Lead Removal from the Contaminated Soil by Electro-Kinetic Remediation

Ass. Prof. Dr. Ghazi Maleh Mutter, Ass. Prof. Dr. Nagam Obaid kariem and Laith Hamdan Howel

Iraq – Baghdad, Bab-AL-Muthem, Al-Mustansiriyah University, College of Engineering

ABSTRACT

In this research, an electro-kinetic technique applied for the purpose of removing lead (heavy metal) from two types of contaminated soils (silt clay loam, and sandy), and this technology is applicable in low permeable soils, where pressure driven techniques are prone to flow channeling through cracks or soil rupture. Many sets of experiments were conducted with different enhanced conditions, including different electrode purging solutions, voltage gradient, type of the soil, addition of (ZVI) to the soil. The results showed that the best removal efficiency was 92.36 %, when we used the EDTA 0.2 M as an enhanced condition purging solution for sandy soil comparison with other tests. The results showed that the removal efficiency increase with decrease in PH of the purging solutions, and we noticed that when we had three tests using purging solution at PH 4, 5.5 and 7 respectively, the best removal efficiency was 86.86% at PH=4 comparison with other two tests at PH 5 and 7, where the removal efficiencies were 82.32% and 74.2% respectively. The experiments proved that the Pb removal from the soil increased when voltage gradient increased, we saw that at 1.5 V/cm where the removal efficiency was 86.86% comparison with the test at 1 V/cm, where the removal efficiency was 82.1%. The (ZVI) is good enhanced condition for removal lead, we noticed that when we added it to the two types of soil, the removal efficiency was 90.74% for sandy soil and 71.1% for silt clay loam soil, comparison with the tests have same conditions but without use (ZVI). The removal efficiency for silt clay loam 67.6% was less clearly than of sandy soil 86.86% with the same condition. In this search also, the results proved that the inverse relationship between removal efficiency and increase concentration of lead in soil, and this is what we noticed when we had three tests, the efficiency of removal 88.44% was the best when the initial concentration of lead in the soil was 300 mg/kg compared to the tests with 1000 mg/kg and 1500 mg/kg, where the removal efficiencies were 86.86% and 81.6% respectively.

INTRODUCTION

Electro kinetic remediation technique was developed in order to overcome the limitations of established in situ remediation techniques and to apply to the fine-grained soil. Previous research proved removal efficiency of contaminants from low permeable soil by electro osmosis and ion migration. Electro kinetics is a simple process. Two electrodes are placed within the soil and a direct electric current is passed between them making one the anode and the other the cathode. This electrical current passes through the soil and creates a pathway on which ions can travel (Acar and Alshawabkeh, 1993; Alshawabkeh et al., 1999; Lindgren, 1994).

The application of electric current has several effects: (1) It produces an acid in the anode compartment that is transported across the soil and desorbs contaminants from the surface of soil particles; (2) It initiates Electro-migration of species available in the pore fluid and those introduced at the electrodes; and (3) It establishes an electric potential difference which may lead to Electro osmosis generated flushing of different species. Application of electro-kinetic process for the removal of contaminant may vary mainly due to the variation in soil type and type of contaminant in the soil (Virkutyte et al., 2002; Reddy and Cameselle, 2009).

The main problem of electro kinetic processing application to the ground which contaminated by heavy metal is that transporting heavy metal ion to cathode encounters the OH- movement toward the anode and then most hydroxide precipitates at the region above the solubility, thus do not transport to the cathode reservoir (Shapiro & Probstein, 1993).

Various enhancement techniques are used to overcome the problem of electro-kinetic processing, such as decreasing pH using the acidic solution and injection of the complex agent. The most frequently used
enhancement technique is to add the EDTA as purging solution and (ZVI) powder to the soil. These enhancement techniques considered very good for removing contamination but not completely from the soil sample (Eykolt and Daniel, 1994; Taha et al., 1994; Yeung et al., 1996).( Mahsa Madani Hosseini, Mohsen Farahbakhsh, 2011).

Different studies using to modeling the electro kinetic remediation process for removing contaminated from soil (Al-Hamdan and Reddy (2008); Rubio-Nieblas et.al. (2014).

Electro-kinetic Reactions:

Electro-kinetic remediation involves applying low-level D.C. current or a low voltage gradient across electrodes, which are inserted in the contaminated soil. The dominant and most important electron transfer reactions that occur at electrodes during the electro-kinetic process is the electrolysis of water equation (1) and (2) show the anode and cathode reactions) (Probstein et al., 1993; Acar and Alshawabkeh 1993).

