BROOKHAVEN NATIONAL LABORATORY

TECHNOLOGY FACT SHEET

PECONIC RIVER REMEDIAL ALTERNATIVES

Electrochemical Remediation

Introduction

Electrochemical remediation technologies (ECRTs) are part of a broader class of technologies known as direct current technologies (DCTs). These technologies use an electric current in the treatment process to either mobilize or break down contaminants in soils or sediments. The technologies can be applied to both organic and inorganic contaminants. Two ECRTs are currently being evaluated for possible use at the Peconic River. The first is Electrochemical Geo-oxidation (ECGO), an on-site electrochemical process that can destroy organic contaminants, such as PCBs and pesticides. The second is Induced Complexation (IC), which enhances the mobilization of metals and anions, as well as radionuclides that behave as metals. When both metals and organic contaminants are present in soils or sediment (as in the Peconic River), the remedial strategy will be to first use IC to remove the metals, followed by ECGO to destroy the remaining organic contaminants.

Both ECGO and IC technologies have been used for on-site and off-site remediation of organic and inorganic contaminants in over two million metric tons of soil and sediment at more than 50 different projects in Europe. Two full-scale projects have been completed by the technology developer in Washington and New Jersey. The owners of these sites have not released the results to the public. Three full-scale pilot demonstrations have been funded for 2001. The first project is in the state of Washington, where 1,500 cubic yards of both organic and inorganic contaminated sediment will be treated using ECRT. The second project is located in Texas. This pilot test will treat 1,500 cubic yards of soil and groundwater contaminated with chlorinated compounds. The final pilot demonstration will treat PCB-contaminated soils at a site in New York. The results of these pilot tests will be posted on the Peconic River Web site.

These technologies are trademarked and patented by the Direct Current Joint Venture, which comprises Weiss Associates, Electro-Petroleum, Inc., and the technology developer – P2-Soil Remediation, Inc.

Technology Description

Both ECGO and IC operate by sending an electric current between electrodes (cathodes and anodes) installed in the soils or sediments to be remediated (Figure 1). Locally provided electric power is passed through a proprietary direct current (DC)/alternating current (AC) converter that produces a low-voltage, low-amperage DC/AC current. When this modified electric current flows through the soil or sediment between the electrodes, the soil particles become polarized and develop electrical properties similar to those of

