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Assessment of Soil Contamination Due to Leaching of Industrial Wastewater

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This research has investigated the soil pollution at a lead and zinc contaminated site (Deezaj Abad). For many years the leakings of waste-water generated by National Lead and Zinc Plant (NLZP) has polluted the soil at the site. The study was carried out by conducting toxicity characteristics leaching procedure (TCLP) leach tests and performing lead and zinc analysis on soil and liquid samples to determine the concentration of the metals. Following testing and analysis of the samples, concentrations of lead and zinc in soil and plant's wastewater were compared with TCLP standards, European Union limits (EC-175) and World Health Organization guidelines. By comparing the total analysis results (ranging from 110 to 370 ppm for lead and 540 to 690 ppm for zinc) for the soil samples with the allowable concentrations of 84 and 200 ppm proposed by the above guidelines it could be concluded that the soil at the site was polluted with the heavy metals. Regarding the plant's waste-water, the concentration of the metals exceeded the allowable concentrations of TCLP test and World health Organization limits. At the end of this study, remediation methods for treatment of contaminated soils at the site are proposed.

Key Words: Heavy metals, Soil contamination, Lead, Zinc, Hazardous wastes, Wastewater.

INTRODUCTION

Development of urban life and the industrial progresses during recent decades have compelled major concerns regarding mineral processing wastes in the twenty first century. The outcome of such development has increased the consumption of the limited natural mineral resources, hence causing more soil and ground water pollution. It is therefore essential to minimize the environmental impacts of mineral processing industries and satisfy environmental requirements for a sustainable development[1].

In Iran, the existence of lead and zinc mineral resources in Zanjan province has affected the industrial development in this region based on establishment of lead and zinc processing and other related industries. One of the largest metal processing industries in Iran is the National Lead and Zinc Plant (NLZP) which is located on a steep zone running across the 12th kilometer of Zanjan-Tehran road[2].

Due to the presence of lead and zinc in wastewater outlet of NLZP plant and its leakings to surface water and Zanjanrood river, the soil adjacent to the plant has become contaminated, hence destructing agricultural and farming activities in the area. Figs. 1 and 2 present a topographic photo of the region as well as a sample of contaminated soil at the vicinity of the plant.

In this study, samples of soil and wastewater were collected for total analysis of lead and zinc. Some of the soil samples were also tested using TCLP leach tests and the corresponding leachates were analysed for the metals. The results of the analysis of the samples were compared with allowable concentrations proposed by European Union Community (EC-175)[3], World Health Organization (WHO) Guidelines[4] and TCLP leach test concentrations[5]. The results of this study indicated the soil pollution at the site due to the leaching of NLZP plant's wastewater and based on these findings, treatment methods for remediation of the site have been proposed.

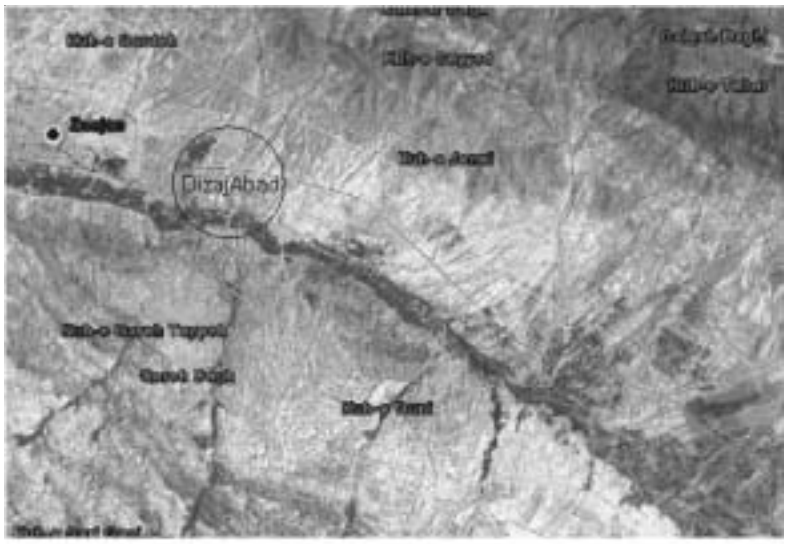

Fig. 1. Topographic photo of Deezaj-abad area in Iran

Effects of lead and zinc on the environment

Lead is known as a hazardous environmental pollutant for its toxicity to humans. It adsorbed through various paths in human body which caused intense toxicity[6]. If lead is present in agricultural soils, it will be adsorbed by the plants stems, hence poisoning its consumers[7]. Short-term exposure to high doses of lead can make humans seriously ill. Long term overexposure can cause numerous health problems including: anemia and other blood disorders, kidney disease, damage to nervous system and brains and reproductive impairments in men (impotency) and women (decreased fertility, abnormal menstrual cycles and miscarriages).