Anode Reaction: \( 2\text{H}_2\text{O} - 4e \rightarrow \text{O}_2 \uparrow + 4\text{H}^+ \)  \hspace{1cm} (1)

Cathode Reaction: \( 2\text{H}_2\text{O} + 2e \rightarrow \text{H}_2 \uparrow + 2\text{OH}^- \)  \hspace{1cm} (2)

Ion exchange reactions between hydrogen ion and adsorbed metallic ion in clay particle surface can be defined as following reactions:

\( 2\text{H}^+ + \text{Pb}^{2+} \rightarrow 2\text{H}^+ \text{(clay)}^{-2} + \text{Pb}^{2+} \)  \hspace{1cm} (3)

And also, hydroxide ion produced in cathode neutralized by hydrogen ion migration which is produced in anode. However, cathode region shows high PH by surplus hydroxide ion having low mobility, and produce a precipitate by reaction with lead ion.

**Materials and Method**

**Experimental Work:**

To simulate the soil contamination by lead, a solution of \( \text{Pb}\left(\text{NO}_3\right)_2 \cdot 6\text{H}_2\text{O} \) were prepared and added to the specimen to obtain a (manufactured in British Drug House, BDH England) representative concentration. As a sample of calculation for preparing 1000 mg/kg of Lead to soil weight and initial moisture content equal to 30% .we used 15.9 g weight of \( \text{Pb(NO}_3\)\(2 \cdot 6\text{H}_2\text{O} \) ( molecular weight of 331.21 g/mol) and dissolved in 1000 ml of distilled water to obtained a 10000 PPM of lead solution. A 30 ml of this solution was taken and completed to 300 ml with distilled water and added to 1 kg of dry soil. In this research three artificial Pb contaminated soil samples 500 mg/kg, 1000 mg/kg and 1500 mg/kg were prepared to be studied.

In this study, we used two types of soil as a porous medium in the experiments. The first type (Soil I, brought from a local plants nursery) was polluted artificially by the contaminant (lead). Other type (Soil II) was naturally polluted with lead, This type of soil was taken from the State Battery Manufacturing Company- Ministry of Industry And Mineral Of Iraq. The composition and properties of the two soil types are described in table (1).

Zero Valant Iron (ZVI) powders continue to be one of the leading remedial solutions for the myriad of soil and water contaminants encountered today.

Sawdust was used in the electro-kinetic cell to prevent reverse electro-osmotic flow occurrence, a low cost adsorbent with high efficiency is used from the naturally available sawdust which is biodegradable.

Ethylene Diamine Tetra Acetic is a complex agent. EDTA 0.2 M was used as the purging solutions in the present study and prepared by dissolving 74.4 g of \( \text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8\cdot 2\text{H}_2\text{O} \) in 1 L of distilled water. EDTA is a complexing agent that is readily available and environmentally benign and does not interact with soils. It is an excellent solubility agent for many metals including lead, zinc and nickel.

**Table 1:** Composition and properties of the soils.

<table>
<thead>
<tr>
<th>Property</th>
<th>Soil I</th>
<th>Soil II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size distribution (ASTM D 422)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand (%)</td>
<td>89</td>
<td>12</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>6</td>
<td>58</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Atterberg limits (ASTM D 2487)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid limit (%)</td>
<td>26</td>
<td>29.5</td>
</tr>
<tr>
<td>Plastic limit (%)</td>
<td>Not. Detected</td>
<td>19.4</td>
</tr>
<tr>
<td>Plasticity index (%)</td>
<td>Not. Detected</td>
<td>10.1</td>
</tr>
<tr>
<td>Coefficient of permeability (cm s (^{-1}))</td>
<td>2.7×10(^{-3})</td>
<td>....</td>
</tr>
<tr>
<td>Cation exchange capacity (meq/100g)</td>
<td>14.06</td>
<td>....</td>
</tr>
<tr>
<td>Initial pH</td>
<td>6.9</td>
<td>7.2</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>2.544</td>
<td>2.299</td>
</tr>
<tr>
<td>Electrical conductivity EC (µS/cm)</td>
<td>460</td>
<td>2640</td>
</tr>
<tr>
<td>Porosity (%)</td>
<td>0.32103</td>
<td>0.54314</td>
</tr>
<tr>
<td>Soil classification</td>
<td>Sandy</td>
<td>Silt clay loam</td>
</tr>
</tbody>
</table>
Reactor Setup:
Figure (1) shows the schematic diagram of the electro-kinetic test setup used for this study. The system in figure (2) consists of an electro-kinetic cell, two electrode compartments, a power supply, and a multi-meter. The glass electro-kinetic cell has an inner dimension of (45 cm x 8 cm x 12 cm) high. The actual length of the soil specimen of this cell equal to 20cm. Sawdust was used as a barrier in the electro-kinetic cell between the soil and the cathode compartment having a thickness of 5 cm. Each electrode compartment consisted of a valve to control the flow in the cell, a slotted graphite electrode and filter paper.
Perforated plastic plates were used to separate the sawdust barrier from the soil at one end and from the cathode electrode from the other end. The plates have a dimension of 8 cm x 12 cm and have holes 6 mm in diameter at space 1 cm from center of hole to center of another hole. A D.C. power source was used to apply a constant voltage to the electrodes, and a multi-meter was used to monitor the voltage and measure the current flow through the soil sample during the test.

