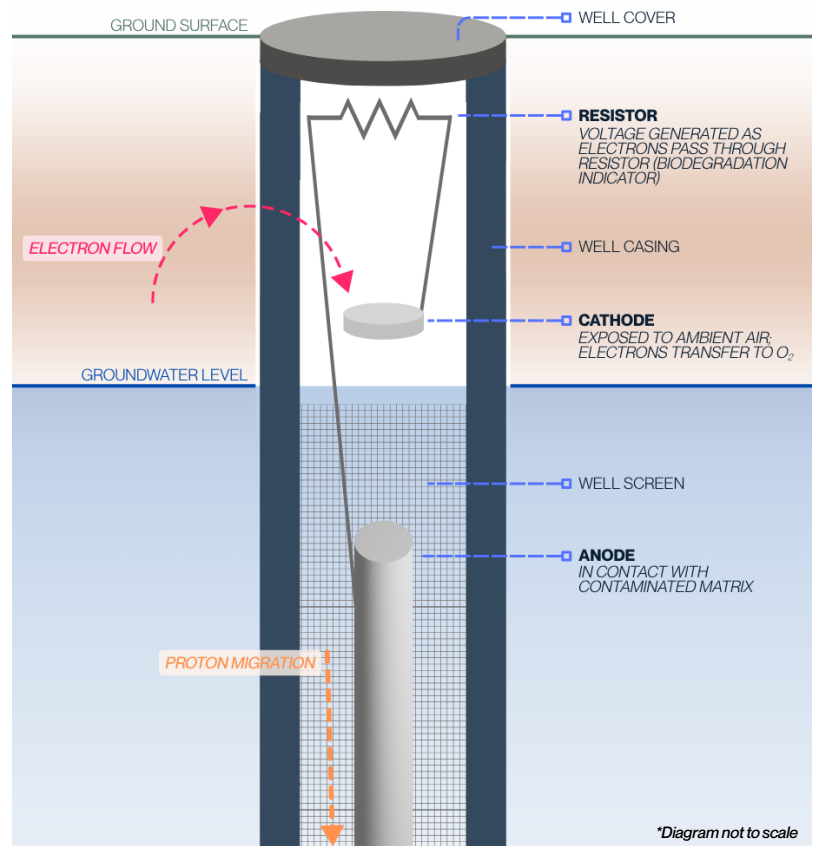
E-Redox® (O) is optimized to treat:

- BTEX
- PAHs
- MTBE
- GRO/DRO
- LNAPL

This technology can reduce contaminants in both soil and groundwater matrices and is effective in low-permeability soils and fractured bedrock, where electrical conductivity is typically high.

Treatment Timeline

Biodegradation rates are typically enhanced by a factor of 5x to 10x when using E-Redox® (O) compared to natural attenuation processes. At most gas station sites, the standard deployment duration for E-Redox® (O) ranges from 15 to 24 months. Sites containing non-aqueous phase liquids (NAPL) or unidentified contaminant mass trapped in low-permeability zones may require extended treatment durations. Regardless of site complexity, E-Redox® (O) consistently accelerates biodegradation, reducing the overall remediation timeframe.



E-Redox® (O) system stimulates microbial oxidation by facilitating electron transfer through a passive redox circuit. Voltage generation serves as a real-time biodegradation indicator.

Mechanism of Action

The E-Redox® (O) system contains anodic and cathodic sections suspended in screened wells. The system promotes oxidative biodegradation by accelerating electron transfer from contaminant-degrading microbes to ambient oxygen via the following sequence:

- Microbes in the contaminated matrix degrade hydrocarbons, releasing electrons that are transferred via electron shuttles toward the anode.
- The anode, placed in contact with the contaminated matrix, acts as an electron collector.
- These electrons migrate through the circuit and reduce oxygen at the cathode-water interface.
- The cathode, exposed to ambient air, serves as the terminal electron acceptor. Electrons react with oxygen, completing the circuit.
- Proton migration occurs concurrently through the matrix to the cathode, enhancing redox gradients.

The result is a reverse electron path that enables continuous oxidation reactions in saturated, anoxic environments without the use of external power. Voltage generated across the circuit serves as a real-time indicator of biological activity. This continuous, passive system accelerates natural biodegradation rates without requiring injection or surface infrastructure.

E-Redox® technology is developed and patented by AET. ISOTEC is an approved specialist remediation contractor authorized by AET to install E-Redox® systems.

System Design

- Each E-Redox® (O) device is installed within new or existing screened PVC wells with an internal diameter of 2 inches or larger. Devices may be deployed in existing remediation wells or monitoring wells, subject to regulatory approval.
- Installation typically involves suspending the device inside the well by tying it off to the well's J-plug. No above-ground infrastructure, specialized equipment or surface connections are necessary for device operation, making the system compatible with active, high-traffic sites.
- E-Redox® (O) devices operate continuously and unattended after installation.
- Real-time performance monitoring is conducted through the in-well devices, enabling direct measurement of in-situ biological activity levels throughout the treatment process.
- Periodic maintenance may include cleaning or replacing the cathode segment of the devices and recording voltage profiles to ensure proper operation.

