Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

Vol. 8	No. 3	pp. 613-618	2009

Original Research Paper

Heavy Metal Status of Soils in Industrial Belts of Coimbatore District, Tamil Nadu

T. Sherene
Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore-641 003, T.N., India

Key Words:
Industrial wastes
Heavy metals
Soil contamination
Industrial belts

ABSTRACT

A study was conducted to investigate the heavy metal contamination of soils in the vicinity of industries in and around Coimbatore city of Tamil Nadu. Categorically the soils were collected from electroplating, textiles, casting, foundry and sewage water irrigated fields. The concentration of total Cd , Cu , Mn , Fe , Pb , Ni, Cr, Zn ranged from 0.3-4.6, 18.4-404.2, 28.1-2514.72, 2064.83-8577.14, 7-170, 3.0-157.0, 3.3-593.99, 14.56-651.82 mg/kg respectively. The total metal content was high in soils of electroplating industries. In all the industries, Cd was found above the background metal levels. The total Ni concentration was very high in sewage water irrigated fields followed by electroplating industries. Most of the metals in contaminated soils were in the value of maximum tolerable level in the vicinity of industrial sites of Coimbatore city.

INTRODUCTION

Industrial wastes and effluents are being discharged randomly on soils, into canals, rivers, along road sides or in the vicinity of industrial operations without any treatment in Coimbatore district of Tamil Nadu. They pollute productive soils, natural water systems as well as groundwater. Industrial effluents and municipal wastewater usually contain high amount of heavy metals such as As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb and Zn (Arora et al. 1995). Their continuous use on agricultural land may result in metal accumulation in surface soil (Gupta et al. 1986). Some heavy metals are essential in trace amounts like Zn, Cu, Fe, Mn, Mo and Co for plants, and in addition Cr, Ni, Sn for animals, whereas As, Cd, Hg and Pb have not been known to have any function for either plants or animals (Greenland & Hayes 1981). A number of cases of health problems related to environmental Cd and Hg poisoning and elevated levels of Pb in the blood of infants have been reported (Singh & Steinnes 1994). Anthropogenic pollution of heavy metals and their phytotoxicities have been reported by many other investigators (Schindler 1991, Krosshavn et al. 1993). Against the background information described above, the aim of this investigation was to investigate the levels and causes of heavy metal contamination in soils in the vicinity of industries in and around Coimbatore city.

MATERIALS AND METHODS

A rapid traverse was made in various taluks of Coimbatore district, where major industries are located, to know the level of soil contamination by heavy metals with the assistance of Tamil Nadu Pollution Control Board and farmers of the study area.

Five sampling sites were selected in Coimbatore city. The industries are localized in an unorganized manner; about 10 soil samples were collected from each industrial surrounding. The first study

Table l: General characteristics and some selected properties of the experimental soils.

Industrial areas	Soil Series	pH	OC%	CEC Cmol(P^+)/kg
1. Electroplating	Palathurai and Peelamedu	8.02-8.97	2.19-3.99	40.0-50.20
2. Textile	Irugur	7.75-8.71	0.18-0.94	9.80-16.40
3. Casting	Palathurai	8.08-8.74	1.95-2.95	28.0-37.20
4. Foundries	Peelamedu	8.43-9.09	2.10-3.15	42.30-51.50
5. Sewage water irrigated field	Noyyal, Peelamedu	7.34-8.01	2.2-5.3	25.30-50.80

area was the electroplating industrial areas. There are about 1194 electroplating industries located inside the city. Some of them are in clusters. Most of the electroplating industries are seen in black soils (Vertisols). The study area was nearby the industries and also 1 km away from the main disposal point of wastes and effluents. Agricultural fields are located nearby the factory areas, situated mainly at low lying areas. The common agricultural crops are, paddy, sorghum, coconut and pulses.

The second study area was textile industries located mainly at Therkupalayam, Sirumughai, Karamadai and Mettupalayam, the soils of which are coming under the order Alifisol. There are about 4491 textile industries located around Coimbatore city. Third study area was casting industries. They are located in Kurichi SITCO, which come under Alfisols. Around 3892 casting industries are there. The fourth experimental site was foundries, mainly located in Peelamedu and Avarampalayam. The fifth experimental site is the sewage water irrigated field.

A total of 50 soil samples in the five industrial sites were collected from the depth of 0-15 cm. Excavating micropit did sampling and collection was started from the lower site of surface horizon to avoid contamination. The collected soil samples were thoroughly mixed, air dried in a clean environment to avoid contamination and ground to pass through 2 mm sieve. The selected physical and chemical properties were determined following standard procedures (Piper 1966, Jackson 1973).