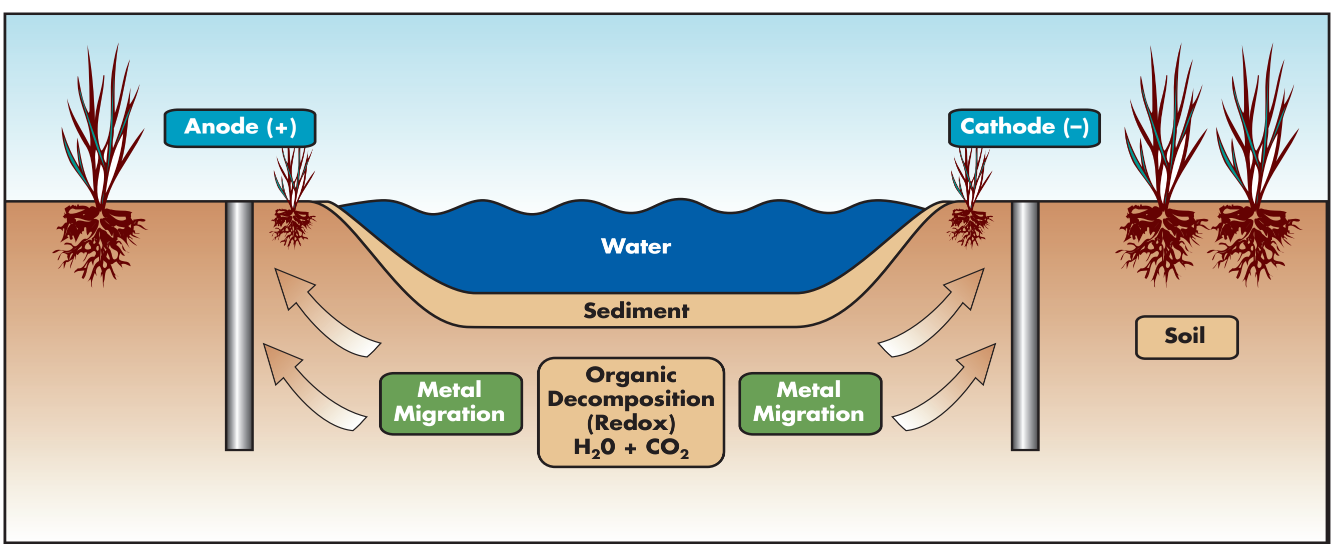

Figure 1 Schematic showing how ECGO and IC technologies work.

a capacitor. When the polarized soil particles discharge electricity, the energy given off induces chemical reactions (redox reactions), which decompose organic contaminants. In theory, in the case of organic compounds, such as PCBs and pesticides, the chemical reactions break up the contaminants into their basic components of carbon dioxide and water.

Metals remediation is achieved with IC technology, which relies on ECGO to convert metals to mobile ions that migrate to the electrodes, where they accumulate and are removed. Inorganic contaminants (in the case of the Peconic River, sediments containing mercury, copper, and silver) undergo chemical reactions that make the metals more mobile.

Most radionuclides that behave as metals also are remediated by this process.

The radionuclide cesium-137 will migrate to the electrodes. However, this metal will not plate on to the electrodes. Any accumulation of cesium at an electrode would have to be removed by other remediation techniques such as phytoextraction or excavation.

The electrodes would be placed in the ground using the most cost-effective method available while minimizing impact to the wetlands. The depth of contamination of the sediments in the Peconic River is generally limited to the top 6 inches. Because the contamination is shallow, the electrodes would not be placed any deeper than the depth of the contamination. Options for installing the electrodes include, but are not limited to: (1) use of flat steel sheets that can be hammered into the sediment; (2) use of a trencher to cut a trench a few inches wide; or, (3) use of a ditch witch or other similar equipment. Electrode spacing can range from 5 to 15 meters. A typical field installation consists of:

- At least one anode/cathode electrode pair;
- Electrodes placed either vertically or horizontally, at distances of about 10 meters; and
- A source of direct electric current connected to the electrodes.

Advantages

- ECGO can destroy organics on-site in fine-grained saturated and unsaturated sediments.
- The ecosystem is not harmed. There are no adverse effects on humans, fish, reptiles, birds, or mammals unless they are in direct contact with the electrodes; even then, only a mild shock results. No adverse effects on worms, insects, or soil microbes are known, so long as they are not in direct contact with the electrodes.
- IC enhances the mobilization of metals and precipitates or plates these metals onto the electrodes.
- Either technology can typically complete the remediation process in 6-12 months or less for each field installation.
- ECGO/IC minimizes physical disturbance to the site.
- No surface treatment system is necessary for soil remediation. Since this technology has enhanced metals mobilization capability, anions and radionuclides can also be remediated.
- Resuspension of contaminants does not occur during installation because the electrodes are installed slightly outside the area of contamination.

Disadvantages

As with any on-site remediation technology, the media being treated must be compatible with the technology. There are some technology limitations:

- The process is dependent on many variables, including the soil characteristics, organic matter, contaminants, moisture content, and competing ions in the soil. In practice, the process is used to reduce contamination to levels that meet regulatory limits and not necessarily to zero concentrations.
- To date, the full pathway of destruction of organic contaminants has not been followed. In most cases, only the concentration of the pollutant of interest has been measured before and after treatment. The potential for harmful, contaminant-specific breakdown products must be considered.
- In many demonstrations, there was an apparent increase in the contaminant concentration before the concentration decreased. This is believed to occur because of desorption of tightly bound contaminants from the media.
- The process is not effective in frozen ground. Remediation must be postponed for part of the winter in northern climates.
- Cesium will not bind or plate to the electrodes. Any accumulation will have to be removed by other methods.
- The power converter and electrode array must be secured in a fenced area. This may damage localized areas in the wetlands or adjacent areas. These impacted areas will have to be restored later.
- Power lines to the power converter and electrode arrays will be placed underground. This will damage localized areas of the wetlands and adjacent areas. These areas may be subject to restoration.