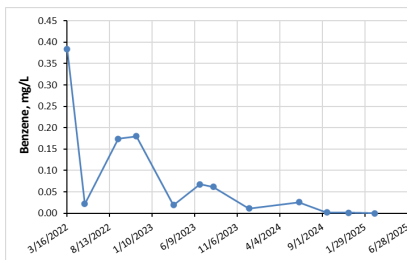
Capabilities & Advantages

- E-Redox® (O) has been successfully operated at dozens of active, high-traffic gas stations without requiring surface infrastructure.
- Devices can be installed using existing and/or new wells to create a virtual reactive zone or barrier for in-situ treatment of contaminant source zones and downgradient plumes.
- Each device has an effective radius of influence (ROI) of approximately 10 to 15 feet, depending on subsurface factors such as lithology and electrical conductivity of the surrounding matrix.
- The system performs best in conditions where matrix conductivity is elevated and electron acceptors (e.g., oxygen, nitrate, sulfate) are deficient—a common scenario in saturated matrices at many contaminated sites.
- The technology can be deployed as a stand-alone remedy or used in combination with other remedial approaches, such as chemical oxidation, bioaugmentation, biostimulation, aerobic bioremediation, or thermal treatment to achieve synergistic effects.

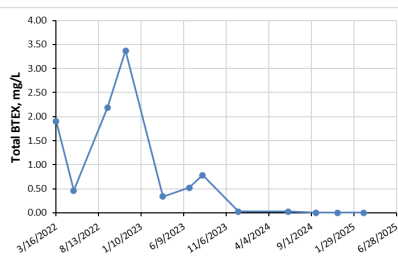
Design Considerations

- The following parameters are recommended to design and assess the performance of the E-Redox® (O) system: groundwater conductivity, hydrocarbon-degrading bacteria or total heterotrophic bacteria, essential nutrients (e.g., total nitrogen and phosphorus), and dissolved organic carbon (DOC).
- Performance may be limited by insufficient levels of indigenous bacteria and/or essential nutrients in the subsurface. Conducting nutrient and DOC analysis prior to installation is recommended to evaluate potential nutrient deficiencies or excessive oxidant demand from background organics.
- Supplemental nutrients and/or bacteria may need to be injected before or during installation.
- The effective radius of influence (ROI) of the devices may be reduced in certain conditions, including coarse-grained soils, high-porosity vadose zones, or in lithologies with low electrical conductivities (<100 µS/cm).
- Irregular or highly conductive subsurface features (e.g., metal piping or steel conduit) within 1-2 feet of the installation point may disrupt current flow and inhibit treatment effectiveness.

BTEX Biodegradation Enhancement with E-Redox® (O)



BTEX concentrations over time from an on-site monitoring well.



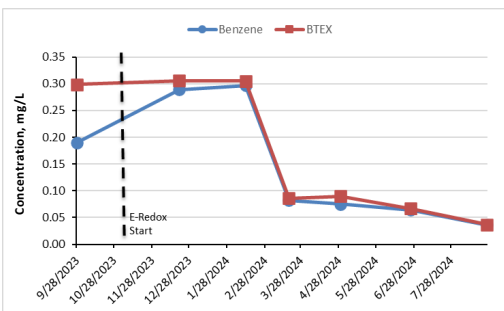
Location: Active Fuel Station in Colorado
Contaminants of Concern: BTEX Compounds
Contaminated Matrix: Groundwater
Impacted Lithology: Clay

Treatment & Results: E-Redox® (O) units were installed within the BTEX-contaminated plume. Voltage production ranging from 114 to 166 mV confirmed active electron transfer and microbial degradation. Despite continued migration of residual contamination, the system successfully reduced benzene and total BTEX concentrations to non-detect levels. The site is now in post-remediation monitoring.

Targeting Dual-Zone Contamination with E-Redox® (O)

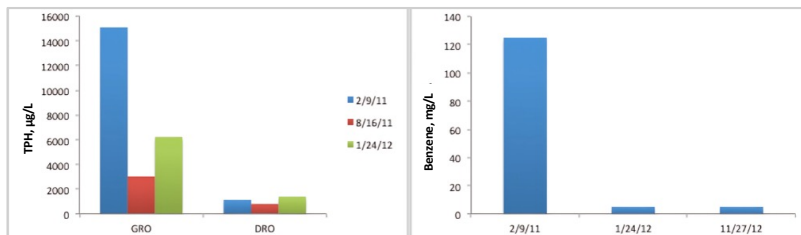
Location: Active Fuel Station in Colorado
Contaminants of Concern: BTEX Compounds
Contaminated Matrix: Groundwater
Impacted Lithology: Clay & Bedrock

Treatment & Results: E-Redox® (O) devices were installed to address persistent dissolved-phase BTEX impacts. Voltage readings between 20 and 186 mV were recorded, reflecting increased biodegradation rates. Substantial reductions in benzene and total BTEX concentrations were observed following deployment, confirming system effectiveness across both fine-grained and fractured lithologies.



BTEX concentrations from an on-site monitoring well.

Free-Product Dissolution with E-Redox® (O)



Concentration changes of GRO- and DRO-TPH (left) and benzene (right) in a treated well.

Location: Former Fuel Station in South Dakota
Contaminants of Concern: Petroleum Hydrocarbons, Benzene
Contaminated Matrix: Groundwater

Treatment & Results: E-Redox® (O) was implemented at a former UST site to remediate a groundwater plume impacted by petroleum hydrocarbons and benzene, with approximately 3 feet of free product observed in monitoring wells. Within one year of deployment, over 60% of GRO-TPH and more than 90% of benzene mass was degraded. Voltage generation confirmed active biodegradation despite the presence of NAPL.

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