REMOVAL OF LEAD AND CHROMIUM FROM THE CONTAMINATED SOIL BY SOIL WASHING USING A MODIFIED BENCH SCALE MODEL

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Abstract-In present scenario, Soil contamination through heavy metals is rising day by day. Countries like India, USA are also affected by such problem. Now a day's soil contamination is becoming a persistent problem as soil is used in various ways like production construction etc, thus decontamination of soil is becoming a serious concern to handle. Soil contamination leads to several threats to health of human, animal and their environment. Heavy metals are released in environment from industrial discharge, energy production, pesticides and fertilizers, mining and quelling. Heavy metals like Cadmium, Chromium, Nickel, Lead, Mercury, Zinc, Copper etc are considered as most hazardous metals if present above the permissible limits. These heavy metals accumulate in soil at sites and ultimately contaminate ground water and drinking water. Numerous technologies are developed to decontaminate the soil till date; these are physical, chemical as well as biological treatment methods. Soil washing is a physio-chemical treatment substitute available for decontamination of soil with high efficiency. Soil washing is very cost effective and easy to handle operation. In this paper an attempt has been made to evaluate soil washing and its efficiency by using a modified bench scale model/rotating soil washing unit for decontamination of heavy metals present in soil. Heavy metal like Pb and Cr are reduced in soil by optimizing various parameters like reaction time, concentration of washing solution etc. Results confirmed that the new soil washing process can remove the heavy metals from the contaminated soil.

Index terms-Contamination, Heavy Metals, Soil washing, Bench Scale Model

1. INTRODUCTION

Metals contamination is an importunate problem at many contaminated sites these days. There are countless hazardous waste sites in developed countries due to severe contamination by the improper disposal of wastes, surface spills, industrial and military activities, spillage, mining, preservatives and petroleum products [1]. Major contaminants are volatile organics, hydrophilic and hydrophobic organics, heavy metals and radioactive materials[2]. Heavy metals easily found in any contaminated soil sites include Metals like Chromium, Cadmium, Lead, Nickel, Zinc, Mercury etc. The U.S. Environmental Protection Agency (EPA) classified Chromium VI as a Group A Carcinogenic element for humans [3]. Likewise Lead at high levels of human exposure leads to damage all organs systems, badly the central nervous system, kidneys and blood, resulting in death at excessive levels. At low levels, RBC synthesis and other biochemical processes are affected, psychological and neurobehavioral functions are distorted [4]. These metals possess great threat to environment by polluting it and are also associated with health hazards. Metals are usually immobile by nature in surface and subsurface systems due to their precipitation or adsorption reactions; therefore remediation technique's major center of attention is generally solid phase sources of these metals like sludge, debris, soils, and wastes [5]. Existing Remediation techniques are combined in two groups: Immobilization i.e. In situ fixation and separation techniques utilizing immobilizing agents i.e. soil washing [6].

Soil washing is an ex-situ remedial strategy that can be used to treat soil contaminated with both organic and in organic compounds like PCBs, PAHs, pesticides, petroleum residuals, SOVCs. Soil washing involves use of different wash solution may be simply as water such that heavy metals can be removed from the dredged soil sediments to wash solution added[7]. In order to increase the efficiency of soil washing, washing additives can be used. The commonly use wash additives used in soil washing processes are various acids/alkali available like H_2SO_4,HCl etc or certain chelating agents like EDTA, EDDS, NTA, DTPA or some surfactants are also utilized these days like Rhamnolipid ; However acid washing results in reduction of soil productivity and disturbance in chemical and physical structures due to mineral solubilization[8]. Chelating agents binds with impurity and form a metal –ligands compounds. Soil washing has a demonstrated efficiency of >90%, which is in fact very high. Soil washing is confined to use for coarse soils types such as silt, sandy loam and sand soils [9].

2. MATERIAL AND METHODS

A. Soil

The soils were collected from Madan Mohan Malviya University of Technology, Gorakhpur campus for experiment. The soil samples collected were air dried for about one week at room temperature. Air dried soil were then sieved through 4.36mm sieve to remove stones and large particulates and other unnecessary things. Soils were then mixed thoroughly with hand to ensure uniformity [10].

