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Research Article

Study of Heavy Metal Pollution in the Sediment Sample of River Adyar, using Geochemical Indices

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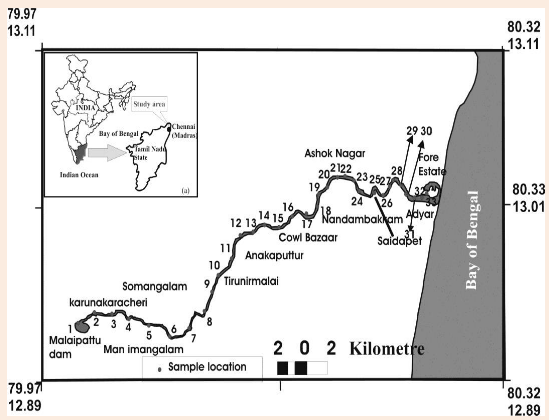
Abstract

Enrichment factor (EF), Geoaccumulation index (I_{geo}), Effects range - low (ERL) and Effects range – medium (ERM) were used to assess the heavy metal contamination and ecological risk in the sediment of the Adyar River. The decreasing order of Ef of trace metals in the pre monsoon is Ni> Zn> Cr> Pb> Cu> Fe> Mn and for the Post monsoon the order is Zn> Cr> Pb> Cu> Fe> Ni> Mn. The average Ef value for Ni is higher than 4 indicating the polluted nature of sediment with respect to this metal. Geoaccumulation index for the pre monsoon decreases in the order Zn> Cr> Cu> Pb> Fe> Ni> Mn and during the post monsoon the order is Zn> Cr> Pb> Cu> Fe> Ni> Mn. Geoaccumulation index for both the monsoon are less than 1 indicating uncontaminated nature of the sediment Adverse effect calculated with respect to ERL and ERM shows the same order for both the pre monsoon and post monsoon i.e., Zn> Cu> Cr> Ni> Pb. Zn shows the maximum biological adverse effect in both the monsoon warranting immediate remedial action. Heavy metal contamination in the sediment was mostly due to the anthropogenic activity, activities ranging from industrial pollution to domestic effluent.

Keywords: River Adyar, Enrichment Factor, ERL and ERM



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Introduction

The Heavy metal contamination in the sediment of the river is an indicator of the condition of the river water in the past and in the present. Many studies have been carried out all around the world in the sediment of the rivers to analysis the heavy metal contamination. The sediment quality assessment parameters such as inter-element correlation, bioaccumulation and geo-accumulation index support the order of enrichment of heavy metal in the sediment. Many metals are precipitated from the river water to sediment and precipitation of Pb, Cu, Cr, Zn, Ni and Cd may be attributed due to alkaline pH, as their insoluble hydroxides, oxides and carbonates. Metals like Cr, Cu and Ni have interacted with organic matter in aqueous phase and settled down, resulting in high concentrations in their sediments. Mineralogical studies of polluted sediments indicate that heavy metals are found associated with fine particles of silt and clay size which have large surface area and tendency to adsorb and accumulate metal ions due to their intermolecular forces. Heavy contamination in the sediment of in the river water were studied using different indices by many authors [1], [2], [3],[4]. ERM and ERL were also used for assessing the pollution levels of the river water sediments. [5]. In this study River Adyar sediments were analyzed for heavy metal contamination using the indices and ERM and ERL.

Experimental

Materials and Reagents

The sediment samples of river Adyar is taken up for Geochemical analysis during pre monsoon and post monsoon of 2006 (fig 1). River Adyar starts from Malaipattu Dam (80.00^0 latitude and 12.93^0 longitude) near Manimangalam village, Sriperumbathur taluk, at about 15km west of Tambaram near Chennai.

