Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2016, 8(5):629-634

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Assessment of heavy metal pollution in soil of Jhajjar, Haryana-India

Urmila*, Archana Garg and Annu

Chemistry Department, Maharishi Dayanand University Rohtak, Haryana-124001, India

ABSTRACT

Heavy metal contamination of soil of Jhajjar city of Haryana is studied in the present work. Soil samples were collected from Jhajjar-Gurgaon road. Heavy metals from soil samples were extracted by using acid digestion method and their concentration was determined by atomic absorption spectroscopy (AAS). Concentration of lead varies from 17.82 mg/Kg to 93.25 mg/Kg; Copper from 17.00 mg /Kg to 74.13 mg/Kg; Zinc from 11.31 mg/kg to 71.93 mg /Kg; Cadmium from 0.28 mg/Kg to 4.08 mg/Kg and Nickel from 14.05 mg/Kg to 52.87 mg/Kg of soil. Some physicochemical properties of soil like pH, conductance, TDS and percentage organic carbon were also determined. Geo-accumulation index (I_{geo}), Contamination factor (C^i_f) and potential ecological risk factor (RI) is studied to assess the quality of soil. These indexes showed that except Cd all other metals included in study were below contamination level. Pearson's correlation was also applied on physicochemical properties and metals concentration to study interrelationship.

Key words: Heavy Metal, soil, Geo-accumulation index, Potential ecological risk factor, Correlation

INTRODUCTION

In most of developing countries human activities like industrialization, agricultural activities, automobiles and anthropogenic activities are leading to soil pollution. A number of pollutants are added day by day in our environment; heavy metals are one of them. They are more hazardous due to their persistency and tendency of accumulation in biota. Exhaust emission and fossil fuel were identified as main source for metallic pollution especially for road side soil. Fossil fuels contain many kinds of heavy metals which are emitted during the combustion [1-3]. In road side soil, the wear of auto tires, degradation of parts and greases, peeling paint and metals in catalysts are all suspected as sources of heavy metal pollution due to automobiles [4-6]. Some of these metals like Cu, Zn, Mn, Fe, Co, Ni are essential elements but toxic at high level [7]. Heavy metals like lead, cadmium, mercury are toxic even at low concentration to the brain, kidney, reproductive system and cardiovascular system [8].

To analyze the contamination of soil different analytical methods are in use, Pollution index is one of them [9]. Contamination factor, pollution load index, enrichment factor, ecological risk index, and geo-accumulation index are example of single indices. Geo-accumulation index is used to quantify metals in soil and also their health risk grades [10-11]. Potential ecological risk is the statistical tool used to determine ecological risk of heavy metals in soils by using toxic response factor of each metal.

In the present study geo accumulation index, contamination factor and potential ecological risk index was determined for Pb, Cu, Zn, Cd and Ni. The main objectives of this study are: 1) to determine if concentration of any metal exist up to toxic level in environment, 2) to study Interrelationship of these heavy metals with some other parameters of soil.

EXPERIMENTAL SECTION

i) Sampling Site

Jhajjar district came into existence on July 15, 1997. It was carved out of Rohtak district. It came under Hot and semi Arid South Eastern Agro climatic Zone. The district lies between 28° 19’ to 29° 18’ North latitude and 76° 13’ to 77° 13’ East longitudes. It is surrounded by Rohtak district on the North, Rewari and Gurgaon districts in the South, the National Capital Delhi in the East and Bhiwani district in the West. The farming sector today is undergoing to a dual nexus of stress in agriculture. The soil is classified as alluvial having loamy sand texture.

ii)Sample collection

Three locations were selected randomly on Jhajjar-Gurgaon highways of Jhajjar city. Samples were collected from road side soil designated as R1, R2, R3 and agricultural land designated as F1, F2 and F3. Samples were collected in the month of March, July and November of year 2013 and 2014. Soil samples were taken from three depths at each site i.e. 0-5 cm, 5-10 cm and 10-15 cm. Ten soil samples were collected from each site and mixed thoroughly to get uniform sample. These samples were stored in polythene bags and brought to laboratory for further study.