B. Soil Contamination Procedure

To imitate the possible field soil contamination situation, campus soil was contaminated artificially with known quantity of heavy metals like Cr and Pb. About one kg of sieved air dried soil was thoroughly mixed with de-ionized water (DI), about 3L containing salts of potassium dichromate $k_2Cr_2O_7$ and lead nitrate Pb $(NO_3)_2$. The concentration of these heavy metals was around 10000ppm. The soil and heavy metals were mixed with the help of hand for about a week. The physical and chemical characteristics of the soil used are analyzed by different geotechnical properties. These properties were determined according to IS standard codes summarized in table.1. Soil grain size distribution tests were also performed, size distribution curve obtained is depicted in fig.1. Soil sample used contain 47.2% sand and 52.7% silt. Soil pH (8.46) was determined by pH meter.

Table1. Properties of the Soil Sample

Characteristics	Test method(IS Code)	Value
Sand size content (%)	I.S:2720(Part 4): 1985	47.2
Silt size content (%)	I.S:2720(Part 4): 1985	52.7
Atterberg limits	I.S:2720 (Part 5): 1985	Non-plastic
Specific gravity (g)	I.S:2720 (Part 3-Sec.2): 1980	2.40
MDD (g/cc)	I.S:2720 (Part 10): 1991	1.76
OMC (%)	I.S:2720 (Part 6): 1972	13.62
Permeability k (cm/sec)	I.S:2720 (Part 10): 1991	3.831×10^{-6}

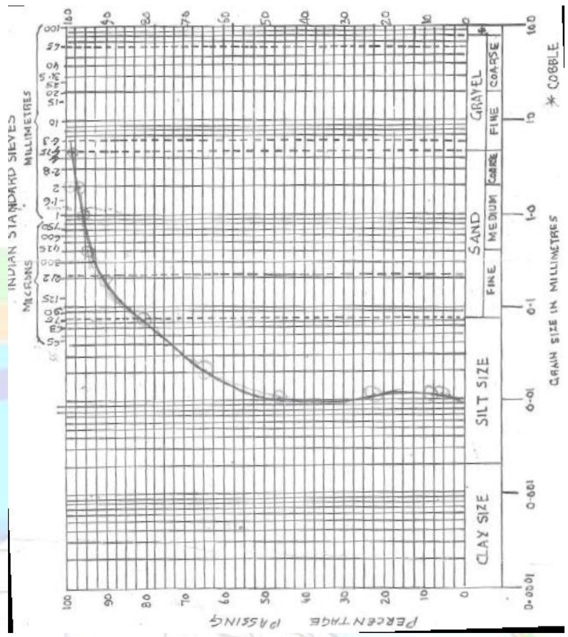

Fig 1: Grain Size Distribution Curve

C. Bench Scale Model Design

A modified bench scale setup was prepared and installed in laboratory according to description defined by Reddy etal. , 1996. The model can process up-to 5kg of soil at a time .it is composed of a PVC tumbler of 8 inch in diameter and 3 ft in length with a bottom cap which is removable such so for feed input. This is driven by variable speed AC motor. The alignment of this setup is done in inclined position to allow proper mixing of the feed. The modified bench scale model is shown in fig 2.

Fig 2: Bench Scale Model for Soil Washing

D. Soil Washing Procedure

The soil and wash solution were added in tumbler of machine designed and is set to rotate at 23 revolutions per minute .Batch extraction of heavy metal contaminants using a frequently used chelating agent is done for 1 kg soil and 3l DI water. The whole feed is allowed to rotate and mix at 24 rpm at room temperature (28-33 ℃) for different time intervals After completion of time of single batch, mixture is then filtered through regularly used filter paper for heavy metal analysis. The concentration of Heavy metals was measured by flame atomic absorption spectrometry (AAS). The washing solution was prepared from analytical grade reagents. In this experiment different operating variables for removal of heavy metals from the soil using EDTA, counting its different concentration, particle size, effect of different time interval is studied. EDTA disodium is used for the experiments. In this with four different concentrations (0.005, 0.01, 0.05, and 0.1) of Na_2EDTA were chosen for experiment. Washing of soil is carried out at different time intervals with Na_2EDTA for 1, 4, 6, 12, 24, 48 h.

3. RESULT AND DISCUSSIONS

A. Particle size vs. Contamination

As the particle size decreases the heavy metal concentration in the particle increases. The major reason behind this is the fact that small particle size has larger surface area. Soils composed of minerals and humid constituents which are richly present in smaller fraction of the soil. These humid and mineral constituents of soil carry carboxylic and hydroxyl functional group which contribute in creation of charge over soil surface and in metal retention in soil. Hence so metal concentration increases in smaller fraction [11].

