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Study of Heavy Metal Concentrations in the Industrial Waste Effluents

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The concentrations of twelve different heavy metals in the waste effluents were studied, namely As, Cd, Pb, Cu, Zn, Mo, V, Ni, Hg, Se, Cr and Mn. Waste effluents were collected from different locations around various chemical industries. Samples were collected at regular interval of two months, during day time. Each samples were analysed for heavy metal concentration using standard methods and by ICP-AES technique at RSIC, I.I.T., Mumbai.

INTRODUCTION

The rapid pace of industrialization even in underdeveloped countries is intensifying the problem of pollution. According to Kudesia, **Environmental pollution by metals is a greatest sin a man is doing against Universe.**[1] Toxic metals to a large extent are dispersed in the biosphere through industrial effluents, organic wastes, refuse burning, transport and power generation. Metallic pollutants are ultimately washed out of the air by rain to the land or the surface of the water ways.

Heavy metals and their salts, unlike most other pollutants are insidious pollutants and non-biodegradable. They persist in nature for long period and toxic to living organisms at a fairly low concentrations and tend to either biologically magnify or accumulate in plants or animals systems. When any such chemical is released from a large area like industrial plant, it enters the environment and causes environmental pollution.

The major cause of heavy metal toxicity in common is its accumulation in water. Regardless of the source, most metallic wastes eventually end up in surface and subsurface waters. In addition to the direct discharge of industrial wastes large quantities of many metals which are released to the air by industrial plants, incinerators, automobiles, ultimately reach water after sedimentation or precipitation from the air by rain or snow. Solid wastes disposed on the land also contribute to the water pollution by adding metals to run-off from the disposed area and by leaching of the soluble metallic salts by leachate.

Heavy metal salts are harmful and insidious pollutants because of their non-biodegradable nature and their potential to cause adverse effects in human

being at certain levels of exposure and absorption[2]. Such metal pollutants inhibits the biological activity, which is responsible for self-purification of water bodies, even at low concentrations. Once accumulated, these metals disturb the metabolism of living organisms.

Various chemical industries, situated in Tarapur Industrial area, discharge their waste effluents, rich in organic and inorganic load, in open spaces, which ultimately find its way in water bodies. Thus, polluting surface and subsurface water and to some extent ground water. In developing country like India, use of ground water along with the surface water resources is an utmost necessity in the recent time to cope up with growing requirements of water in all sectors.[3]

The solubility of these metals depend on pH. Dean *et al*[4] reported that very small heavy metal ion concentrations is expected in neutral solutions. Low concentrations of heavy metals in aquous phase is also due to their tendency for sorption on particulate matter including suspended sediments, bed sediments and small organisms. In present work, an attempt is made to evaluate the quality of waste effluents, with respect to the heavy metal concentration, discharged from various industries, in chemical zone of Tarapur Industrial Area in Thane district of Maharashtra (India).

EXPERIMENTAL

The samples of the waste effluents fromsix different collection sites (P1 to P6) were collected on bimonthyl basis. All the samples were stored in airtight polythene bottles and proper sampling procedure was followed as reported in the literature[5]. Each effluent samples were analysed using standard methods[6] by atomic absorption spectroscopy. The concentration of heavy metals was determined by atomic emission spectrometer and inductive coupled plasma[7]. Calibration curve for each metal ion was constructed and then amount of metal was calculated from the curve. The results of this findings are tabulated in the Table 1 to 6, while averge concentrations of these metal ion is summerized in Table 7 and 8. The results are also represented by bar diagram in Figures 1 to 6.

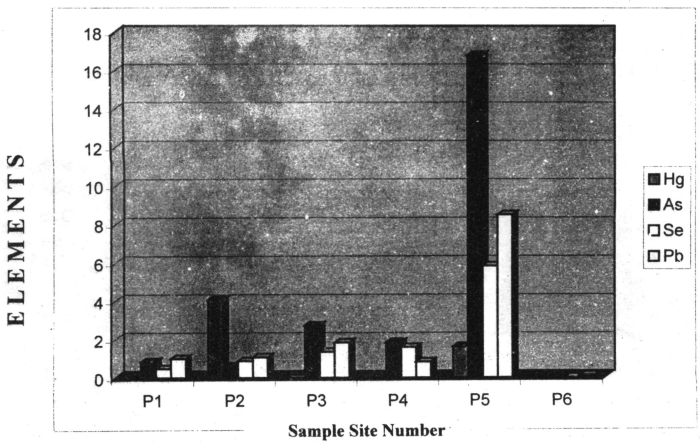

Fig. 1 Variation in heavy Metal Concentration of the Waste Effluents with respect to Season

