United States
Environmental Protection
Agency

EPA/540/F-95/504
March 1995

EPA

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

Emerging Technology Bulletin

Electrokinetic Soil Processing

Electrokinetics, Inc.

Process Description: Electrokinetic Soil Processing (or Electrokinetic Remediation) uses two series of electrodes (anodes and cathodes) positioned inside compartments that allow egress and ingress of pore fluids to the porous media. The compartments are filled with water or other process fluids and inserted into contaminated soil. A direct current (DC) is applied across the electrodes. Under such conditions, moist soil acts as an aqueous electrolyte and ions and solution move toward the electrodes. The coupling between electrical, chemical, and hydraulic gradients is responsible for the movement of both contaminants and the processing solution through the soil.

Figure 1 presents a schematic diagram of the process. Chemical species present in the process fluid/and or desorbed from the soil surface will be transported toward respective electrodes depending on their charge. Ion migration, advection and diffusion contribute to the movement of the species through the soil mass. Cations will collect at the cathode and anions at the anode. Heavy metals and other cationic species will be removed with the processing fluid, or they will be deposited at the cathode. Processing involves the regeneration of the solution through removal and recovery of the contaminants and return of the regenerated solution to the electrode compartments.

Waste Applicability: This technology extracts heavy metals, radionuclides and other inorganic species and polar organic species below their solubility limits. Bench scale tests have shown removal of arsenic, benzene, cadmium, chromium, copper, ethylbenzene, lead, nickel, phenol, trichloroethane, toluene, xylene, and zinc from soils. Limited pilot-scale field tests displayed zinc and arsenic removal from clays and sandy clay deposits. Treatment efficiency depended on the specific chemicals, their absolute and relative concentrations with respect to other available species, the buffering capacity of the soil, the duration of treatment, the current level used and the conditioning scheme employed. In bench-scale tests, the technique proved 85-95%

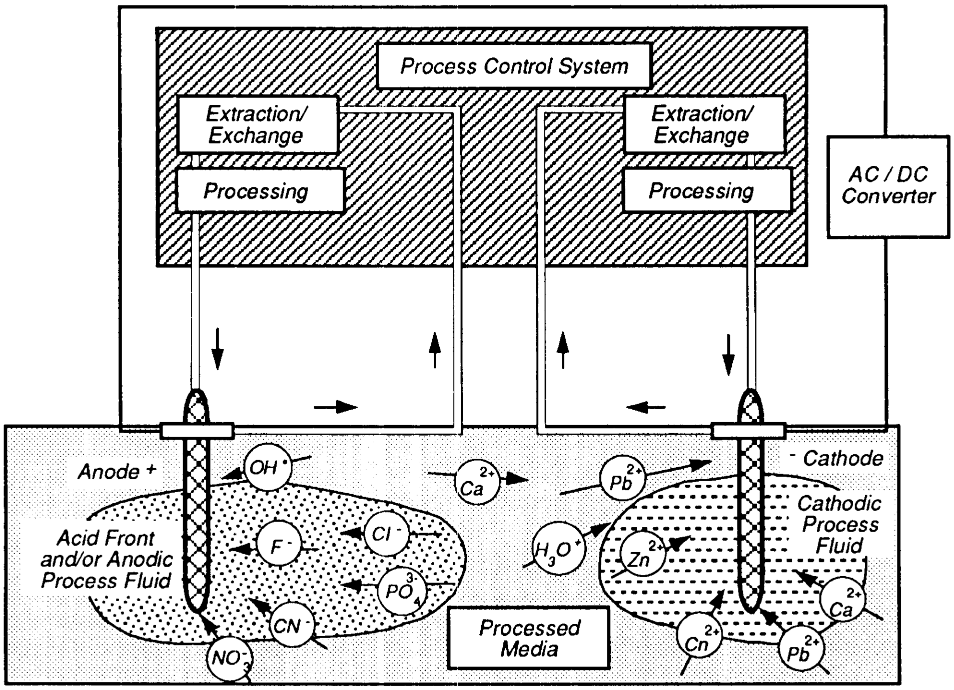

Figure 1. A schematic diagram of electrokinetic soil processing and one configuration used in remediation of soils.