B. Kinetics of metal Extraction

Extraction time play a vital role in removal of metal and thus in soil washing. In order to figure out the washing kinetic study was performed by soil washing with concentration of 0.1M Na_2EDTA. It is observed clearly that EDTA enhanced process shows better result. From the kinetic study it was found that as the contact time is increasing the removal efficiency also increased as shown in Fig.3. From the figure it was found that removal efficiency of chromium increases from 48.60%-75.26 and for lead it ranges from 53.87%-76.82%. Washing efficiency of metal Lead was higher than that for chromium. Thus from observation it is clear that EDTA concentration and washing contact time plays a very crucial role in washing.

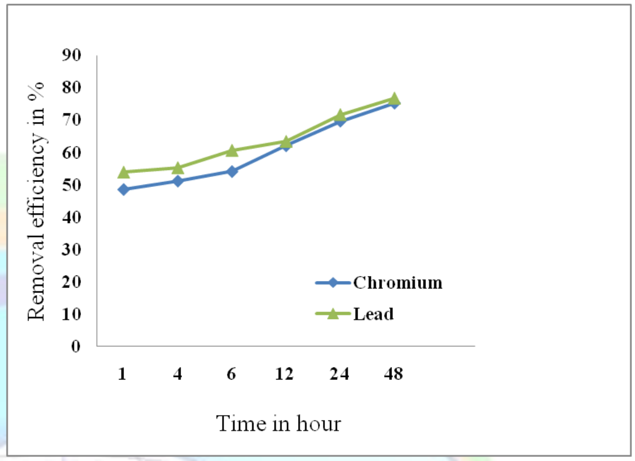

Fig 3: Removal of Chromium and Lead with EDTA

C. Effect of EDTA concentration

Experiments were performed with 0.005M, 0.01M, 0.05M, 0.1M concentration of Na_2EDTA and samples were collected at different time interval. The results were obtained by the Varian AA240 flame AAS. EDTA was found efficient in removal of both lead and chromium .The effect of different concentration with time is shown. Fig.4 shows the removal efficiency of EDTA at 0.005M concentration for lead and chromium from 1 to 48 hr. The removal of chromium was in range of 39.20 % to 55.30 % and that of lead was in range of 41.20% to 60.12%. Thus with increasing contact time between samples and EDTA enhances removal efficiency. At 48 hr, chromium removal was 55.30% and lead removal was 60.12% which is really efficient.

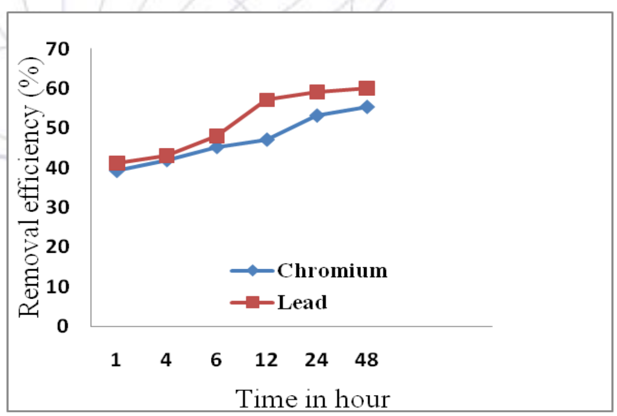

Fig 4: Effect of EDTA (0.005M) on Removal of Pb and Cr.

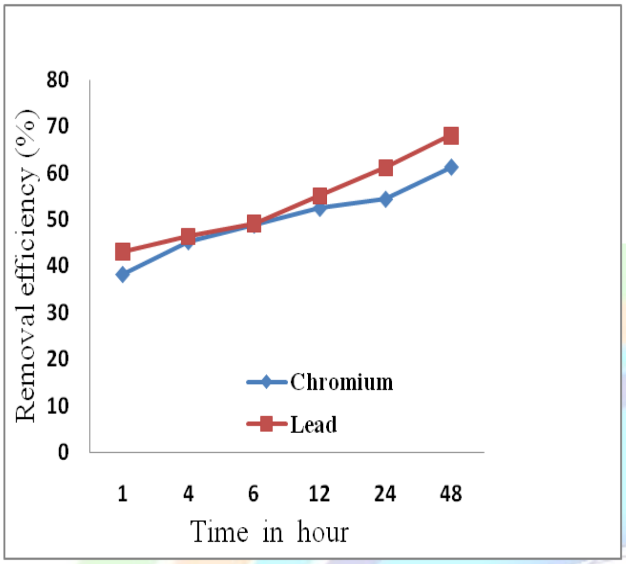

Fig 5: Effect of EDTA (0.01M) on removal of Pb and Cr.