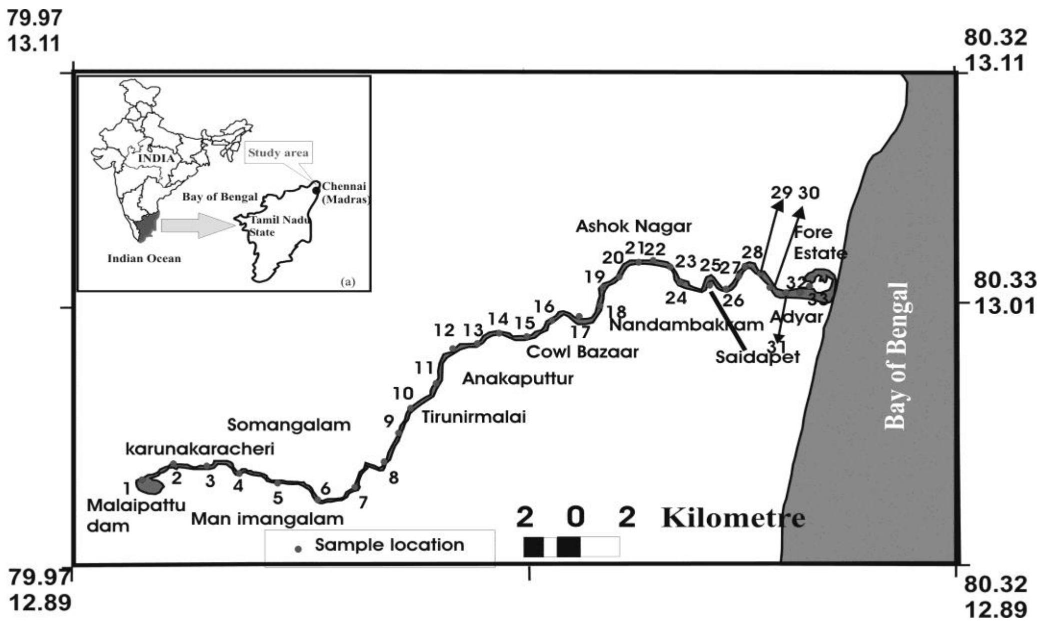

Figure 1 Base Map of Adyar river depicting the sample locations

Though it originates from the above point, it assumes the appearance of a stream only after it receives surplus water from the chembarambakkam tank. It flows through Kancheepuram, Tiruvallur and Chennai districts for a distance of about 50km and enters into the Bay of Bengal near Adyar. The river receives a sizeable quantity of sewage from its neighborhood after it reaches Nandambakkam near Chennai. This river is almost stagnant and do not carry enough water except during rainy season (NW-monsoon). Rapid industrialization and urbanization along the river course during 80's and 90's of last century has increased the pollution of the river watershed which Pbs to the present day deteriorated condition of water level. River water near the midstream is found to be contaminated by the industrial and domestic effluents directed into the river course and the lower part of the river water is observed to be polluted by domestic effluents and saline water intrusion

Thirty three sediment samples were collected from the origin of the river to the confluence point (Fig.1). For the collection of bed sediments, the standard methods were adopted. Samples were collected from the subsurface at a depth of 10-15 cm. About 250 g of the samples were collected in polythene bags and were kept frozen to preserve their chemical integrity until analysis. The sediment samples were air dried at room temperature and sieved through a 2-mm nylon sieve to remove coarse debris. The sediments were then ground until all particles pass through a 200-mesh nylon sieve. Sample solutions were prepared by hydroflourization and subsequent digestion with perchloric acid and final extraction with 6M HCl. The concentrations of heavy metals were determined using Graphite Furnace Atomic Absorption Spectrophotometer (Perkin-Elmer Analyst 700). Multi element Perkin-Elmer standard solutions were used for the estimation of trace metals. Precision of the analysis was monitored by running triplicates for every 20 samples and it was found that the results are <7% relative standard deviation. The total metal content was also determined to assess the quality of the study. The percent ratios of the sum of concentrations of five fractions to the total concentrations measured separately of Cr, Cu, Fe, Ni, Mn, Pb and Zn were 96, 108, 97, 93, 109, 94 and 92%, respectively.

Results and Discussion

The quality of the sediment in a river bed depends upon the quality of the river water. If the river is highly polluted with the trace metals, their concentrations in the sediments will also be high. The study of the trace metal chemistry in the river water differs from that of the sediments. The present state of the pollution can be inferred from the trace metal chemistry of the river water but the sediment chemistry would provide the history of the pollution. So studying sediment quality like enrichment factor, geoaccumulation factor, bioaccumulation will provide an insight of the state of the river water over a period of time.