Printed on Recycled Paper

effective when removing phenol at concentrations of 500 ppm. Removal efficiency for lead, cadmium, chromium, and uranium at levels up to 4,000 mg/kg ranged between 75% and 95%. The efficiencies of radium and thorium removal from soils were very low due to formation of insoluble precipitates in soil.

Test Results: Three pilot-scale studies using 1-ton specimens were conducted by Electrokinetics Inc. under the SITE program; two pilot-scale tests using kaolinite spiked with lead at initial concentrations of 850 mg/kg, 1,500 mg/kg and another using fine sand and kaolinite mixture spiked with lead at 5,322 mg/kg. The kaolinite had lead adsorption capacity of about 1,100 mg/kg. Lead nitrate salt is used as the source of lead. Tap water is used both as the catholyte and the anolyte. The electrode spacing was 70 cm and a one-dimensional electrical field was applied. Energy expenditure in the pilot-scale tests ranged from 300-700 kWh/m^3. Processing times in pilot-scale tests ranged from 1,300 h-2,950 h. Figure 2 shows the lead concentration profile after 123 days of processing at a current density of 133 $\mu A/cm^2$. More than 90% of the lead in the soil is transported across to the cathode compartment and preciptitated wiithin the last 7 cm of the specimen. Lead prematurely precipitates close to the cathode compartment at its hydroxide solubility value if the chemistry of the electrolyte at the electrodes is not altered or controlled (unenhanced electrokinetic remediation). One objective of these pilot-scale tests was to formalize and validate the principles of multi-species transport under electric fields and develop design/analysis packages. Therefore, pilot-scale tests did not employ any enhancement technique. Enhancement techniques which employ cathode depolarization schemes such as acetic acid depolarization technique prevent the precipitation close to the cathode compartment. A special electrode system (CADEX™) designed and manufactured by Electrokinetics Inc. efficiently depolarizes the cathode reaction and promotes electrodeposition of species on the cathode.

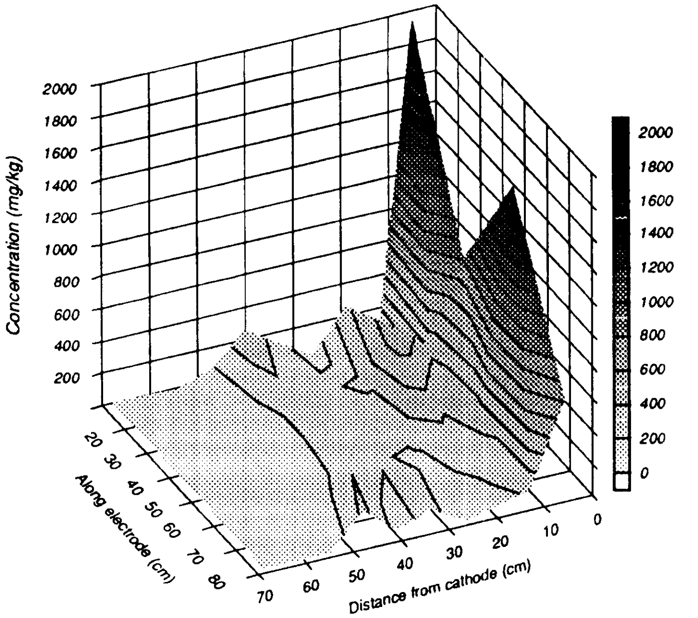

Figure 2. Lead concentration profile after 123 days of processing kaolinite/fine sand mixture spiked at 5,322 mg/kg. [Precipitation close to the cathode compartment is avoided and transport of species in the cathode compartment are promoted through cathode depolarization techniques and the CADEX™ electrode system].

For Further Information:

EPA Project Manager
Randy Parker
Risk Reduction Engineering Laboratory-USEPA
26 West Martin Luther King Drive
Cincinnati, OH 4528
(513) 569-7271

Technology Developer Contact:

Yalcin Acar
Electrokinetics, Inc.
Louisiana Business and Technology Center
Louisiana State University
South Stadium Drive
Baton Rouge, LA. 70803-6100
(504) 388-3992

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

Official Business
Penalty for Private Use
$300

EPA/540/F-95/504