It was clearly observed that the further increase in removal efficiency occurs with use of EDTA at 0.01 M concentration. Chromium and lead removal was found to be in range of 38.12% to 61.12% and 42.99% to 68.12 % respectively as shown in Fig 5.

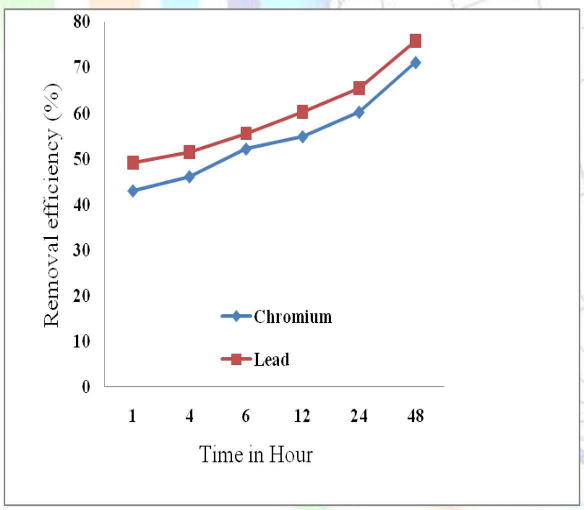

Fig 6: Effect of EDTA (0.05M) on removal of Pb and Cr

Similar type of results is obtained from 0.05M and 0.1M concentration of EDTA and is shown in Fig.6 & Fig. 7. It is clear by the result that bench sale model is also very efficient in removal of chromium and lead by soil washing. Concentrations of wash solution along with contact time play a crucial role in soil washing. In this experiment more than 0.1 M solution of EDTA can be used but cost and time factor should also be considered.

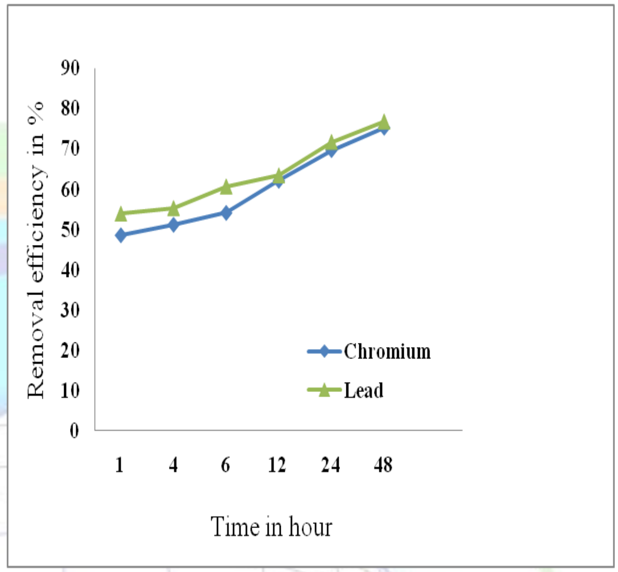

Fig 7: Effect of EDTA (0.1M) on removal of Pb and Cr.

4. CONCLUSION

Bench Scale model was found to be much efficient and effective for soil washing technique. Remediation of contaminants like lead and chromium was efficiently done from soil. This work shows that as the concentration of wash solution like here as EDTA increases remediation efficiency also increases. Pb shows higher removal at 0.1M concentration of EDTA with that of chromium. With increase in time, removal efficiency increases for both lead and chromium. Use of higher concentrations may enhance further removal efficiency but it adversely affects the soil micro organisms and plants. In case of soil washing and particle size, larger particle shows higher removal efficiency due to presence of weak bond within soil particles and heavy metals.

5. FUTURE SCOPE OF THE WORK

Since soil washing is somewhat a newly developed technique, there is a large scope for its advancement. There are many available effective wash solutions, additives and parameters which need to be experimented yet. Thus additional research and advancement is required to better facilitate remediation process as soil contamination is serious threat to health of living organisms, humans and environment.

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