Study on Electrokinetics to Enhance the Contaminated Soil

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Abstract - *Due to enormous increase in modern globalization and industrial activities led to the increase in generation of larger industrial pollutants. Since the traditional practices failed to manage the industrial waste both economically technically, researches focused on a better way to treat the industrial waste within dischargeable limits. The proposed project is mainly focused on electrochemical treatment of industrial wastewater contaminated soil, in this regard the experiments shall be carried out by two methods using the soil which is naturally contaminated and synthetically contaminated of same level. The experimental conditions shall be carried out during the project is Effect of Current Density, Effect of pH, Effect of Amount of Electrolyte with variation in time. Finally the treated soil will be subjected to suitable agricultural purposes.*

KEY WORDS: Electrochemical treatment, Electrokinetics, Wastewater contaminated soil, Bio-Remediation, Agricultural purpose.

1. INTRODUCTION:

Land sites contaminated by anthropogenic activities are of great concern worldwide and where exposure to harmful substances occurs there is potential for intolerable risks to human and environmental health. Bioremediation is a well-established technology used to treat biodegradable contaminants, according to concepts based in general on ex situ treatment of excavated material (mainly used in pollutant source removal), and in situ treatment of sites with restricted access (where less disturbance is acceptable and extended remediation timescales are acceptable). Bioremediation requires environmental conditions which are favourable for the particular biochemical process and interaction between microorganisms, contaminants, nutrients and electron acceptors/donors. In situ biodegradation can be limited by contaminant bioavailability: the immediate contact between microorganisms and substances required for contaminant biodegradation, and bio accessibility: the fraction of these components accessible to microorganisms in the environment. Consequently, biodegradation processes may occur in the subsurface environment, but not at a rate to mitigate risks at a particular site. These limitations can be overcome by coupling bioremediation with electrokinetics, a remediation technology where direct current is applied within subsurface porous media to induce specific transport phenomena namely: (1) electroosmosis – the bulk movement of fluid through pores; (2) electromigration – the movement of ions in solution; and (3) electrophoresis – the movement of charged, dissolved or suspended particles in pore fluid. It is also characterised by the electrolysis of water at the electrodes. The sudden increase in the industrial use of land from the 17th century onwards has left a legacy of derelict and polluted sites across much of the developed world. In some areas of the developing world, rapid commercial and technological growth is increasing the extent of the problem. Often, the industrial processes have led, accidentally or otherwise, to chemical spill or leaks. These chemicals would then escape into the ground, and from there could contaminate groundwater supplies or remain in the soil until disturbed at a later date.

1.1 ELECTROKINETIC

Electrokinetic remediation is a technique of using direct electric current to remove organic, inorganic and heavy metal particles from the soil by electric potential. The use of this technique provides an approach with minimum disturbance to the surface while treating subsurface contaminants. Electrokinetic remediation may also be referred to as electrokinetics, electro migration, electro restoration, electro remediation and electro osmosis.

1.2 EK AND MIXED CONTAMINANTS

Contamination in the natural environment often occurs as mixtures of organic and inorganic contaminants that may require treatment by different remediation technologies. EK has been applied to remove both simultaneously. However, the removal of organics and heavy metals without facilitating agents can be problematic as both require different conditions for mobilisation, i.e. electromigration of metal ions under acidic conditions and electroosmotic flow of hydrophobic organics under neutral conditions. Successful removal of mixed contaminants from soils has required the use of cyclodextrin or non-ionic surfactants and EDTA .

2. EXPERIMENTAL PROCEDURE

The following are the materials that is used for the treatment and the tests that are conducted before treating the soil sample.

2.1 MATERIALS USED

2.1.1 Municipal solid waste

Municipal solid waste commonly known as garbage, is a waste type consists of items that are discarded by the public every day. It specifically refers to food waste.

2.1.2 Tannery effluents

Tannery effluents are characterised by high contents of organic, inorganic, chromium, suspended solids and dissolved solids.

2.1.3 Seeds sown

Green grams, Red Kidney beans, Cluster beans, Spinach seed, Fenugreek.

