Electrokinetic Remediation of Metals

Technology Need

DOE is responsible for the cleanup of millions of tons of contaminated soil. Much of this contamination is present in unsaturated soils above aquifers. These contaminants may slowly leach into groundwater over periods of time. Currently, soil excavation is the baseline method available for removing inorganic contamination from unsaturated soils. Electrokinetic (EK) remediation has been applied successfully to saturated soils. However, if applied to unsaturated soils, these existing processes would likely saturate the soil near the electrodes which could compound the problem by washing the contamination to greater depths. Adaptation of EK remediation to unsaturated soils could avoid excavation of large volumes of heavy metal contaminated soils.

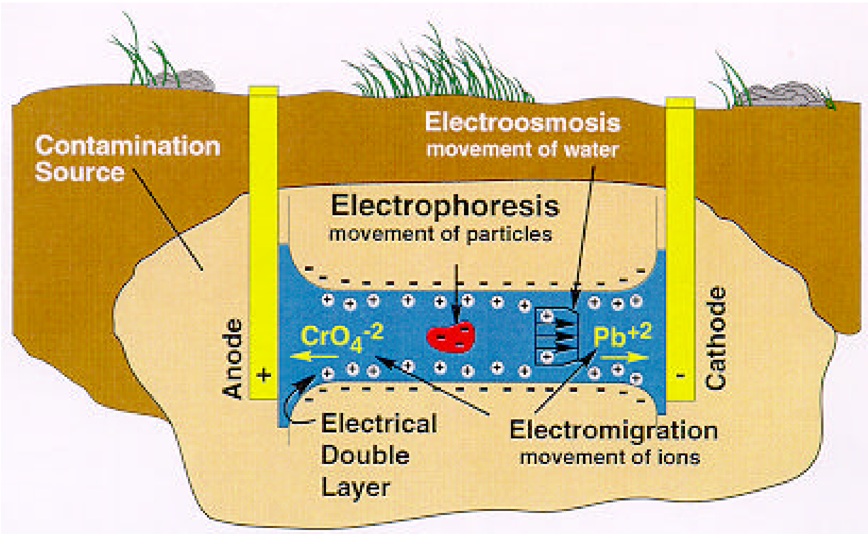
Objective

The electrokinetic program at Sandia National Laboratories (SNL) has extended EK remediation technology to unsaturated soils. This technology provides a method for in situ removal of anionic (negatively charged) heavy metal contaminants directly from unsaturated soils without raising soil moisture content significantly. This includes chromium in soils which is one of the contaminants of interest in the SNL Chemical Waste Landfill (CWL) Unlined Chromic Acid Pit (UCAP).

Project Description

Electrokinetics is based on the principle that when direct current (DC) is passed through contaminated soil, certain (negatively charged) types of contaminants will migrate through the soil pore water to a place where they can be removed. At the CWL, electrokinetics has been used to remove negatively charged chromium ions from the chromate plume in the vadose zone below the UCAP.

To use the patented system, electrode assemblies are installed in the ground in a square array and connected to a DC voltage power supply. Each electrode assembly contains water, a pump, an electrode, and various controllers and sensors. The outer casing of the electrodes is made of porous ceramic through



which the electrical current and contaminants pass. A vacuum is applied to the casings which keeps the water inside the assembly from flowing out and saturating adjacent soils. These electrode assemblies are placed in the desired treatment zone with the ceramic casing at the treatment depth. When the DC power supply is activated, a current passes through the soil. As the electric current is applied to the soil between the electrodes, water flows by electroosmosis in the soil pores usually toward the cathode. This movement of the water can deplete soil moisture adjacent to the anode as water collects near the cathode. However, the SNL electrode design allows water to enter the soil at the anode replenishing the pore water adjacent to the electrode casing but never saturating the soil. The ions are then pumped to the surface by circulating water within the ceramic casing. This system overcomes the difficulty of soil drying near the anode, allowing operation of the electrokinetic process in unsaturated soil for much longer periods of time than if simple electrodes are used.

Buried metal objects are a problem for this system. Buried metal objects divert the current from the soil needing remediation. Another limitation can arise if large percentages of non-targeted contaminants are present in the soil to be treated. For example, if chromate (the targeted contaminate) only represents 0.0001% of the total number of ions in the soil and chloride ions (i.e., sea water was present at the site) are present in a higher percentage, than the current would be carried by the chloride (from the sodium chloride in the sea water), preferentially removing the chloride ions from the soil and not the chromate ions.

Recently a field test was completed in the UCAP, inside the CWL, to field validate this technology. The technology has been extended to treat cationic contaminants which adsorb strongly to soil or exist as solid precipitates. Biodegradable organic complexants are electrokinetically injected into the soil at the cathode and form anionic complexes with certain contaminants which are attracted to and removed from the anodes. Gas phase manipulation is used to inhibit biodegradation during the EK remediation and then stimulate biodegradation of the complexing agent afterwards. This process has application for uranium.

Advantages

Electrokinetics is an in situ process which can be highly targetable to the specific area to be cleaned since treatment only occurs between the electrodes. It also allows decontamination without removing contaminated soil. Its energy needs are relatively small compared to excavation.

Costs

Because the system is currently being moved into the field, cost information will not be available until after field tests and demonstrations are completed. However, the research prototype currently costs $15,000 per electrode assembly. In some cases, passive, solid state electrode capture systems can be used which will greatly reduce costs. Commercial availability of the technology is planned for 1998.

Contacts

Eric R. Lindgren, Principal Investigator
Sandia National Laboratories, P.O. Box 5800, MS-0719, Albuquerque, NM 87185-0719
(505) 844-3820 phone, (505) 844-0543 fax, erlindg@sandia.gov

George C. Allen, Department Manager
Sandia National Laboratories, P.O. Box 5800, MS-0719, Albuquerque, NM 87185-0719
(505) 844-9578 phone, (505) 844-0543 fax, gcallen@sandia.gov

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