Relative Cost

The cost to implement any particular technology depends on the site conditions and size. Due to the fixed costs associated with the technology, the cost per cubic yard is highly dependent on the volume and surface area to be treated. For a combination of IC and ECGO, a small site with 3,000 cubic yards of sediment to be treated will probably cost about $130 per cubic yard. A large site of 100,000 cubic yards (with no unusual requirements) will cost about $35 per cubic yard.

With ECGO and IC, the depth of treatment is a very important factor. For the same surface area, the cost per cubic yard treated drops significantly as the depth of treatment increases. As an example, the cost to install an electrode 20 feet deep is not much different than that of installing one 5 feet deep. However, for the same surface area, the 20-foot-deep electrode treats four times the volume of soil.

These costs are for treatment at a well-characterized site. The costs include mobilization, equipment, installation, monitoring, and equipment removal costs. The cost estimate includes only the initial site sampling and final confirmation sampling for each treatment electrode array. Site-specific costs, such as permitting, power line installation, and cathodic protection, are not included.

Maturity of the Technology

The full-scale process has been used at two U.S. upland sites (Washington state and New Jersey) by the technology developer. The reports describing these remediation projects have not yet been released to the public. Weiss Associates and/or Electro-Petroleum, Inc., are planning to conduct at least four demonstrations (two in sediment) and possibly one full-scale upland remediation in 2001. The results of these projects will be posted on the TechCon web site when they are available.

Performance Data

Information on the performance of the ECRT technology on the two full-scale projects recently completed in the United States has not been released to the public. Performance data on projects completed in Europe on sites with similar contaminants as found in the Peconic River sediments are provided in the Peconic River feasibility study addendum (June 2001).

Potential Technology Applicability – Peconic River

This technology has been demonstrated to be effective in removing both inorganic and organic contaminants in environments similar to that of the Peconic River. Figure 2 depicts a potential deployment of this technology in the Peconic River. The technology could be deployed to treat large areas of the river or it could be used to treat isolated hot-spot areas. Both ECGO and IC technologies are in-situ processes, which minimize impact to the environment during deployment and operation.