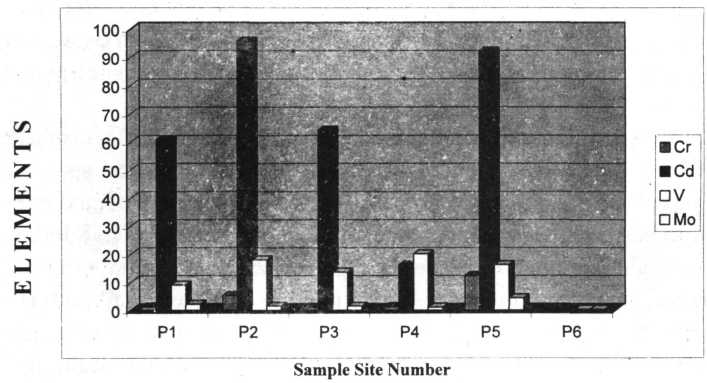

Fig. 2 Variation in heavy Metal Concentration of the Waste Effluents with respect to Season

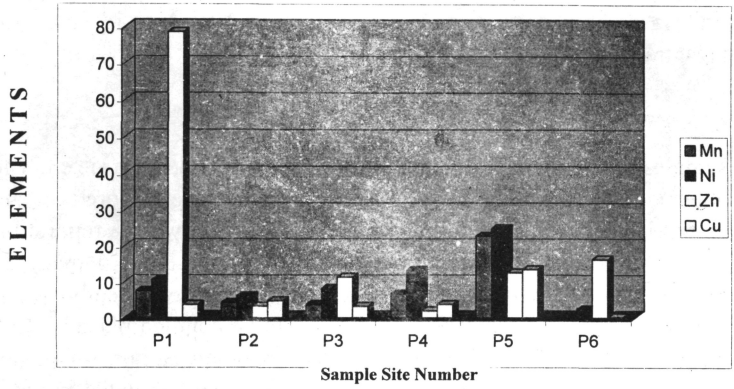

Fig. 3 Variation in heavy Metal Concentration of the Waste Effluents with respect to Season

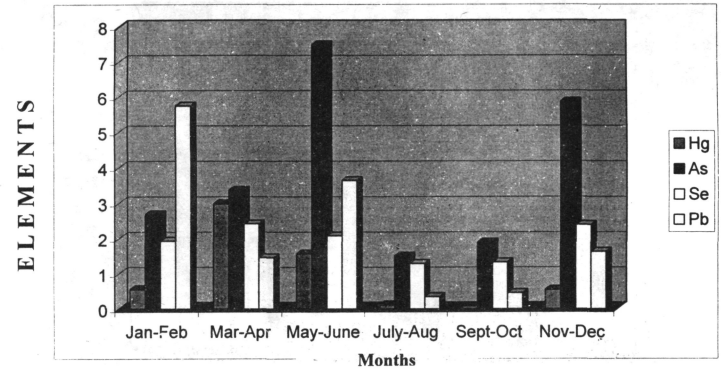

Fig. 4 Variation in heavy Metal Concentration of the Waste Effluents with respect to Sample Sites.

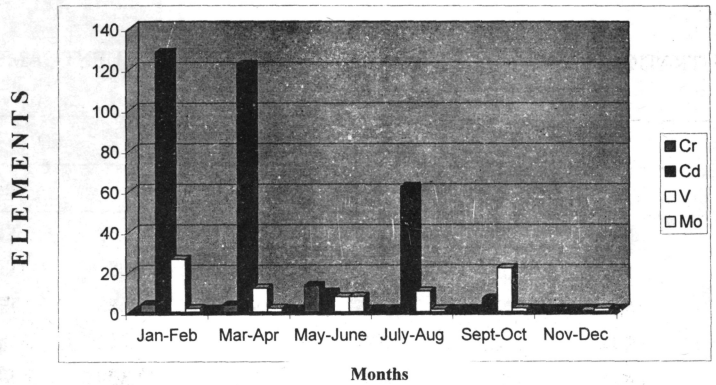

Fig. 5 Variation in heavy Metal Concentration of the Waste Effluents with respect to Sample Sites.