iii) Extraction of metal from soil samples

In the laboratory soil samples were air dried and heated in oven at 100° C till constant weight. They were powdered and passed through 2 mm sieve to get uniform composition. Then 5 g of soil sample was taken in 250 ml beaker and 50 ml distilled water, 5 ml HCl and 0.5 ml HNO_3 was added to the beaker. Beaker was covered with watch glass and heated on hot plate until 15 ml left. Cooled the solution and filtered through whatman filter paper No. 42. Volume of solution was made 50 ml by using double distilled water [12-13]. Each sample was prepared in triplicate. Blank was also prepared by using same chemicals but without soil. All apparatus were washed with 2% nitric acid and then with double distilled water. All chemicals used were of AR grade.

Atomic absorption spectrophotometer AAS-4141 (EC Electronics Corporation of India Limited) equipped with a deuterium lamp for background correction was used for determination of heavy metals. Standards were prepared either by using pure metal or by using their salts. Five standard solutions of different concentrations in linear range were prepared for each metal.

pH and conductance of soil was measured by preparing a solution of 20 g soil in 100 ml double distilled water (ratio of 1:5). It was stirred for 15 minutes and then left to settle down for an hour. pH was measured by using Eutech instrument pH 510 meter and conductance was measured by using microsil conductometer.

Statistical analysis was done by using EXCEL and IBM SPSS-20. Statistical significance was determined at 95% confidence level.

iv) Pollution indices and statistical analysis

a) Geo accumulation index (I_{geo})

Geo accumulation index is used for assessment of soil quality. It was developed for the global standard shale values [14]. The formula used for the calculation of *Igeo* is expressed as follows:

$Igeo = \log_2 (Cn/1.5\ Bn)$

Here, *Cn* is the measured concentration in the soil for metal *n*, *Bn* is the background value for the metal *n*, and the factor 1.5 is used because of possible variations of the background data due to litho-logical variations. The quantity *Igeo* is calculated using the global average shale data [15].

b)Contamination Factor

This is a single pollution index, based on the values of the Concentration of metal in soil. Contamination factor (C^i_f) of each metal in the soil was calculated as:

$C^i_f = C_{m\ Sample} / C_{m\ Background}$

Where, $C_{m\ Sample}$ was measured concentration of heavy metal in soil and $C_{m\ Background}$ was the average shale concentration of the metal.

c) Potential ecological risk index

This index is used to determine the overall contamination level of soil. It was assessed according to Hakanson [16] to know the toxic level of metal and response of environment. The calculating method is given below-

$E^i_r = T^i_r \times C^i_f$

$RI = \sum_{i=0}^{n} E^i_r$

Where E^i_r is ecological risk factor for a single metal and RI is potential ecological risk factor for overall contamination. C^i_f is contamination factor for metal. T^i_r is the metal toxic response factor according to Hakanson [16], values for different metals are as- Zn =1, Cu = Ni = Pb = 5, Cd = 30.

d)Pearson's correlation

Pearson's correlation coefficient is a statistical tool to determine variation of matrix of heavy metal and some physicochemical parameters. It is used to detect any linear relationship between two quantitative variables.

RESULT AND DISCUSSION

i) Descriptive analysis of soil samples

Total 108 soil samples were collected from six locations and each sample was in triplicate. Heavy metal concentration of lead, zinc, cadmium, copper and Nickel at different location with physicochemical properties of soil is given in Table-1. Conductance of soil samples vary from 0.17 mS cm^{-1} to 0.83 mS cm^{-1} with an average value of 0.38 mS cm^{-1}. Total dissolved solid (TDS) was measured, value varied from 0.11 ppt to 0.55 ppt with an average value of 0.25 ppt. pH shows slightly alkaline nature of soil. It varies from 6.75 to 8.29 having overall average value 7.49. Percentage organic carbon of soil varies from 0.11 % to 2.49 % having mean value of 1.05%.