Soil pH was determined in a 1:2.5 soil to water ratio. The suspension was allowed to stand overnight prior to pH determination. Electrical conductivity was determined in saturation extract of soils using conductivity bridge. The total concentration of Cd, Cu, Mn, Ni, Pb, Fe and Zn in soils was determined after digestion with concentrated HNO_3-$HClO_4$ (2:1) acids. The available Cd, Cu, Mn, Ni, Pb, Fe and Zn contents of soils were extracted with 0.005M DTPA-extractant (Lindsay & Norvell 1978). All the heavy metals (total and extractable) were estimated by using atomic absorption spectrophotometer.

The results were statistically evaluated by Pearson correlation coefficients stepwise regression analysis, analysis of variance and descriptive statistics using IRRISTAT programme.

RESULTS AND DISCUSSION

General characteristics and some properties of the soils are presented in Table 1. The range and standard error of mean (SEM) of total and extractable Cu, Mn, Fe , Zn, Cd, Cr, Ni and Pb contents in soils are presented in Table 2. The higher concentrations of Fe, Mn and Zn were noticed in all the industrial areas. The highest concentration of Cu (404.20 mg/kg) was found in electroplating industrial areas, and the lowest in the textile industrial areas. The DTPA-Cu content was higher in electroplating and sewage water irrigated fields (27.31 mg/kg). Cu is used for metal plating (Manahan 1991) and in electrical industries, windings, water pumps, stills, roofing materials and pigments (Scheinberg 1991) which might have contaminated the soil around the industry.

Table 2: Heavy metal status of soils in the vicinity of industries (mg/kg).

Metals	Total heavy metals in soil (HNO_3-$HClO_4$)			DTPA-extractable heavy metal in soils		
	Range	Mean	SEM	Range	Mean	SEM
1. Electroplating Industrial Areas (n = 10)						
Cd	0.40-4.60	2.07	436.94	2.91-34.06	8.63	3.04
Cu	18.40-404.20	116.83	214.11	3.15-27.31	13.14	2.63
Mn	55.60-1938.11	574.99	74.70	3.81-23.41	14.69	2.92
Fe	3665.01-7874.07	6529.56	37.28	0.28-29.32	9.22	2.87
Pb	63.0-170.0	106.33	11.81	0.66-21.38	3.92	1.97
Ni	23.90-157.0	71.87	10.64	3.18-31.8	15.63	2.57
Cr	30.60-581.97	153.49	0.39	0.01-1.20	0.31	0.16
Zn	22.57-651.82	200.29	57.12	11.28-181.50	51.53	18.33
2. Textile Industrial Areas (n = 7)						
Cd	0.40-2.10	1.30	756.29	1.34-36.17	8.12	4.74
Cu	17.70-96.0	58.29	200.88	0.91-12.31	6.79	1.85
Mn	71.20-1518.49	510.63	16.03	4.31-21.31	11.91	2.19
Fe	2064.83-7999.31	6087.71	11.33	2.78-10.31	6.94	1.25
Pb	9.0-134.0	54.0	1.11	0.01-0.72	0.26	0.13
Ni	63.90-108.10	76.39	9.02	8.31-17.31	5.39	1.70
Cr	15.0-256.60	81.26	5.85	8.31-29.12	19.82	2.57
Zn	58.98-160.29	98.310	18.00	0.08-5.52	1.43	0.81
3. Casting Industrial Areas (n = 7)						
Cd	0.30-1.50	1.09	146.97	1.58-3.54	2.02	0.25
Cu	18.40-148.80	74.76	305.89	1.97-21.28	11.30	3.29
Mn	28.10-2514.72	981.49	39.45	3.51-14.51	8.95	1.54
Fe	6704.19-8030.34	7381.08	17.66	0.30-33.47	13.68	4.43
Pb	7.0-110.50	87.26	0.14	0.01-0.07	0.02	0.01
Ni	18.90-72.20	39.56	11.79	1.08-10.51	3.28	1.77
Cr	3.30-71.80	23.16	28.98	0.66-11.81	4.46	1.59
Zn	46.94-355.69	132.11	7.28	4.58-12.81	9.12	1.22
4. Foundry Industrial Areas (n = 8)						
Cd	0.5-2.0	1.32	465.12	1.9-23.2	6.22	2.48
Cu	24.3-350.49	124.69	132.37	0.98-3.32	2.02	0.33
Mn	165.1-1252.83	498.22	41.96	0.22-25.19	9.56	3.45
Fe	3858.62-8577.14	6754.52	42.74	0.38-44.86	17.82	5.00
Pb	30.0-101.0	55.01	0.16	0.01-0.40	0.06	0.06
Ni	3.0-157.0	67.20	123.23	17.11-23.28	5.05	1.55
Cr	20.8-193.99	86.85	7.32	0.36-19.76	7.34	4.92
Zn	14-56-378.17	112.89	15.88	9.58-31.52	13.15	3.01
5. Sewage Water Irrigated Fields (n = 10)						
Cd	0.8-2.4	1.67	0.14	0.03-1.20	0.76	0.09
Cu	18.1-105.2	64.30	8.01	0.30-28.75	12.80	2.87
Mn	45.10-1861.89	791.47	225.49	4.31-112.80	39.08	11.95
Fe	4616.55-8559.31	6998.92	330.46	1.22-36.93	7.32	3.39
Pb	3.0-159.0	87.70	15.31	10.36-39.78	9.23	4.17
Ni	38.9-116.8	77.05	10.17	12.89-64.31	31.82	5.25
Cr	45.6-493.99	81.84	82.42	18.36-128.31	19.96	3.16
Zn	28.16-363.13	146.30	34.71	3.80-33.81	20.29	2.97