Experimental Design:
Different tests were performed to investigate the effects of the different electrode purging solutions and addition configuration on the electro-kinetic remedial efficiency on two types of soil. Table (2) illustrates the summary of testing conditions. For the first test EX-1, tap water at EC=1750 µS/cm and PH=4 was used in both the anode, and cathode compartments at 30 V and with soil lead concentration of 1000 mg/kg and moisture content of 30%. For the second test EX-2, tap water at EC=1400 µS/cm and pH=5.5 was used in the electro-kinetic cell but other conditions are kept as in EX-1.
For the third test EX-3, purging solution was a tap water at pH =7 was used in the electro-kinetic cell but other conditions are kept as in EX-1, the experiments EX-1, EX-2 and EX-3 were carried out to study the effect of increasing PH on the remedial efficiency. To maintain the PH at 4, 5.5, and 7 in the experiments, nitric acid (HNO₃) must be added at the cathode compartments. Whereas, sodium hydroxide (NaOH) added to anode compartment.
Fig. 2: Experimental set-up of electro-kinetic cell used in the present study.

For the fourth test EX-4 purging solution was a tap water at PH=4 and soil lead concentration of 1500 mg/kg, but other conditions are kept as in EX-1.

For the fifth test EX-5 purging solution was a tap water at PH=4 and soil lead concentration of 500 mg/kg, but other conditions are kept as in EX-1, the experiments EX-4 and EX-5 were carried out to study the effect of change concentration of lead on the remedial efficiency.

The sixth test EX-6 was conducted by using 0.2 M EDTA as catholyte in the test for buffering of these hydroxide ions and maintaining the low PH at PH=4, and 0.2 M EDTA anolyte was used also to boost the propagation of hydrogen ions throughout the soil bed and this will increase the reactivity of these factors.

The test EX-7 was conducted by mixing 2 g of ZVI powder with 1 Kg of dry soil as enhancement condition, and then the contaminant material Pb was added and mixed well with the soil and left for one day to achieve homogeneity. This test used to study the effect of (ZVI) particle on removal efficiency of lead compared with EX-1 without using of this material.

For the purpose of comparison, the tests EX-8, EX-9 and EX-10 were implemented on the natural polluted soil, with conditions shown in the table (2). In these tests, the same conditions in the test of EX-1, EX-6 and EX-7 were used, respectively. At the end of each test, the soil specimen and saw dust were extruded from the cell. The soil specimen was sectioned into five parts and each part was weighed and subsequently preserved in a glass container. From each part of the soil, 5 gm of dry soil was taken and mixed with 12.5 ml distilled water. The mixture was shaken thoroughly by hand for several minutes and the solids were then allowed to settle for 1 hour. PH and electrical conductivity of the soil were measured.

The total lead concentration after each test was determined by using Jackson method (Jackson, M.L. 1958).

Table 2: Electro-kinetic remediation experiments.