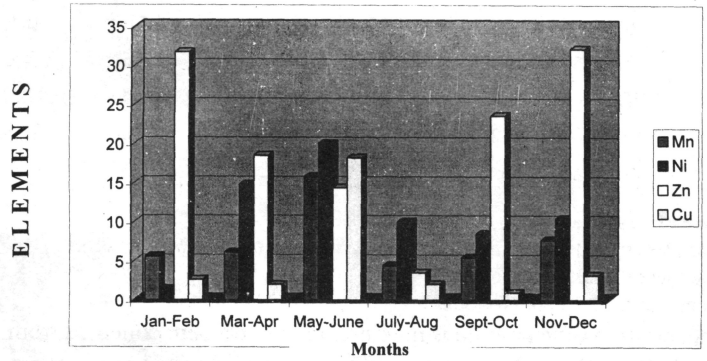

Fig. 6 Variation in heavy Metal Concentration of the Waste Effluents with respect to Sample Sites.

RESULTS AND DISCUSSION

The results are summerised in Table 1 to 6 indicate the large variations in the concentration of the metal ion of the waste effluents. In the month of January–February, the concentration of these heavy elements is very high, especially in the effluents collected from sample site 'P5'. The effluent flowing through the location 'P5' is a aggregate effect from all the zone effluents, P1 to P4 and likely to exhibit higher values of these metals.

The effluents from sample site 'P1' shows higher concentration of cadmium ion. This is most likely since chemical industries in the 'P1' zone manufacture cadmium salts. However, the concentration of cadmium ion in the effluent in the later part of the year declines and the average value over the year is 60.85 ppm which is considerably higher than the recommended value.

The concentration of toxic elements like arsenic, selenium and lead is also very high near the MIDC principle drainage line situated near the location 'P5'

The average concentration of mercury is 1.61 ppm while it is below detectable level near the point 'P4' and 'P6'. Surprisingly, the amount of mercury found inthe effluent collected from location 'P2' is very high indicating that chemical industries in this zone discharge higher amount of mercury salts.

TABLE-1
CONCENTRATIONS OF HEAVY METAL ION IN THE WASTE EFFLUENT SAMPLES COLLECTED DURING JANUARY–FEBRUARY

Elements	Sample Site Number					
	P1	P2	P3	P4	P5	P6
Hg	ND	ND	0.52	ND	**2.83**	ND
As	ND	0.81	0.52	ND	**14.8**	ND
Se	ND	ND	3.32	ND	**8.25**	ND
Pb	5.44	ND	ND	3.22	**25.21**	0.63
Cr	ND	ND	0.53	0.32	**22.30**	ND
Cd	239.25	70.26	74.22	33.57	**352.06**	0.33
V	22.97	9.05	10.78	56.16	**58.30**	0.43
Mo	1.65	1.24	1.20	1.12	**5.40**	0.42
Mn	6.72	0.64	1.18	0.82	**23.6**	0.45
Ni	ND	ND	ND	ND	**8.43**	ND
Zn	84.12	1.12	ND	0.51	7.84	**96.58**
Cu	**6.92**	0.69	0.71	0.59	6.35	0.46

*All values are expressed as ppm.
(i) ND means less than 0.1 ppm for (Cd, Cu, V, Zn, Cr, Hg, Ni, Mn, Mo and Pb).
(ii) ND means less than 0.5 ppm for As.
(iii) ND means less than 0.7 ppm for Se.

The concentration of vanadium is maximum in the effluent collected from 'P4' site in the month of September–october. The amount of vanadium is more than the permissible value as per the environmental legislation. However, its amount decreases during November–December season due to sedimentation process.

In general, the variation in concentration of these toxic metal ions is very high because of following probable reasons:

(i) Most of the industries in these selected points are manufacturing laboratory or industrial chemicals. During production of chemicals, the washed solution from main plant is discharged to the MIDC drainage without taking care and without noticing the hazardous effect on environment.

(ii) Some industries send effluents collectively to the centrally located treatment plant. It was expected that by proper biological and chemical treatment, effluents can be made pollutant free. The degree of treatment depends upon the effluent load and quality of liquid wastes.

(iii) The large seasonal variation in the amount of these toxic metal ions in the effluent waste is due to rain water drain off.

(iv) The amount of these heavy metals is appreciably low in the effluent collected from the site 'P6'. The major flow of effluents from all the industries are in the direction of sample site 'P5'. The sample site 'P6' is in orthogonal direction to the main flow of effluents. Hence, the 'P6' sample site may have effluent with lower amount of pollutants. However,

the presence of many heavy metal ions in the effluent 'P6' is due to leaching process.