TABLE -1: MATERIAL TESTING

PARAMETERS	CONTAMINANTS RANGE	PERMISSIBLE LIMIT
B.O.D	250 mg/l	200 mg/l
C.O.D	400 mg/l	250 mg/l
Total dissolved solids	2760 mg/l	2100 mg/l
Total suspended solids	178 mg/l	100 mg/l

TABLE-2: EFFLUENT TESTING

CONTENT	**CONTAMINANTS RANGE**	**LIMIT**
Available nitrogen	50 ppm	200-5000 ppm
Electrical conductivit	1278 µs/cm	**2250** µs/cm

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Ion exchange capacity	1151.98 meq/100g	1100 meq/100g
pH range	5.76	7-8.5
Phosphoro us	27 mg/kg	100-2000 mg/kg
Potassium	620 mg/kg	1700-33000 mg/kg
Total organic carbon	1615 mg/kg	1400 mg/kg
Permeabili ty test	0.0045 cm/sec	.001388 cm/sec
Specific gravity test	2.45	2.65-2.85
Moisture content test	12.69%	10%

3. PROCEDURE

The Soil sample is taken and mixed with effluent for this project. 500 grams of soil is taken and 115 ml of diluted nickel nitrate solution is taken (50 g of nickel nitrate in 1 litre of water) and mixed together to form a semi solid phase.

The sample is then filled upto ¾ th of the depth of the apparatus at the middle compartment of the apparatus. On the other two outer compartments tap water is filled. Tap water is the electrolyte of this process. Nickel nitrate is added to induce the electrokinetic process.

The two electrodes are placed in the electrolyte one at each compartment containing the electrolyte. There should be continuous supply of water. The connections are made appropriately. The electrodes are connected to the DC power supply and the experiment is started by supplying electricity.

The pH of the soil is noted before the experiment is started. During the duration of the process the pH of the water that is used as electrolyte is noted at periodic interval using pH meter to check the flow of ions and the removal of the contaminants. Once the pH of the electrolyte reaches 7 the supply of electricity is stopped as it shows that the ionic contaminants are removed and the soil is neutralized.

After the electrokinetic process the soil is taken out of the apparatus and filled in a tray and the seeds are sown. The seeds that we are going to sow are a mix of the following Green grams, Red Kidney beans, Cluster beans, Spinach seed, Fenugreek .

TABLE -3: FINAL TESTS

CONTENT	CONTAMINANTS RANGE	LIMIT
Available nitrogen	275 ppm	200-5000 ppm
Electrical conductivity	1278 µs/cm	**2250** µs/cm
Ion exchange capacity	1151.98 meq/100g	1100 meq/100g
pH range	7.6	7-8.5
Phosphorous	547 mg/kg	100-2000 mg/kg
Potassium	2000 mg/kg	1700-33000 mg/kg
Total organic carbon	1245 mg/kg	1400 mg/kg
Permeability test	0.00125 cm/sec	.001388 cm/sec
Specific gravity test	2.67	2.65-2.85
Moisture	12.69%	10%

content test		
B.O.D	142 mg/kg	200 mg/kg
C.O.D	213 mg/kg	250 mg/kg
TDS	2032 mg/l	2100 mg/l
TSS	80 mg/l	100 mg/l
Chromium	127 mg/kg	200 mg/kg

3.1 Effect of pH

pH is a important parameter in a electrokinetic process which has more influence than any other process. The Fig.1 shows the effect of pH on chromium and COD removal from contaminated soil during electrokinetic process. The pH of the soil was varied from pH 3 to 11 to evaluate better pH for removal chromium and COD removal. The pH was adjusted with 1M NaOH/1N H_2SO_4 for acidic and basic pH. From the results it was evident that chromium removal was found to be maximum at neutral pH. At acidic pH (3,5) it was found to be very less and at basic pH (9,11) the chromium removal was found to be very low this is mainly due to the high formation of chromium hydroxides which interupts the chromium removal rate and increases the COD values.

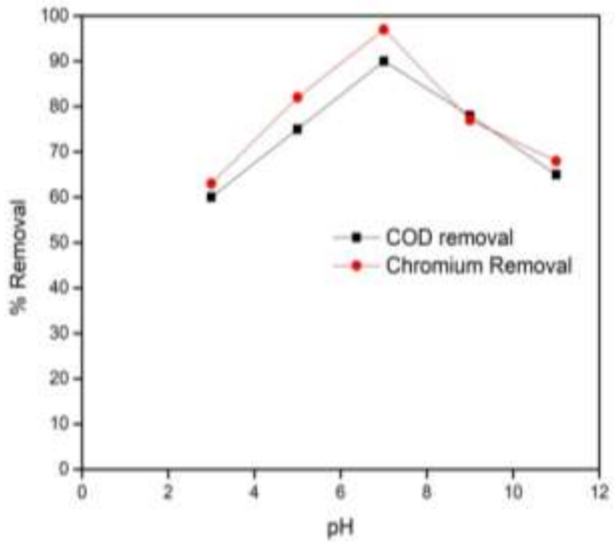

Fig. 1 Effect of pH on Chromium Removal in contaminated soil

3.2 Effect of Current Density

Fig. 2 reperesents the effect of Current density on chromium removal in contaminated soil using electrokinetic process. The current density was varied from 0.02A/cm^2 to 0.12 A/cm^2, from the fig it was notably found that the removal rate found to linear when there is increase in the current density. This is mainly due to that when there is a increase in current density the flow of electrons will be high, so the chromium removal rate from the soil will be also high. In this process current density was optimised at 0.10 A/cm^2 considering economic feasibility and cost effective rate