Table-1: Some physicochemical properties and concentration of heavy metals (mg/Kg of dry soil) present in soil

Month	Site	Conductance (mS cm^{-1})	TDS (ppt)	pH	% O.C.	Cu	Zn	Cd	Pb	Ni
Mar-13	R1	0.46	0.30	8.29	0.11	24.03	29.34	0.76	42.28	29.53
	R2	0.51	0.34	7.51	0.13	20.70	25.08	0.57	39.70	15.59
	R3	0.24	0.16	7.54	0.12	28.53	16.93	0.47	37.01	28.46
	F1	0.23	0.15	7.51	1.84	17.97	13.37	0.44	38.91	26.58
	F2	0.18	0.12	7.42	1.93	17.00	25.56	0.43	35.21	20.60
	F3	0.64	0.42	7.81	1.59	23.05	17.45	0.56	35.06	15.74
Jul-13	R1	0.67	0.44	8.15	0.16	26.49	28.48	1.30	75.25	29.89
	R2	0.31	0.20	7.26	0.19	22.65	16.93	0.73	68.83	32.45
	R3	0.43	0.28	7.55	0.15	26.63	40.54	0.30	53.96	37.55
	F1	0.29	0.19	7.90	1.06	54.66	25.13	0.28	17.82	24.88
	F2	0.32	0.21	7.23	1.30	33.05	11.31	0.45	63.07	14.05
	F3	0.45	0.29	7.17	1.55	25.14	12.61	0.39	74.11	20.09
Nov-13	R1	0.35	0.23	7.69	0.33	29.73	40.37	0.51	63.55	33.95
	R2	0.60	0.39	6.75	0.79	40.21	25.84	1.71	56.12	31.76
	R3	0.21	0.14	7.15	0.60	36.32	30.57	1.04	52.37	21.30
	F1	0.23	0.15	6.99	1.41	37.92	21.26	0.91	46.76	28.47
	F2	0.23	0.15	7.39	1.50	37.95	22.56	0.81	57.48	31.90
	F3	0.32	0.21	7.65	1.82	40.35	37.03	0.94	60.91	23.63
Mar-14	R1	0.36	0.23	6.98	0.64	36.62	44.26	1.00	71.22	34.57
	R2	0.24	0.16	7.39	0.41	52.19	31.55	1.29	65.43	34.18
	R3	0.23	0.15	7.73	0.58	52.40	55.29	0.89	72.42	37.86
	F1	0.23	0.15	7.79	1.38	34.14	30.87	1.24	68.58	30.26
	F2	0.40	0.26	7.56	1.85	33.23	32.37	1.27	61.53	30.82
	F3	0.33	0.22	7.21	1.55	31.73	21.45	1.49	58.34	38.55
Jul-14	R1	0.17	0.11	7.46	0.38	64.82	43.23	1.69	65.92	41.25
	R2	0.53	0.34	8.18	0.46	66.44	63.34	1.29	67.57	49.85
	R3	0.75	0.49	7.80	0.55	74.13	69.09	3.54	77.22	32.09
	F1	0.37	0.24	7.40	1.55	59.82	50.75	0.65	74.10	34.24
	F2	0.38	0.25	7.77	1.69	58.96	59.67	1.07	66.43	41.25
	F3	0.83	0.55	7.40	2.15	65.60	49.39	1.63	73.07	50.83
Nov-14	R1	0.29	0.19	7.52	0.54	65.79	70.47	2.67	66.21	52.09
	R2	0.58	0.38	7.01	0.12	65.93	65.21	2.34	93.02	48.81
	R3	0.38	0.25	7.11	0.30	65.77	69.24	4.08	92.90	50.06
	F1	0.29	0.19	7.37	2.38	69.88	54.01	2.94	93.25	52.87
	F2	0.31	0.20	7.33	2.49	60.92	50.02	1.96	79.18	50.66
	F3	0.28	0.18	7.83	2.29	68.39	71.93	2.91	76.13	31.13
Average		0.38	0.25	7.49	1.05	43.59	38.12	1.29	62.25	33.55
Standard Deviation		0.17	0.11	0.35	0.76	18.02	18.61	0.95	17.31	10.84