Table 3: Extent of contamination according to total heavy metal contents in soils (mg/kg).

Metals	Group 1	Group 2	Group 3
1. Electroplating Industrial Areas (n = 10)			
Cd	< 0.2 (0)	> 0.2-3.0 (80)	> 3.0 (20)
Cu	< 27 (20)	> 27-100 (40)	>100 (40)
Pb	< 20 (0)	> 20-100 (50)	> 00 (50)
Ni	< 22 (0)	>22-50 (20)	> 50 (80)
Zn	< 68 (40)	> 68-< 300 (30)	> 300 (30)
2. Textile Industrial Areas (n = 7)			
Cd	< 0.2 (0)	> 0.2-< 3.0 (100)	> 3.0 (0)
Cu	< 27 (29)	> 27-< 100 (71)	> 100 (0)
Pb	< 20 (29)	> 20-< 100 (43)	> 100 (28)
Ni	< 22 (0)	> 22-< 50 (0)	> 50 (100)
Zn	< 68 (29)	> 68-< 300 (71)	> 300
3. Casting Industrial Areas (n = 7)			
Cd	< 20 (0)	> 0.2-< 3.0 (100)	> 3.0 (0)
Cu	< 27 (14)	> 27-< 100 (57)	> 100 (29)
Pb	< 20 (14)	> 20-< 100 (43)	> 100 (43)
Ni	< 22 (17)	> 22-< 50 (50)	> 50 (33)
Zn	< 68 (29)	> 68-< 300 (57)	> 300 (14)
4. Foundry Industrial Areas (n = 8)			
Cd	< 0.2 (0)	> 0.2-< 3.0 (100)	> 3.0 (0)
Cu	< 27 (13)	> 27-< 100 (50)	> 100 (37)
Pb	< 20.0 (0)	> 20.0-< 100 (86)	> 100 (14)
Ni	< 22.0 (13)	> 22.0-< 50.0 (0)	> 50 (87)
Zn	< 68.0	> 68.0-< 300	> 300
5. Sewage Water Irrigated Field (n = 10)			
Cd	< 0.2 (0)	> 0.2-< 3.0 (100)	> 3.0 (0)
Cu	< 27 (10)	> 27-< 100 (80)	> 100 (10)
Pb	< 20.0 (11)	> 20.0-< 100 (33)	> 100 (55)
Ni	< 22.0 (0)	> 22.0-< 50.0 (25)	> 50 (75)
Zn	< 68.0 (10)	> 68.0-< 300 (70)	> 300 (20)

Percentage of samples in parantheses; Group 1 = Background level; Group 2 = Maximum tolerable level; Group 3 = In excess of tolerable level; Background concentration for Cd = 0.01-0.2, Pb = 12.20 mg/ kg, Cu, Ni and Zn = 27, 22 and 68 mg/kg respectively. Tolerable total concentrations are, 3, 100, 50, 100 and 300 mg/kg for Cd, Cu, Pb and Zn respectively (Kloke 1980).

The highest total Ni concentration (157 mg/kg) was seen in the electroplating industrial areas followed by sewage water irrigated fields. The favourable pH of the soils enhanced their solubility. Similarly, the highest Cr pollution (582 mg/kg) was noticed in electroplating industrial areas followed by sewage water irrigated fields. The textile industrial soils also showed considerable Cr content.