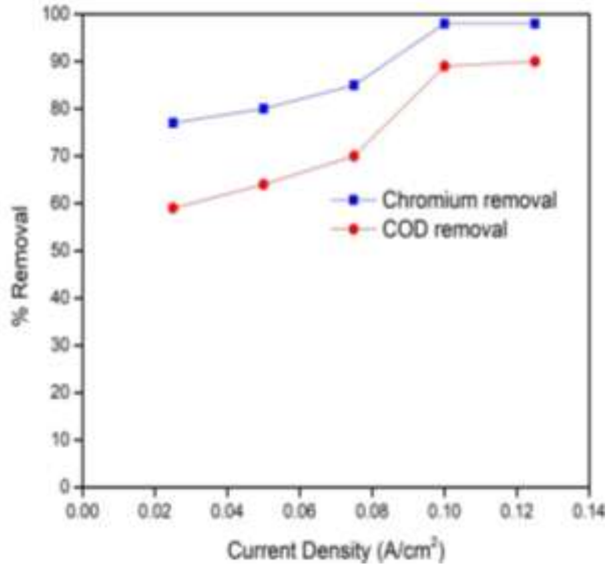

Fig.2 Effect of Current Density on Chromium removal from contaminated Soil

3.3 Effect of distance between the electrodes

In a electrokinetic process the distance between the electrode plays a vital role in electron transfer rate. In this study the distance between the electrodes was varied from 11cm to 27 cm and it as shown in fig.3. the results shows that the chromium removal rate was found to be higher in minimum distance such as 11 cm whereas the removal rate was very lower at a maximum distance at 27 cm it is mainly due to that when there is increase in the electrode distance the electron transfer rate will be very lower in some cases there electron transfer will not be possible due to less mobility of electrons. The COD removal rate also found to be higher at minimum electrode distance.

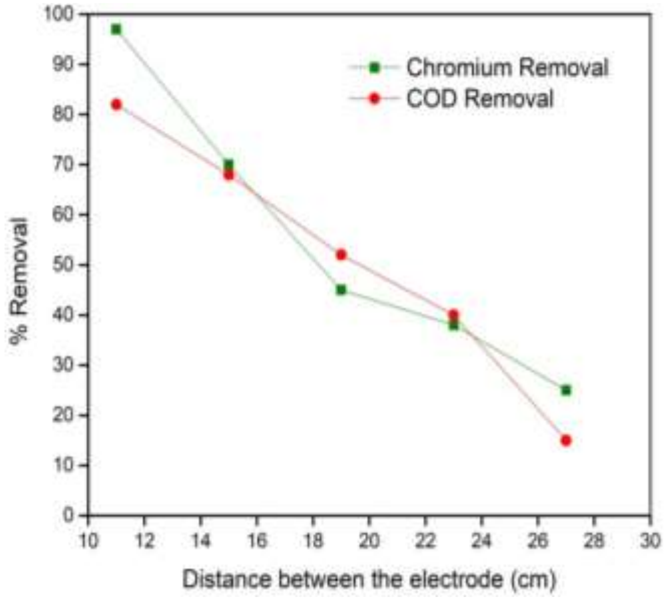

Fig.3 Effect of distance between the electrodes for treatment of contaminated Soil

3.4 Effect of Process Time

The optimised parameter such as pH, current density, electrode distance were maintained constant to find out the optimum time and to find out the feasibility of process at a longer run. The process was carried out for a period of 7 hours to find out the maximum removal rate. From the results as shown in fig.4 it reveals that 6 hours of time was optimum for higher chromium removal rate, whereas more than 6 hours there was no further removal rate and it attains steady state.

Fig.5 shows the overall removal rate during the electrokinetic treatment of contaminated soil. The results proved that electrokinetic treatment of tannery wastewater contaminated soil reclaims back for more useful process and land can be used for agricultural purposes.