	Cu	Zn	Cd	Pb	Ni
Target level*	36	140	0.8	85	35
Intervention level*	190	720	12	530	210

**Dutch Target and Intervention Values, 2000[18]*

Concentration of Cu ranged from 17.00 mg/Kg to 74.13 mg/Kg with average value 43.59 mg/Kg; Zn ranged from 11.31 mg/Kg to 71.93 mg/Kg with average value 38.12 mg/Kg; Cd ranged from 0.28 mg/Kg to 4.08 mg/Kg with average value 1.29 mg/Kg; Pb ranged from 17.82 mg/Kg to 93.25 mg/Kg with average value 62.25 mg/ Kg and Ni ranged from 14.05 mg/Kg to 52.87 mg/Kg with an average value of 33.55 mg/Kg. Overall average concentration of heavy metals decreased in the order Pb > Cu > Zn > Ni > Cd. Concentrations of heavy metals except Cu and Zn were below those measured in road side soil of Rohtak, Haryana-India [17].

Comparative account with Dutch soil standards showed that only Copper and Cadmium were above target value but concentration of all metals were below intervention value.

ii)Geo accumulation index (I_{geo})

According to Singh *et al.,* [19] the intensities for geo-accumulation index (Igeo) of element as per their values are classified into seven different classes as given in Table-2.

Table-2: Geoaccumulation index (*Igeo)* for heavy metal contamination of soil

Igeo class	*Igeo* value	Contamination level
0	$I_{geo} < 0$	Background Concentration
1	$0 < Igeo < 1$	Uncontaminated
2	$1 < Igeo < 2$	Uncontaminated to moderately contaminated
3	$2 < Igeo < 3$	Moderately contaminated
4	$3 < Igeo < 4$	Moderate to Highly contaminated
5	$4 < Igeo < 5$	Highly Contaminated
6	$5 < Igeo$	Severely contaminated

In present study average shale concentration was taken as background value, which has Cu 45mg/Kg; Zn 90 mg/Kg; Ni 68 mg/Kg; Cd 0.3 mg/Kg and Pb 20 mg/Kg of soil. Average concentration of metals at each site was determined and compared with average shale value to measure Geo accumulation index at different site and shown in table-3.

Table-3: Contamination level of soil in terms of geo-accumulation index of different heavy metals

Site	I_{geo} Cu	I_{geo} Class	I_{geo} Zn	I_{geo} Class	I_{geo} Cd	I_{geo} Class	I_{geo} Pb	I_{geo} Class	I_{geo} Ni	I_{geo} Class
R1	-0.71	0	-0.94	0	1.55	2	1.09	2	-1.47	0
R2	-0.60	0	-1.05	0	1.55	2	1.12	2	-1.53	0
R3	-0.51	0	-0.96	0	1.93	2	1.10	2	-1.56	0
F1	-0.56	0	-2.05	0	1.26	2	0.92	1	-1.63	0
F2	-0.75	0	-2.01	0	1.15	2	1.01	2	-1.69	0
F3	-0.67	0	-1.95	0	1.55	2	1.07	2	-1.77	0

It was observed that Cu, Ni and Zn at all sites were below contamination level. Uncontaminated to moderately contaminated level was observed in Lead and Cadmium.

iii) Contamination Factor (C^i_f)

Contamination factor is a single index used to determine the contamination of soil. The C^i_f values and contamination level of the soil are presented in Table-4.