TABLE-2
CONCENTRATIONS OF HEAVY METAL ION IN THE WASTE EFFLUENT SAMPLES COLLECTED DURING MARCH–APRIL

Elements	Sample Site Number					
	P1	P2	P3	P4	P5	P6
Hg	ND	**16.36**	ND	ND	1.60	ND
As	ND	ND	ND	ND	**20.20**	ND
Se	1.40	1.20	0.80	ND	**11.10**	ND
Pb	ND	ND	1.60	0.66	6.50	ND
Cr	ND	ND	ND	ND	**21.20**	ND
Cd	46.42	**422.63**	167.11	12.69	85.04	0.24
V	6.72	**37.15**	10.70	1.43	15.18	0.58
Mo	1.57	1.66	1.42	1.20	**4.96**	0.36
Mn	2.56	0.77	**3.67**	1.45	28.1	ND
Ni	15.88	15.00	14.32	15.80	**23.70**	3.97
Zn	**97.40**	1.24	ND	1.68	10.50	ND
Cu	2.52	3.28	0.61	0.73	**4.57**	0.14

*All values are expressed as ppm.

TABLE-3
CONCENTRATIONS OF HEAVY METAL ION IN THE WASTE EFFLUENT SAMPLES COLLECTED DURING MAY-JUNE

Elements	Sample Site Number					
	P1	P2	P3	P4	P5	P6
Hg	ND	**8.06**	*0.53*	ND	0.81	ND
As	0.65	ND	11.53	7.61	**25.13**	ND
Se	ND	0.79	ND	0.87	**10.83**	ND
Pb	ND	5.39	**8.15**	0.75	7.53	ND
Cr	6.17	**31.29**	5.21	7.39	28.59	ND
Cd	6.51	8.61	15.86	7.78	**20.15**	0.19
V	8.21	6.50	9.25	8.31	**12.56**	0.58
Mo	**5.65**	2.51	1.65	1.12	4.68	0.36
Mn	15.85	11.53	9.56	**31.20**	26.50	ND
Ni	15.60	9.81	10.56	41.60	**39.51**	2.95
Zn	22.63	18.65	10.51	8.93	**25.51**	ND
Cu	6.50	21.80	15.60	19.20	**45.60**	0.13

*All values are expressed as ppm.

TABLE-4
CONCENTRATIONS OF HEAVY METAL ION IN THE WASTE EFFLUENT SAMPLES COLLECTED DURING JULY–AUGUST

Elements	Sample Site Number					
	P1	P2	P3	P4	P5	P6
Hg	0.10	ND	ND	ND	**0.60**	ND
As	1.00	1.50	2.10	1.40	**3.00**	ND
Se	1.40	ND	1.40	0.75	**4.20**	ND
Pb	0.21	0.15	0.25	0.28	**1.20**	ND
Cr	0.20	0.25	0.20	0.20	**0.60**	ND
Cd	62.14	64.92	**119.67**	29.38	95.54	0.89
V	7.45	13.35	**20.93**	5.05	15.30	ND
Mo	1.20	1.30	1.20	0.62	**3.65**	0.30
Mn	**8.68**	4.08	4.64	1.82	7.24	ND
Ni	6.96	0.82	14.52	4.27	**31.20**	2.36
Zn	7.80	ND	ND	ND	**13.10**	0.19
Cu	1.97	ND	0.49	0.69	**8.86**	0.16

*All values are expressed as ppm.

TABLE-5
CONCENTRATIONS OF HEAVY METAL ION IN THE WASTE EFFLUENT SAMPLES COLLECTED DURING SEPTEMBER–OCTOBER

Elements	Sample Site Number					
	P1	P2	P3	P4	P5	P6
Hg	ND	ND	ND	ND	**0.50**	ND
As	1.80	ND	1.60	1.20	**6.71**	ND
Se	ND	ND	2.50	0.86	**4.60**	ND
Pb	0.15	0.87	**0.96**	ND	0.78	ND
Cr	ND	ND	ND	ND	**0.65**	ND
Cd	10.55	7.84	7.77	**13.24**	0.26	0.22
V	8.83	41.10	30.30	**49.69**	0.34	0.20
Mo	1.66	1.20	2.08	1.44	**3.75**	0.32
Mn	6.64	0.51	3.02	4.41	**17.60**	0.54
Ni	14.60	6.00	1.57	9.44	**16.60**	2.64
Zn	**71.16**	ND	56.8	0.44	13.00	0.13
Cu	**2.17**	ND	0.82	0.51	2.01	0.21

*All values are expressed as ppm.