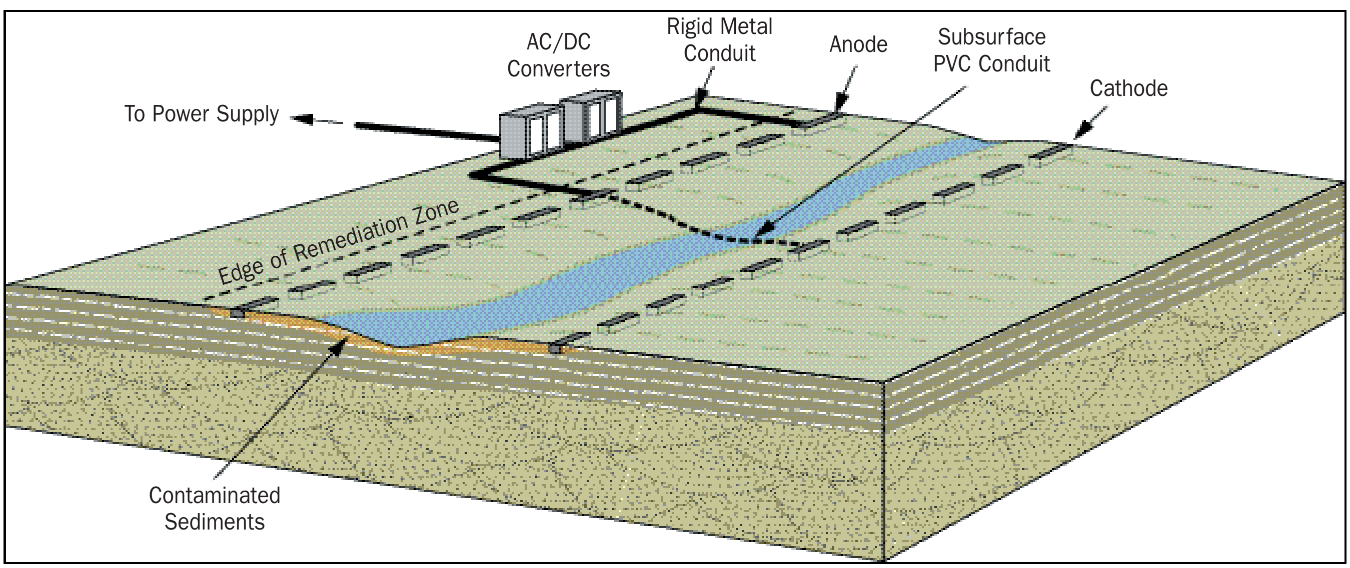

Figure 2. Potential deployment of electrochemical technology in the Peconic River.

Infrastructure Requirements

The process requires that a series of electrodes be inserted into the soil at several locations, chosen on the basis of a site characterization study. The system uses utility power, which must be accessible. Power supplies must be located above the flood levels of the Peconic River. Road access to within several hundred feet of the area to be treated should be provided. A small area for staging is required, and a standard decontamination area must be set up at the time of installation and removal of equipment. Temporary fencing is required to protect both people and equipment (the transformers and field array).

Long-Term Remedy

Careful initial planning for the layout of the arrays and support equipment will minimize any impact to the wetlands and adjacent areas. After a short regrowth period of one or two seasons, the treated or impacted area will return to its pre-remediated state. Short-term monitoring of the affected areas may be required to ensure that the expectations for full recovery are met.

Impact to Wetlands/Adjacent Areas

Impact to the wetlands and adjacent areas should be limited to those areas that contain the electrode arrays and those areas affected by placement of cables and fences. Once these are removed, it is anticipated that these areas will rapidly regenerate to their native state. Re-growth of these areas could also be augmented with selective seeding of native plant species if necessary.

Process Residuals Management

Electrodes and soil removed in the vicinity of electrodes may need to be handled as hazardous waste, depending on final metal concentrations as determined by chemical analysis.

Need for Site-Specific Testing

A pilot-scale test should always be completed prior to conducting a full-scale remediation. A test performed in the field on a two-cubic-yard section of soil will cost about $160,000 to $180,000. This will require placing approximately two cubic yards of similarly contaminated soil in a trench elsewhere on the site where there is no contamination. A larger pilot-scale test that does not require excavating (disturbing) any contaminated soil will cost $300,000 to $500,000. A pilot test will include the treatment of up to 1,500 cubic yards of material.

Need for Long-Term Monitoring

Confirmation testing of the treated areas will be required to assure that the treatment has reached the goals established for the Peconic River. Once an area has been certified as meeting the treatment goals, there is no need for further monitoring.

Synergy with Other Technologies

It has been suggested that electrochemical techniques be used in conjunction with other technologies, such as phytoremediation. There are no known technical barriers to combining the two technologies. For contaminants such as cesium that migrate toward but do not adhere to the electrodes, there are several remedial alternatives that can be considered. Technologies such as phytoextraction or phytostabilization can be employed to remove or stabilize the cesium. In addition, surgical excavation can be considered to remove cesium that has accumulated around the electrode.

Resources

In-Situ Electrokinetic Remediation for Metal Contaminated Soils
http://aec-www.apgea.army.mil:8080/prod/usaec/et/restor/insitu.htm

Resource Guide for Electrokinetics Laboratory and Field Processes Applicable to Radioactive and Hazardous Mixed Wastes in Soil and Groundwater from 1992 to 1997.
http://www.epa.gov/radiation/mixed-waste/docs/electrok.pdf

Weiss Associates Web Site
http://www.weiss.com/

Electro-Petroleum, Inc., Web Site
http://www.electropetroleum.com

Contact

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