Fig. 2. A sample of contaminated soil

People who have held jobs with high levels of lead exposure have a 3.4 times greater likelihood of developing Alzheimer disease[8].

Regarding zinc, it is a trace element that is essential for human health. Nevertheless, too much zinc can still cause serious health problems, such as stomach cramps, skin irritations, vomiting, nausea and anemia. Very high levels of zinc can damage the pancreas and disturb the protein metabolism and cause arteriosclerosis. Extensive exposure to zinc chloride can cause respiratory disorders.

In the work place environment zinc contagion can lead to the flue-like condition known as metal fever. Zinc can also be a danger to unborn and newly born children through blood or milk of their mothers.

On zinc-rich soils only a limited number of plants have a chance of survival. That is why there is not plant diversity near zinc disposing factories. Due to the effects upon plants zinc is a serious threat to productions of farmlands. Despite of this zinc-containing manures are still applied[9].

The average zinc concentrations in soils fluctuate between 30-50 ppm and at concentrations above 50 ppm, it will give a grey colour to water. Zinc could also cause headache, nausea, body's water loss and malfunctioning of kidneys[10].

EXPERIMENTAL

In this research a total of 14 soil and 4 waste-water samples were collected for TCLP leach tests and total analysis for lead and zinc. Followings include testing activities that were performed in present studies.

Testing program

TCLP leach tests: To determine whether the soil at the site is polluted or not, TCLP leach tests were conducted on the samples. The tests were carried out at Environmental Laboratory of the College of Environment, University of Tehran. A summary for performing the test is as follows:

50 g of well homogenized soil was weighed and placed in a stainless-steel cylindrical container for leaching. 1000 cm^3 of extraction solution was then decanted into the container until the weight of soil to extraction solution was reached to 1:20. The solution was prepared by adding 5.7 mL of acetic acid to 500 mL of de-ionized water in a volumetric flask. While mixing the solution, water was added to the flask until the solution volume was reached to 1 L. The pH of the solution was measured to be 2.9.

The cylindrical container was placed in a rotary mixer and the soil-solution mixture (slurry) was mixed for 18 h. The slurry in the container was then filtered and the leachate was placed in refrigerator for lead and zinc analysis[5]. The analysis methods for lead and zinc are described in Standard Methods for Evaluating Solid Waste, Physical/Chemical Methods, U.S.EPA, SW-846[11].

RESULTS AND DISCUSSION

Results of lead and zinc analysis

In present studies, total analysis for lead and zinc were performed on 6 of the soil samples and the TCLP tests were carried out on the remaining 8 samples. Results of the analysis along with concentrations proposed by World Health Organization (WHO) and European Union Community (EC-175) are listed in Table-1.

TABLE-1
TOTAL CONCENTRATIONS OF LEAD AND ZINC IN SOIL SAMPLES COMPARED WITH WORLD HEALTH ORGANIZATION AND EC-175

Sample No.	Concentration (mg/kg)	
	Zinc	Lead
WHO	-	84
EC-175	200	100
1	630	140
2	540	110
3	560	370
4	610	170
5	690	220
6	580	130

The total concentrations of lead in 6 of the soil samples were ranging between 110 and 370 ppm. These concentrations were beyond the allow-

able concentration of 84 ppm as specified by the World Health Organization. The comparison of lead concentrations (Table-1) with the 100 ppm concentration suggested by European Union Community indicates the soil contamination with this metal.

With regard to zinc, it should be noted that the concentrations of this metal in all the samples were ranging between 540 and 690 ppm. Comparison of the above results with that of 200 ppm set by EC-175 guidelines indicates that the soil is contaminated with zinc. Fig.3 illustrates the pollution chart for the samples.

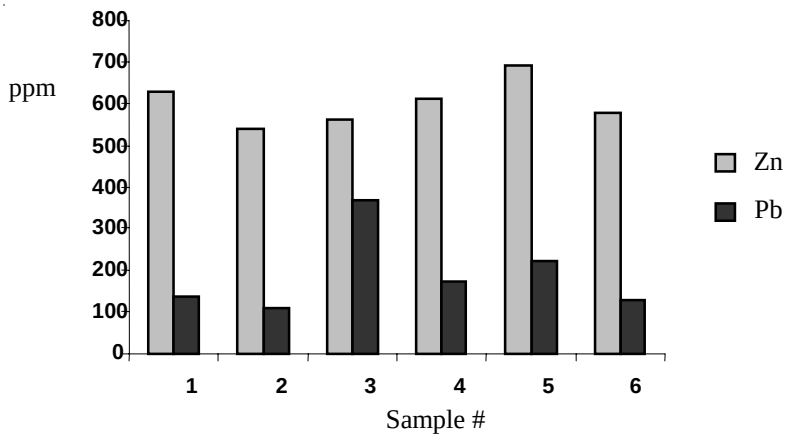

Fig. 3. Total lead and zinc concentrations in soil samples

Leaching test results

By comparing the leaching concentrations of lead and zinc with allowable TCLP limits, it could be concluded that in 4 of the samples leaching of lead exceeded the allowable concentration of 5 ppm as a result of samples contamination. With regard to zinc, however this metal is not listed among toxic constituents of the leach test (Table-2).