TABLE-6
CONCENTRATIONS OF HEAVY METAL ION IN THE WASTE EFFLUENT SAMPLES COLLECTED DURING NOVEMBER–DECEMBER

Elements	Sample Site Number					
	P1	P2	P3	P4	P5	P6
Hg	ND	ND	ND	ND	**3.30**	ND
As	1.60	1.20	0.60	0.80	**31.00**	ND
Se	ND	3.23	ND	**7.00**	4.10	ND
Pb	0.11	ND	ND	ND	**9.68**	ND
Cr	**1.65**	ND	0.56	ND	0.85	ND
Cd	**0.23**	0.22	0.21	0.21	0.22	0.22
V	ND	**1.06**	ND	ND	0.27	0.87
Mo	1.62	1.23	1.55	1.20	**4.05**	0.29
Mn	4.80	7.72	ND	0.74	**32.90**	ND
Ni	10.20	4.80	7.84	8.04	**29.40**	2.24
Zn	**188.00**	ND	ND	ND	4.77	ND
Cu	2.07	2.65	0.84	0.67	**12.66**	0.23

*All values are expressed as ppm.

TABLE-7
AVERAGE CONCENTRATION OF METAL ION IN THE WASTE EFFLUENTS

Elements	Sample Site Number					
	P1	P2	P3	P4	P5	P6
Hg	0.02	**4.07**	0.17	ND	1.61	ND
As	0.84	0.59	2.72	1.84	**16.81**	ND
Se	0.47	0.87	1.34	1.58	**5.82**	ND
Pb	0.99	1.07	1.83	0.82	**8.48**	***0.11***
Cr	1.34	5.26	1.08	1.32	**12.37**	ND
Cd	60.85	**95.75**	64.14	16.15	92.21	**0.35**
V	9.03	18.04	13.66	**20.11**	16.27	**0.44**
Mo	2.23	1.52	1.52	1.13	**4.42**	**0.34**
Mn	7.54	4.21	3.70	6.60	**22.66**	**0.17**
Ni	10.54	6.07	8.14	13.16	**24.81**	2.34
Zn	**78.52**	3.26	11.22	1.93	12.45	16.15
Cu	3.69	4.74	3.19	3.73	**13.34**	0.22

*All values are expressed as ppm.

TABLE-8
AVERAGE CONCENTRATION OF METAL ION IN THE WASTE EFFLUENTS DURING THE YEAR

Elements	Months					
	Jan-Feb	Mar-Apr	May-June	Jul-Aug	Sept-Oct	Nov-Dec
Hg	0.56	**2.99**	1.57	0.12	0.08	0.55
As	2.69	3.37	**7.49**	1.50	1.89	5.87
Se	1.93	2.42	2.08	1.29	1.33	**2.39**
Pb	**5.75**	1.46	3.64	0.35	0.46	1.63
Cr	3.86	3.53	**13.11**	0.24	0.11	0.51
Cd	**128.28**	122.36	9.85	62.09	6.65	0.22
V	**26.28**	11.96	7.57	10.35	21.74	0.37
Mo	1.84	1.86	**7.68**	1.38	1.74	1.66
Mn	5.57	6.09	**15.78**	4.42	5.45	7.69
Ni	1.41	14.78	**20.01**	10.02	8.48	10.42
Zn	31.69	18.47	14.37	3.52	23.59	**32.13**
Cu	2.62	1.98	**18.19**	2.03	0.95	3.19

*All values are expressed as ppm.

Conclusion

Conclusively, we recommend following suggestions to protect the environment from the industrial hazards:

(i) The entire effluents from each industry must be properly chanalize and connected to the main drainage pipe.

(ii) Entire load of pollutants must be treated at several points at an interval of 500 meters.

(iii) Before discharging effluents to the drainage, End-Of-Pipe treatment must be given to each of these effluents.

(iv) The quantum of effluents is very high. Therefore sedimentation and lagooning of these effluents is not recommended.

(v) The effluents must be treated chemically to precipitate out these heavy metal pollutants.

(vi) The villagers in the nearby vicinity should not use any underground water for their domestic use, especially at location site 'P6' where most of the residence quarters exist.

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