Table 4: Contamination categories of soil based on C^i_f

Class	C^i_f	Contamination level
1	$C^i_f < 1$	Low contamination
2	$1 < C^i_f < 3$	Moderate contamination
3	$3 < C^i_f < 6$	Considerable contamination
4	$C^i_f > 6$	High contamination

In the present work contamination factor was determined by taking average shale value as background concentration of heavy metal in soil. Contamination level of study area is presented in figure-1. High contamination of lead and cadmium was observed at all sites.

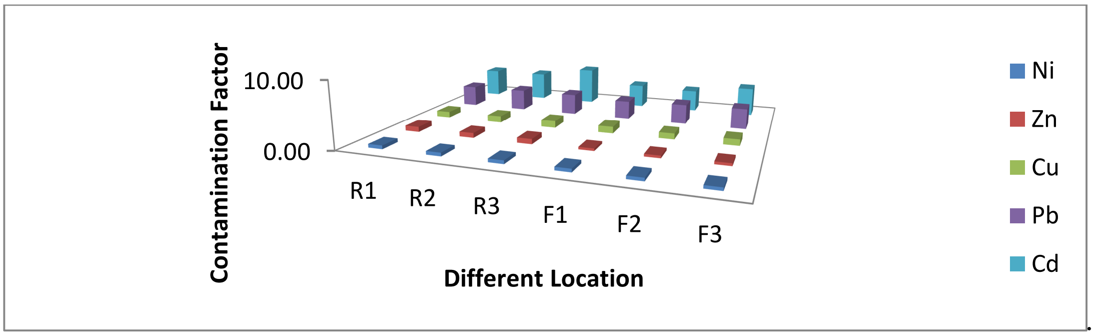

Figure-1: Contamination factor of heavy metals measured at different site

iv) Potential ecological risk index

Ecological risk index and Potential ecological risk index are categorised in five and four categories respectively as given in Table-5.

Table-5: Different categories of Ecological risk index and Potential ecological risk index.

E^i_r	Grades of ecological risk of metal	RI	Grades of overall risk of contamination
$E^i_r < 40$	Low	RI < 150	Low
$40 < E^i_r > 80$	Moderate	150 < RI >300	Moderate
$80 < E^i_r > 160$	Considerable	300 < RI > 600	Considerable
$160 < E^i_r > 320$	High	600 < RI	Very high
$320 < E^i_r$	Very high		

Value of Ecological risk index and Potential ecological risk index of metals of study area are given in Table-6. It was observed that average monomial risk factor for all selected metals except Cd were below 40 which indicate low risk to surroundings. For cadmium it is 129.25 which show considerable contamination of the metal. The overall Potential ecological risk index was within the range of 122.06 to 196.48 with an average value of 152.68 which indicate moderate contamination of soil.

Table-6: Ecological risk index and Potential ecological risk index of different metals in study area

Site	Ecological risk index					Potential ecological risk index
	Cu	Zn	Cd	Pb	Ni	
R1	4.58	0.78	132.11	16.02	2.71	156.21
R2	4.97	0.72	132.06	16.28	2.61	156.63
R3	5.25	0.77	171.83	16.08	2.54	196.48
F1	5.08	0.36	107.67	14.14	2.42	129.67
F2	4.47	0.37	99.78	15.12	2.32	122.06
F3	4.71	0.39	132.06	15.73	2.21	155.09
Average	4.84	0.57	129.25	15.56	2.47	152.68

v)Pearson's correlation

Pearson's correlation was studied between heavy metal concentrations of soil which may contribute in elucidation of common source of metals. Some significant correlations were obtained between metals shown in Table 7.