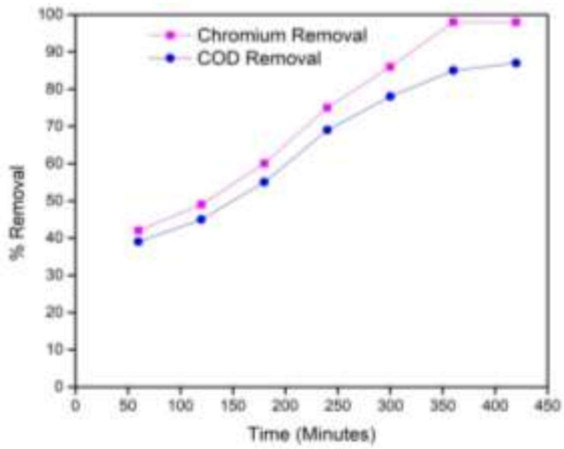

Fig. 4 Effect of Time on treatment of Contaminated Soil

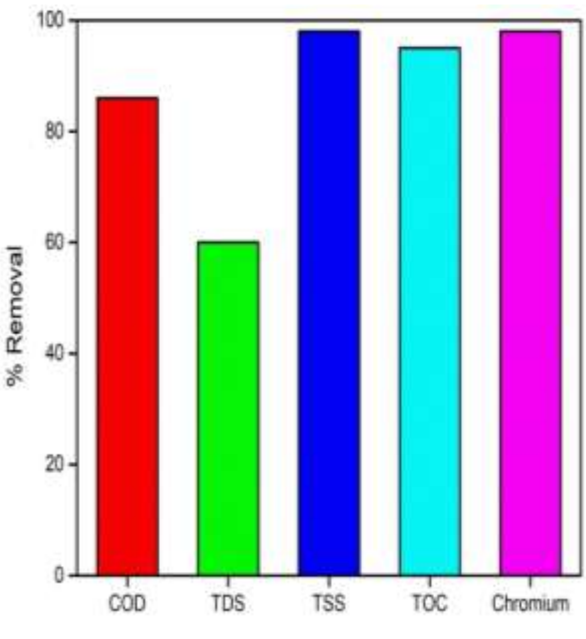

Fig.5 Performance Comparison of Eletrokinetic treatment on Contaminated Soil

4. CONCLUSION

In this study, the feasibility of electrokinetic treatment of tannery effluent contaminated soil was carried out using titanium electrode as anode, whereas mild steel as cathode. Chromium removal rate was found to be high as 98% at a pH of 7, tap water was used as electrolyte for both anode and cathode. The distance between the anode and cathode plays a major role in removal contaminants. The results obtained from the toxicity tests also proves that by electrokinetic treatment the lost ecological balance can be restore. The enhancement of nutrients which is sufficient for a plant growth are mainly provided by the electrokinetic process. Hence this process can be scaled up for industrial scale.

REFERENCES

[1] Gye–Nam, K., Seung–soo, K., Hye-Min, P., Wan-Suk, K., Uk-Ryang, P., Jei-Kwon M.(2013). Cs-137 and Cs-134 removal from radioactive ash using washing–electrokinetic equipment. Annals of Nuclear Energy. 57, 311 – 317.

[2] Hamed, J. T., Bhadra, A. (1997). Influence of current density and pH on Electrokinetics, Journal of Hazardous Materials, 55, 279 - 294.

[3] He J, He C, Chen X, Liang X, Huang T, Yang X, Shang H., (2018) “Comparative study of remediation of Cr(VI)-contaminated soil using electrokinetics combined with bioremediation”, Environmental Science and Pollution Research International.

[4] Ikrema Hassan,Eltayeb Mohamedelhassan,Ernest K. Yanful,Ze-Chun Yuan (2016) “A Review Article: Electrokinetic Bioremediation Current Knowledge and New Prospects” ,Ai magazine, vol 6, 2016.

[5] Jamshidi-Zanjani, A. * and Khodadadi, A. (2017) “A review on enhancement techniques of electrokinetic soil remediation”,Journal of chemistry, vol 3, 2017.

[6] Maturi.K, Reddy.K.R, Cameselle.C (2009) “Surfactant-enhanced electrokinetic remediation of mixed contamination in low permeability soil”, Separation science and Technology.

[7] M.Megharaj, B.Ramakrishna,K.Venkateswarlu,N.Sethunathan, R. Naidu (2011) “Bioremediation approaches for organic pollutants: a critical perspective”, Environment International.

[8] Perez-Corona.M, Ochoa.B, Cardenas.J, Hernandez.G, Solis.S, Fernandez.R, Teutli.M, Bustos.E (2013) “Comparison of different arrangements of electrodes during the electrokinetic treatment of polluted soil with hydrocarbons and its final application in situ”, Recent Research Developments in Electrochemistry.

[9] Richard E. saichek and Krishna Reddy .R (2012) “Electrokinetically Enhanced Remediation of Hydrophobic Organic Compounds in Soils”,Environmental Science and Technology

[10] R.T.Gill,M.J.Harbottle,J.W.N.Smith,S.F.Thornton (2014) “Electrokinetics-enhanced bioremediation of organic contaminants: A review of process and environmental applications”, chemosphere journal, vol 107, 2014.