<table>
<thead>
<tr>
<th>Test NO.</th>
<th>Soil type</th>
<th>Initial water content%</th>
<th>Processing duration (days)</th>
<th>Spike Soil Conc. (mg/kg)</th>
<th>PH Purging solution</th>
<th>Voltage (V)</th>
<th>Purpose Of Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EX-1</td>
<td>Sandy</td>
<td>30%</td>
<td>4</td>
<td>1000</td>
<td>Tap water</td>
<td>30</td>
<td>Effect of PH.</td>
</tr>
<tr>
<td>EX-2</td>
<td>Sandy</td>
<td>30%</td>
<td>4</td>
<td>1000</td>
<td>Tap water</td>
<td>30</td>
<td>Effect of PH</td>
</tr>
<tr>
<td>EX-3</td>
<td>Sandy</td>
<td>30%</td>
<td>4</td>
<td>1000</td>
<td>Tap water</td>
<td>30</td>
<td>Effect of Pb</td>
</tr>
<tr>
<td>EX-4</td>
<td>Sandy</td>
<td>30%</td>
<td>4</td>
<td>1500</td>
<td>Tap water</td>
<td>30</td>
<td>Effect of Lead concentration</td>
</tr>
<tr>
<td>EX-5</td>
<td>Sandy</td>
<td>30%</td>
<td>4</td>
<td>500</td>
<td>Tap water</td>
<td>30</td>
<td>Effect of Lead concentration</td>
</tr>
<tr>
<td>EX-6</td>
<td>Sandy</td>
<td>30%</td>
<td>4</td>
<td>1000</td>
<td>EDTA</td>
<td>30</td>
<td>Effect of EDTA</td>
</tr>
<tr>
<td>EX-7</td>
<td>Sandy</td>
<td>30%</td>
<td>4</td>
<td>1000</td>
<td>Tap Water</td>
<td>30</td>
<td>Effect of adding (ZVI)</td>
</tr>
<tr>
<td>EX-8</td>
<td>Silt clay loam</td>
<td>30%</td>
<td>4</td>
<td>1300</td>
<td>Tap water</td>
<td>30</td>
<td>Effect of soil type</td>
</tr>
<tr>
<td>EX-9</td>
<td>Silt clay loam</td>
<td>30%</td>
<td>4</td>
<td>1300</td>
<td>EDTA</td>
<td>30</td>
<td>Effect of Purging Solution</td>
</tr>
<tr>
<td>EX-10</td>
<td>Silt clay loam</td>
<td>30%</td>
<td>4</td>
<td>1300</td>
<td>Tap water</td>
<td>30</td>
<td>Effect of adding (ZVI)</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

**PH Purging Solution:**

Figures (3), (4) and (5) show the total lead concentration, PH, and EC variation in each section of the treated soil for experiments EX-1, EX-2, and EX-3 that were performed under unenhanced condition using tap water at PH 4, 5.5, and 7, respectively in the anode and cathode compartments. The initial concentration of lead throughout the soil was 1000 mg/kg. Final concentration of lead was lower and varied from 77-120 mg/kg near the anode to 186-500 mg/kg near the cathode. Increased lead concentrations were observed near cathode, maximum concentration of lead was desorbed from the soil and mobilized at pH value of approximately 4.0, then the best removal efficiency 86.86% at PH=4, and the figure (3) indicate that the transport of Pb ions occurred from anode to the cathode and the amount of Pb ions transported increased with an decrease of PH solution because when increase in PH the tendency for metal ions to become adsorbed on to the soil particles also increases.

**Effect of Soil Type:**

Figures (6), (7) and (8) show the variation of results tests EX-1, EX-8 after completed when we use two types of soil (sandy, silt clay loam) respectively. As seen from figure (6), the best removal of contamination occurred in the anodic region and the lead ions are concentrated in the cathode site. In more than half of cell the
removal of lead occurred almost greater than 86% of initial concentration in EX-1. The same trend of lead distribution can be observed in EX-8. However, the lead accumulated in this area where the pH values corresponds to the metals hydroxide deposition and negatively charged hydroxyl metal complexes near the cathode could be formed. Electro-kinetic remediation of silt clay loam soil proceeded relatively slower than that of sandy soil. Lead decontamination region for sandy was relatively larger with low residual concentrations compared to silt clay loam soil. As shown in figures (7) and (8), it can be seen that the pH of anodic part of the cell is enough for the free migration of lead. Therefore the slow remediation could not be explained by hydroxide formation. Probably, lead mobility was restricted by adsorptive forces of silt clay loam soil in compared to sandy soil, and the EC variation from 2.79 - 4.5 mS/cm near the anode to approximately from 1.2 - 3.1 mS/cm near the cathode. The direction of electro-osmotic flow was from the anode to the cathode for tests EX-1 and EX-8, and the cumulative volume of effluent in EX-1 greater than that in EX-8, this explains the high removal efficiency of lead 86.86% achieved compared with 67.6% in EX-8. The current as a function of processing time and approximately increase with a time.