Enrichment factor

The enrichment factor can be determined by comparing the elemental concentration of the sediments in the study area with elemental values in soils or crustal rocks and for a meaningful comparison, normalizing procedure are generally used. For normalization, a conservative element whose concentration is not affected by anthropogenic input is chosen. In this study, Aluminum is used as the conservative element.
EF is calculated according to the formula $\mathbf{EF_s = [(C_X / C_{Al})_{sample} / (C_X / C_{Al})_{crust}]}$

Where $(C_X / C_{Al})_{sample}$ is the ratio of concentration of the element X being tested in mg/kg to that of Aluminum in the sample and $(C_X / C_{Al})_{crust}$ is that of crustal material (shale value).

- EF≈1–2 : Uncontaminated by metals (crustal origin of the metal).
- 2 < EF < 10 : Moderately contaminated by metals.
- EF > 10 : Significantly contaminated by metals (non-crustal sources).

The enrichment factor for the metals in the bed sediments of river Adyar are presented in Table 1. In the pre monsoon Enrichment factor of Cr shows that the Cr is enriched more in the upper part of the river and in the lower part of the river. During post monsoon most of the stations in the upper part of the river (except for 2 and 3) and middle part of the river shows Ef value lesser than 2 indicating there enrichment of the Cr has reduced. The Cr values are due to the dyeing industries which is located around the region. Table 1 indicates that the enrichment of Cr in the sediment is lower than the pre monsoon indicating that there is considerable desorption of the metal during the monsoon precipitation.. The Table 1 indicates that copper in the pre monsoon has a sporadic occurrence of station having Ef higher than 2. During post monsoon no station shows Ef more than 2, signifying that the sediments are not contaminated with copper. The average value of Ef during pre monsoon in case of Fe is less than 2.0 suggesting that the sediments are uncontaminated with Fe. Post monsoon values also suggest that there is no enrichment of Fe in the sediment. Comparing pre monsoon and post monsoon the Ef during post monsoon is less than that of pre monsoon.. In both the monsoon the Ef value is lesser than 2 for all the station indicating that the sediments are uncontaminated with the Metal. All the sediments during the pre monsoon are moderately polluted with respect to Ni and station 4 showing significant contamination. All the bed sediments in the post monsoon show Ef values lesser than 2 indicating that the sediments are uncontaminated with respect to Ni. The monsoon precipitation has diluted the concentration of the Ni to the significant level. During pre monsoon the Enrichment factor about 11 station shows Ef value higher than 2 and the rest of the sample shows value lesser than 2 indicating that there is a sporadic contamination of the Pb in the sediment. Station 4 shows a higher value of 9.55 showing that this station is most contaminated with Pb. The occurance of the Pb in these stations is mainly attributed to the Industries and waste dumping around these sites. Ef value of Pb during post monsoon indicates that all the bed sediments along the river stretch is uncontaminated with Pb. Enrichment factor of Zn for the Pre monsoons shows Ef values higher than 2 indicating that there is a moderate contamination but station 4 shows high contamination with Ef value higher than 10 which is mainly due to industries and waste dumping,. For the post monsoon most part of the upper stretch of the river showed lower value (<2) of EF except for station 3 and are thus uncontaminated with Zn. Most of the lower part of the river sediment showed Ef value of Zn more than 2 suggesting that the sediments are moderately contaminated. Although the monsoonal rainfall has diluted the Zn concentration in the river bed sediment, the river sediment still showed values of moderate contamination suggesting the environmental hazard of Zn.