Table 7: Correlation coefficients of heavy metal concentration of soil

		Cu	Zn	Cd	Pb	Ni
Cu	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	108				
Zn	Pearson Correlation	.701**	1			
	Sig. (2-tailed)	.000				
	N	108	108			
Cd	Pearson Correlation	.600**	.606**	1		
	Sig. (2-tailed)	.000	.000			
	N	108	108	108		
Pb	Pearson Correlation	.530**	.523**	.530**	1	
	Sig. (2-tailed)	.000	.000	.000		
	N	108	108	108	108	
Ni	Pearson Correlation	.581**	.598**	.497**	.492**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	108	108	108	108	108

***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*

Source of contamination may be automobiles as all these metals are the part of automobile; Zinc as a component of galvanizes parts of vehicle, lubricating oil, tyres; Lead by gasoline; Copper as mechanical part. By fuel combustion and wear and tear of vehicles these metals deposit in soil. Lead free fuel is used now a days but lead which is already deposited, still present in the soil.

CONCLUSION

The result showed contamination of soil but below the intervention level i.e. when remediation is necessary. Cadmium contamination is highest among all metals studied. Geo accumulation showed moderate contamination of lead and Cadmium. The monomial ecological risk factor is in the order Cd> Pb >Cu >Ni >Zn. Cd poses high risk to ecosystem with a value of E^i_r 129.25. Potential ecological risk index provided a combined effect of pollutants and showed a moderate contamination of soil. Significant correlation between metals may be due to their common source.

Acknowledgement
The authors are grateful to Chemistry Department of M. D. University, Rohtak for providing the necessary facilities. We are also thankful to Department of Pharmaceutical sciences of M. D. University, Rohtak for providing facility of Atomic Absorption Spectroscopy.

REFERENCES

[1] BJ Alloway. Heavy Metals in Soils, Blackie Academic and Professional, London, UK, **1990.**
[2] R Leygonie, *Pollution Atmospherique.* **1993,** 35, 63–74.
[3] N Pirrone; P Costa; JM Pacyna, *Water Science and Technology,* **1999**, 39, 1–7.
[4] M Sadiq; I Alam; A El-Mubarek; HA Al-Mohdhar, *Bulletin of Environmental Contamination and Toxicology,* **1989** 42, 743–748.
[5] C Wei; GM Morrison, *The Science of the Total Environment* **1994,** 146/147, 169–174.
[6] C Pecheyran; B Lalere; OFX Donard, *Environmental Science and Technology* **2000,** 34, 27–32.
[7] SK Awashthi, Prevention of Food Adulteration Act no 37 of 1954. Central and state rules as amended for 1999, 3rd ed. New Delhi: Ashoka Law House, **2000.**
[8] World Health Organization, Technical Report Series No. 837. Evaluation of Certain Food Additives and Contaminants, WHO, Geneva, **1993.**
[9] KL Speneer; CL Macleod, *Hydrology and Earth System Sciences*, **2002,** 6, 989-998.
[10] DM Grath; C Zhang; OT Carton, *Environ Pollut*. **2004,** 127:239–248
[11] PS Harikumar; UP Nasir; MP Rahman, *Int. J. Environ. Sci. Technol.* **2009,** 6(2):225–232
[12] D ASTM, Standard Practices for Extraction of Trace Elements from Sediments. ASTM International, 100 Barr Harbour Drive, West Conshohocken, United States, **1981,** 3974, p 393-395.
[13] International Institute for Tropical Agriculture (IITA), Selected methods for Soil and Plant Analysis. Oyo road, Ibadan, Nigeria. Anal **1979,** 102.
[14] G Muller, *Geojournal*, **1969,** 2 (3), 108-118.
[15] KK Turekian; KH Wedepohl, *Geological Society of America Bulletin*, **1961,** 72 (2), 175-192.
[16] L Hakanson, *Water Research*, **1980,** 14: 975–1001.
[17] Urmila; Annu; A Garg, *International journal of science, engineering and technology,* **2015**, 3(1), 341-346.
[18] Dutch Target and Intervention Values, **2000.**
[19] AK Singh; SI Hasnain; DK Banerjee, *Environmental Geology*, **2003**, 39, 90-98.