![Fig. 6: The Pb Concentration (mg/kg) versus the distance from anode at two types of soil.](image1)

![Fig. 7: The PH of Soil versus to the distance from anode at two types of Soil.](image2)

![Fig. 8: The EC of Soil (mS/cm) versus to the distance from anode at two types of soil.](image3)

**Effect of concentration of Pb:**

The results of the electro kinetic experiments EX-1, EX-4 and EX-5 were analyzed to assess the effect of variation in contaminant concentration on contaminant migration and removal. Figure (9) shows that the current values for all the tests exhibited a similar trend, and increase with time. The current has to be proportional to the metal contaminant concentration, because the contaminant ions contribute to the ionic strength (and conductivity) of the pore solution, the figure illustrates that, as anticipated. In other words, the test with the highest contaminant concentrations, Pb 1500 mg/kg, generated the highest current, the test with the middle contaminant concentrations, Pb 1000 mg/kg, generated the mid-level current, and the test with the lowest contaminant concentrations, Pb 500 mg/kg generated the lowest current value. Figure (10) shows the electro
osmotic flow measured in tests EX-1, EX-4 and EX-5 versus the time, and indicate that the electro osmotic flow reduce with increase in initial concentration of (Pb), and the decrease proportionally and approximately gradually. From figures (9) and (10), it is evident that a higher current Production corresponded to a lower electro osmotic flow. It seems that as the contaminant concentration increased, the thickness of the diffuse double layer reduced, and this constricted the electro osmotic flow. It is also possible to some extent that contaminant precipitation near the cathode contributed to interesting to note that the two tests with low contaminant concentrations generated comparable amounts of flow, while the test with the highest contaminant concentration produced a significantly lower amount of flow. As seen in figure (11), the pH profiles for the three tests using different concentration levels were almost identical. As seen in figure (10), the two tests using the lower concentrations had nearly the same electro osmotic flow and hence similar pH profiles would be expected.

Fig. 9: Current (mA) versus the time (hr) at different concentrations of Pb.

Fig. 10: Volume of electro-osmotic flow (ml) versus the time (hr) at different concentrations of Pb.

Fig. 11: PH of soil versus the distance from anode at different concentrations of Pb.

Soil contamination with EDTA:

Figures (12), (13) and (14) shows that the variation between use the EDTA and tap water at PH=4 as a purging solution for silt clay loam soil in EX-8 and EX-9. Figures (12), (13) and (14) show the Pb concentration, EC, and pH along the soil specimen after electro-kinetic testing completed. As seen in this figures, the migration of Pb occurred toward the anode in EX-9 which is opposite to the migration direction observed in test EX-8, the EDTA-lead complexes became negatively charged EDTA\(^4^-\) and began to migrate back toward the anode. As a result of this conflict and accumulated in the soil sections near the anode. The figure (12) indicated that best removal efficiency of Pb 72.88% when we used the EDTA as a purging solution in EX-8 compared with 67.6% when we use of tap water at PH=4 for silt clay loam soil, because EDTA is a strong chelating agent that is readily available and environmentally benign and does not interact with soils, and
it may have been thermodynamically favorable for EDTA to complex with lead. In figures (13) and (14) we noticed that the EC decrease along the soil specimen from anode to cathode slightly, and the PH for tests EX-11 was below 6.6 approximately along the entire soil specimen.

![Fig. 12](image12.png)

**Fig. 12:** The Pb Concentration (mg/kg) versus to the distance from anode at enhanced condition EDTA.

![Fig. 13](image13.png)

**Fig. 13:** The EC of soil (mS/cm) versus the distance from anode at enhanced condition EDTA.

![Fig. 14](image14.png)

**Fig. 14:** The PH of soil versus the distance from anode at enhanced condition EDTA.

**Soil Contamination with ZVI:**

Figure (15) show that concentration of lead along the soil specimen after electro-kinetic testing completed, the amount of Pb ions transported increased with addition of the (ZVI) to soil at EX-12 in compare with EX-8, then increase in removal efficiency (88.44%), because the electro osmotic flow increasing, this might be due to standard half reaction of zero valent iron yielding a ferrous cation and two electrons as shown below.

\[
\text{Fe}^0 \rightarrow \text{Fe}^{2+} + 2e^- 
\]

\(\text{Fe}^{2+}\) ions try to migrate towards cathode, the electro-osmotic flow again tends to increase which might happen due to reaction of zero valent iron particle with water to yield ferrous cation, hydroxyl anion and hydrogen gas, then increase in removal efficiency of lead. The current increase with time which increase the rate of electrolysis reaction at the electrodes, then increase in Electro osmotic flow as shown in figure (16), and increase in removal efficiency.

