COST AND PERFORMANCE REPORT

Electrokinetics at an Active Power Substation
(Confidential Location)

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U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

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Background Information

Certain power substation sites across the southern United States have been treated with an arsenic trioxide herbicide over a 30-year period, which has resulted in arsenic contamination in the soil and groundwater at these sites. Electrokinetics, Inc. was contracted by a large southern U.S. power company to explore the feasibility and cost-effectiveness of using electrokinetic extraction and electrokinetic stabilization for selected arsenic contaminated sites. The soil matrices at these sites included mainly silty sands without heavy clay. (LaChiusa, 1999c)

Electrokinetics, Inc. conducted bench scale studies on several representative site soils. Then in the summer of 1998 a pilot scale study was performed at two treatment cells around an active power substation. This pilot scale project represented Electrokinetics, Inc.'s first commercial field application of electrokinetic remediation in the United States.

Technology Description and System Design

To determine the electrical and chemical parameters necessary for optimal field-scale treatment, bench scale studies were conducted using soil samples from several substation sites located in the southeastern U.S. Studies of both electrokinetic extraction and electrokinetic stabilization were conducted. The studies were conducted in three stages (LaChiusa, 1999c):

1. Physical and chemical soil characterization — Extensive analyses of several site soils were performed to gain a more complete understanding of both the physical and geochemical aspects of the soils.

2. Transport tests — Transport tests were conducted using different substation soils in order to gain an understanding of the electrochemical behavior of arsenic under various conditions. The results of the transport tests were used to determine the type of additives that would convert arsenic to a species that was most easily electrically migrated.

3. Bench-scale tests — Incorporating the results from the transport tests, 30-day bench scale tests were conducted using several representative site soils (silty sands) to determine which site had the optimal conditions for electrokinetic treatment.

    a. One test explored an electrokinetic extraction configuration in a soil with low arsenic concentrations. When a depolarizing agent was added at the cathode, more than 99% of the arsenic was extracted at the anode.

b. Another test explored an electrokinetic stabilization configuration. Using electrokinetics, an arsenic-binding compound was injected into the soil which reacted with the arsenic to form an insoluble precipitate. Soil tested after 30 days of processing passed both the TCLP and SPLP leachability tests.

After extensive analysis of both the results of bench-scale studies on representative soils and site conditions at several substations, one active power substation site (confidential location) was ultimately selected for pilot scale electrokinetic treatment. Both electrokinetic extraction and electrokinetic stabilization configurations were explored at this site. The purpose of conducting the pilot scale demonstration was to assess the performance of both engineered systems – extraction and stabilization – and to determine which configuration, or combination thereof, would yield the best results in the field for extracting arsenic and for preventing the species from migrating off site.

The treatment areas consisted of two adjacent treatment cells – one for arsenic extraction and one for arsenic stabilization – each measuring 30 ft long by 20 ft wide by 31 ft deep (equivalent to a volume of 18,600 cubic feet). The key characteristics of the soil matrix, including arsenic concentrations, at these treatment areas are listed in Table 1.

Table 1. Characteristics of the Soil Matrix at the Active Power Substation

Parameter	Value
Soil type	Silty sand
pH	5
Hydraulic conductivity	6×10^{-5} cm/sec
Contaminant concentrations in soil	1 - 1400 mg/kg arsenic

Source: LaChiusa, 1999c and 1999d

In each treatment cell, three anodes spaced 10 feet apart and one cathode located 30 feet from the middle anode were installed. In the first treatment cell, inert anodes were inserted into four-inch PVC wells to a depth of 31 feet. A cathode made of carbon steel was welded and inserted to a depth of 31 feet. In order to enhance the mobilization and extraction of arsenic, a depolarizing agent was pumped in at the cathode to create a neutral to slightly basic catholyte. In the second treatment cell, proprietary reactive anodes, which were designed and fabricated by Electrokinetics, Inc., facilitated the electrokinetic injection of an arsenic-binding compound into the soil mass. A cathode made of carbon steel was welded and inserted to a depth of 31 feet.

A control center was erected at the site to house the data acquisition system and the rectifiers, which converted AC to DC. A voltage of 440 DC was applied to both treatment cells. The first treatment cell (electrokinetic extraction) required 80 kW-hr per cubic yard and the second treatment cell (electrokinetic stabilization) consumed 74 kW-hr per cubic yard. The data acquisition system periodically stored vital processing parameters. These data were downloaded on a daily basis from Electrokinetics, Inc.'s home office in Baton Rouge, Louisiana, allowing the project management team to monitor the site on a 24-hour basis via computer.

On-site mobilization of the electrokinetic extraction and stabilization systems took approximately 4 days. This pilot-scale project, which required minimal on-site maintenance, ran for approximately 6 months and was interrupted only twice for sampling purposes. Key operating parameters for each treatment cell are presented in Table 2.

Table 2. Design and Operating Parameters for the Treatment Cells at the Active Power Substation

Parameter	Value
Treatment area and depth (of each treatment cell)	30 ft long x 20 ft wide x 31 ft deep
Distance between anodes and cathodes (in each treatment cell)	30 ft
Treatment period (for each treatment cell)	6 months
Treatment cell #1 (extraction):	
pH	5
Moisture content	25%
Enhancement added	Proprietary
Electricity supplied	80 kW-hr/yd^3
Treatment cell #2 (stabilization):	
pH	5
Moisture content	25%
Enhancement added	Proprietary
Electricity supplied	74 kW-hr/yd^3

Source: LaChiusa, 1999c and 1999d

Technology Performance

Electrokinetics, Inc., performed the demonstration for a commercial client but has not yet submitted the final report to the client. The performance results are currently confidential and are not available for release to the public. No performance assessment was provided for the electrokinetic extraction system. The performance results will be available after Electrokinetics, Inc., submits the final report of the demonstration to their client, which is expected to be in the first quarter of 2000 (LaChiusa, 1999e).

Technology Cost

Electrokinetics, Inc., has calculated the costs of the bench scale tests and pilot scale demonstration and has also estimated costs for electrokinetic remediation of the entire site [first case study]. However, as stated above, cost summaries and projections are currently confidential. Cost data will be available after Electrokinetics, Inc., submits the final report of the demonstration to their client, expected to be in the first quarter of 2000.

Summary of Observations and Lessons Learned

Summaries of observations and recommendations are currently confidential and will be available after Electrokinetics, Inc., submits the final report of the demonstration to their client, expected to be in the first quarter of 2000.

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