The highest Ni and Cr content in electroplating and sewage water irrigated fields might be due to discharging liquid wastes with excessive heavy metals because of the vast utilization of hard chrome and Ni salts for plating processes. Also, effluents discharged into sewage water contaminated the agricultural fields, which are irrigated by sewage water.

The highest concentration of total Pb in the electroplating industries (170 mg/kg) is not only a problem with respect to plant nutrition and the food chain; they may constitute a direct health haz-

ards as well. The electroplating industries are mainly located in black soils of Coimbatore city, and there may be the ecological implications associated with Pb poisoning (Thorton et al. 1985).

The extent of contamination due to heavy metal deposition in different industrial sites are presented in Table 3. The total metal content of the soil samples showed wide range of values from background to a level considered to reflect severe contamination. The extent of contamination expressed as percentage was identified by using information of background levels of total Cd, Pb, Ni, Cr, Cu, Zn, Mn and Fe for Indian soils (Kloke 1980).

The cadmium content was found in the group of maximum tolerable levels in all the industries except sewage water irrigated field, where the Cd content was in the group of excess tolerable level. The excess tolerable level was found for Ni in all the industries except for casting and foundry industrial areas where Ni concentration in background levels were 17 and 13% respectively. In electroplating industries, the concentration of Ni was in excess tolerable level followed by Pb and Cu.

The higher concentrations of heavy metals were found in soils of the sewage irrigated fields followed by electroplating industries. This makes the plant and soil biota living there quite vulnerable to metal toxicity. Moon et al. (1991) investigated Cd, Cu, Pb and Zn levels in top soils of an industrial complex and found that these metals contributed significantly towards environmental contamination resulting from industrial operations.

CONCLUSION

The results of the present investigation suggest that the industrial solid wastes, effluents and emission of gases are mainly responsible for heavy metal contamination of the urban and semiurban environment of Coimbatore city. The emissions of Cd, Cu, Fe, Mn, Ni, Pb and Zn in the electroplating, casting, foundry, textiles and sewage water irrigated fields led to contamination of soils in the closer vicinity. The present study should be regarded as an indication of detailed investigation on heavy metals (such as solid phase speciation, mobility, adsorption and desorption studies) of terrestrial ecosystems in the vicinity of other industries in Coimbatore city of Tamil Nadu.

ACKNOWLEDGEMENT

The author is very much thankful to Government of India, Ministry of Environment and Forestry, New Delhi, for giving financial assistance to carry out this work.

REFERENCES

Arora, B.R., Azad, A.S., Singh, B. and Sekhon, G. S. 1995. The heavy metal concentration of municipal wastes and industrial effluents. Indian J. Agric. Sci., 45: 80.

Greenland, D.J. and Hayes, M.H.B. 1981. The Chemistry of Soil Processes. John Wiley and Sons, pp. 593-619.

Gupta, A.P., Tntil, R.S. and Singh, A. 1986. Proc. C.S.I.O., Chandigarh, India.

Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India, New Delhi.

Kloke, A. 1980. Orientierungsdaten fur tolerierbare Gesamtgehalte einiger Elemete in Kulturboden. Mitteilungen der VDLUFA. Heft., (1-3): 9-11.

Krosshavn, M., Steinnes, E. and Varsakog, P. 1993. The heavy metal contamination of soils due to anthropogenic activities. Water, Air and Soil Pollution, 71: 185.

Lindsay, W.L. and Norvell, W.A. 1978. Soil Sci. Soc. Am. J., 42: 421.

Manahan, S.E. 1991. Environmental Chemistry. Fifth Edition, Lewish Publishers, Chelsea, MI.

Moon, C.H., Lee, Y.S. and Yoon, T.H. 1991. Environmental Technology. 12: 413.

Piper, C.G. 1966. Soil and Plant Analysis. Hans Publication, Bombay.

Scheinberg, I.H. I991. Copper. In: Metals and Their Compounds in the Environment: Occurrence, Analysis and Biological Relevance (Merian, E., Eds) VCH Publishers, New York, pp. 893-908.

Schindler, P.W. 1991. In: Vernet, J.P. (ed.). Heavy Metals in the Environment. Elsevier Science Publ. Co. Inc., Amsterdam, pp. 95-124.

Singh, B.R. and Steinnes, E. 1994. In: R. Lal and B. Stewart (eds.) Soil Processes and Water quality. Lewis Publishers, Chelsea, Mich., pp. 233-271.

Thorton, L., Gulbard, E.B., Moorcroft, S., Watt, J.M., Weatherly, M., Thompson, M. and Thomas, J.F.A. 1985. Environ. Technol. Letters, London, 6: 137.