**Removal Efficiency of Lead:**

Figure (17) shows the results of lead removal efficiencies for all the experiments after it completed. The removal efficiencies were calculated based on the initial and residual contaminant masses in the soil. We noted that the best removal efficiency 92.36% compared with other tests occurred when we use the EDTA as purging solution in EX-6 for sandy soil compared with other tests depending on residual contaminant masses in the soil, and the removal efficiency 71.45% in EX-9 with use EDTA was greater than 67.6% in EX-8 for silt clay loam without use it because the EDTA is a strong chelating agent that is readily available and environmentally benign
and does not interact with soils. The results of 86.86% in EX-1, 82.32% in EX-2 and 74.2% in EX-3 proved that the best removal efficiency 86.86% occurred when PH=4 at anode and cathode compartments in EX-1 because the lead was desorbed from the soil and mobilized at pH=4, and the transport of Pb ions occurred from anode to the cathode and the amount of Pb ions transported increased with an decrease of PH solution because when increase in PH the tendency for metal ions to become adsorbed on to the soil particles also increases (Chen et al. 2002). The figure (17) indicated that removal efficiency 67.6% of metal fraction in the silt clay loam soil in EX-10 was lower than 86.86% in EX-1 for the sandy soil because lead mobility was restricted by adsorptive forces of silt clay loam soil in compared to sandy soil. In same figure we saw that the removal efficiency 88.44% when we use initial concentration of lead in soil 500 gm/kg in EX-5 was greater than the removal efficiency 86.86% and 81.6%, at 1000, and 1500 gm/kg in EX-1 and EX-4, respectively because the electro osmotic flow reduce with increase in initial concentration of (Pb), then increase in contaminant migration and removal. The results of EX-7 when we added (ZVI) powder to soil as enhancement condition show that removal efficiency of lead 90.74% in EX-7 was greater than removal efficiency 86.86% in EX-1 without use (ZVI) for sandy soil, and, the removal efficiency 71.1% in EX-10 was greater than 67.6% in EX-8 for sandy clay loam soil.

Fig. 15: The Pb C oncentration (mg/kg) versus the distance from anode at enhanced condition (ZVI).

Fig. 16: Volume of electro-osmotic (ml) versus the time at enhanced condition (ZVI).

Fig. 17: Percent of removal efficiency of lead.

Conclusions:
Electro kinetics appears to be a viable solution for remediation of heavy metals contaminated soil. Various tests have been performed that have varying degrees of effectiveness in their results, we noticed that removal efficiency 92.36% more effective when we use the (EDTA) as a purging solution because is a strong chelating agent that is readily available and environmentally benign and does not interact with soils, and best removal efficiency in this study when we use (EDTA). The removal efficiency 86.86% increases with decrease in PH purging solutions, because when increase in PH the tendency for metal ions to become adsorbed on to the soil particles also increases. The removal efficiency increases with decrease in initial concentration of lead because
when the contaminant concentration increased, the thickness of the diffuse double layer reduced, and this constricted the electro osmotic flow. The use of zero-valent iron (ZVI) particle as a enhancement condition is effect on Electro-kinetic process for lead contaminated soil, the removal efficiency 90.74% increase when use (ZVI), because electro-osmotic flow again tends to increase which might happen due to reaction of zero valent iron particle with water to yield ferrous cation, hydroxyl anion and hydrogen gas. There are two mechanisms control on the migration of contamination in soil by Electro kinetics process, the electro-osmosis mechanism is effective in sandy soils when an accumulative electro-osmotic effluent was high in this process, and we saw that electro-osmotic effluent in silt clay loam soil was less than sandy soil, which indicates that the predominant ion transport mechanism in this soil is electro-migration.

REFERENCES

Mahsa Madani Hosseini, Mohsen Farahbakhsh and Gholamreza Savaghebi Department of Soil Science, College of Agriculture and Natural Resources, University of Tehran, Karaj- Iran 2011.