TABLE-2
LEACHING CONCENTRATIONS OF LEAD AND ZINC IN TCLP TESTS

Contaminant	Allowable TCLP concentrations, ppm	Sample No.							
		7	8	9	10	11	12	13	14
Lead	5	5.2	4.1	5.1	4.0	5.4	7.1	0.4	0.12
Zinc	-	19.0	12.4	16.0	13.7	18.1	21.2	1.2	0.70

Two additional samples were also collected from depths of 1 meter of the site. The analysis showed that the concentrations of lead in these samples were below the allowable concentration of 5 ppm, hence the site was not contaminated at this depth.

4 Samples from plant wastewater were also analyzed which their results showed that the concentrations of the metals exceeded the limit of 5 ppm proposed by TCLP and World Health Organization. Therefore the use of plant waste-water for agricultural and farming purposes is not recommended (Table-3).

TABLE-3
COMPARISON OF LEAD AND ZINC IN WASTE-WATER WITH TCLP AND WORLD HEALTH ORGANIZATION CONCENTRATIONS (ppm)

Contaminant	World Health Organization	TCLP Test	Sample No.			
			W_1	W_2	W_3	W_4
Lead	5	5	6.5	5.2	7.8	8.2
Zinc	2	-	17.7	16.8	19.3	21.0

Conclusion

On the basis of the results of leach tests and total analysis of the samples, the following recommendations are proposed for treatment of the site:

Control of pollution source: Due to the presence of NLZP plant and its performance for more than last 20 years, the priority should be given to the design of a new wastewater treatment plant or the rehabilitation of the present one, otherwise all the treatment procedures for the site would be ineffective.

Transportation and removal of polluted Soils from the site: After controlling the pollution source, soils which are intensively contaminated should be removed from the site and transported to a hazardous-waste facility for storage and/or treatment. The contaminated soils could also be used as materials in roads and highways constructions, provided having suitable grading and compaction efforts[12].

Remediation of the soils: To bring the soils contamination to recommended clean up or background levels, some *in situ* remediation techniques could be imposed at the site. Followings include a list of treatment processes recommended for the site[12].

- Solidification/stabilization.
- Soil flushing.
- Soil washing.
- Biological degradation.
- Waste containment systems.

The detailed information regarding each of the above treatment/control methods are described in Hazardous Waste Management[13] and LaGrega *et al.*[14].

REFERENCES

1. S. Gitipour, A. Baghvand and S. Givehchi, *J. Adv. Environ. Res.*, **1**, 34 (2006).
2. A. Aghaii, Investigation of Soil Contamination in Deezaj-Abad due to Leaking of Lead and Zinc Polluted Industrial Waste-water, Master Research, Faculty of Environment, University of Tehran, Tehran, Iran (2006).
3. www.ewaonsine.de/downloads/sludge-en.pdf
4. Guidelines for Safe use of Waste-Water in Agriculture, World Health Organization Symposium, Geneva, www.who.int/water-sanitation-health/wastewater-gsuww/en/index.html (2005).
5. Toxicity Characteristic Leaching Procedure (TCLP), Federal Register Vol. 51, LPC # 203. US.EPA, Cincinnati, Ohio (1990).
6. M. Asadi, R.D.M. Faezee, Z.R. Nabee and M. Vojdanee, Management of Hazardous Wastes, Environmental Protection Agency, Tehran, Iran (2000).
7. A. Abdolvahabi, Distribution of Lead in Soil and Plants, Jahad Daneshgahee, Tehran, Iran (1990).
8. http://www.uwsp.edu/geo/courses/geog100/Lead-InEnv.htm
9. http://www.lenntech.com/periodic-chart-elements/Zn-en.htm
10. http://www.epa.gov/IRIS
11. Test Methods for Evaluating Solid Wastes, Physical, Chemical Methods, www.epa.Gov/epaoswer/hazwaste/test/main.htm
12. P.T. Kostecki and E.J. Calabrese, Hydrocarbon Contaminated Soils and Groundwater: Analysis, Fate, Environmental and Public Health Effects, Remediation, Lewis Publishers Inc. (1991).
13. C.D. Jeffrey, W. Chambers, S. Gitipour, J. Zielenieski, J.F. Rickabaugh, M.J. Mecca and B. Pasin, Handbook on In-Situ Treatment of Hazardous Waste Contaminated Soils, US.EPA, EPA/54012-90/002, Cincinnati, Ohio (1990).
14. M.D. La Grega, P.L. Buckingham and J.C. Evans, Hazardous Waste Management, MacGraw Hill Companies Inc., 1221 Ave. of the Americas, New York, (2001).

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