Table 1 Enrichment factor for trace element of River Adyar bed sediments

	Cr		Cu		Fe		Mn		Ni		Pb		Zn	
	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	Post
1	3.11	1.77	1.89	0.94	1.77	0.95	0.33	0.16	4.61	0.70	1.70	0.80	2.79	1.50
2	2.65	2.72	1.36	1.11	1.37	1.27	0.24	0.20	3.90	1.01	1.30	1.01	1.38	1.21
3	3.72	2.72	1.87	1.14	1.90	1.30	0.37	0.19	4.86	1.01	2.11	1.12	4.34	3.33
4	6.28	0.94	7.06	0.97	6.41	0.79	1.99	0.19	17.91	0.70	9.56	1.37	12.00	1.77
5	2.70	1.41	2.99	1.01	1.64	0.69	1.12	0.52	4.65	0.82	4.65	1.56	3.22	1.67
6	2.52	1.20	2.00	0.73	1.77	0.73	1.28	0.55	4.57	0.65	3.68	1.44	3.03	1.51
7	1.71	1.07	1.15	0.91	1.38	0.97	0.99	0.14	4.72	0.62	2.65	1.65	2.68	1.94
8	1.13	0.76	1.34	0.96	1.39	0.97	0.66	0.37	3.34	0.74	1.82	1.35	2.06	1.59
9	1.81	0.80	1.96	0.89	1.57	1.03	0.45	0.27	3.73	0.57	1.21	0.94	1.75	1.32
10	1.85	1.56	1.51	1.23	0.99	0.86	0.40	0.33	3.57	0.79	1.00	1.51	1.86	1.93
11	2.27	1.40	1.47	0.60	0.72	0.36	0.42	0.22	3.32	0.54	1.92	1.04	3.17	1.91
12	2.27	1.99	1.88	1.06	0.66	0.75	0.67	0.53	3.45	0.74	1.93	1.48	2.52	2.23
13	1.84	1.31	2.10	1.45	1.26	0.93	0.50	0.32	2.85	0.53	1.50	1.17	2.45	1.89
14	2.34	1.31	3.00	1.33	1.90	1.01	0.36	0.19	4.36	0.63	2.02	1.21	3.96	2.38
15	2.09	0.87	2.14	0.90	1.59	0.69	0.33	0.13	5.23	0.54	1.19	0.62	3.24	1.37
16	2.05	1.07	1.93	1.01	1.42	0.78	0.33	0.15	3.76	0.55	1.47	0.88	2.17	1.12
17	2.43	1.29	2.24	1.09	1.51	0.76	0.35	0.14	3.81	0.59	1.85	0.76	1.92	0.97
18	2.04	1.49	1.39	1.02	0.90	0.56	0.24	0.15	3.02	0.70	1.18	0.65	2.36	1.81
19	2.56	1.44	1.20	0.63	1.38	0.79	0.24	0.12	3.22	0.42	1.99	0.67	3.75	2.35
20	3.31	1.80	1.92	0.89	1.76	0.94	0.24	0.11	4.40	0.59	1.38	0.63	4.59	2.40
21	3.15	1.97	2.19	1.13	1.41	0.91	0.21	0.14	4.89	0.72	0.84	0.55	3.95	2.92
22	2.38	2.44	1.59	1.38	1.19	1.04	0.19	0.18	3.90	0.79	0.97	0.76	3.49	3.37
23	3.66	2.03	1.91	0.99	1.85	1.01	0.39	0.20	6.16	0.77	2.20	0.81	5.10	3.08
24	3.32	1.83	1.87	0.86	1.47	0.75	0.37	0.19	4.40	0.60	1.50	0.75	3.65	2.04
25	3.36	2.49	1.39	0.79	0.96	0.53	0.28	0.15	3.21	0.57	1.38	1.03	2.97	2.13
26	4.24	2.30	2.94	1.06	1.61	0.66	0.35	0.16	5.52	0.66	2.50	1.18	3.11	1.65
27	2.54	1.91	1.90	0.97	1.17	0.81	0.14	0.09	3.75	0.64	1.93	1.35	2.99	2.19
28	2.74	1.66	1.60	0.78	1.47	0.95	0.33	0.20	4.56	0.69	2.70	1.60	3.69	2.43
29	4.34	2.77	2.12	1.15	1.39	0.88	0.36	0.23	4.05	0.59	2.39	1.52	3.89	2.89
30	2.78	2.44	2.68	1.84	1.27	0.90	0.46	0.32	4.22	0.82	1.88	0.99	2.66	2.27
31	2.26	1.44	1.82	1.31	1.11	0.68	0.34	0.21	4.57	0.78	1.32	1.01	1.98	1.35
32	2.18	2.10	1.76	1.29	1.21	1.09	0.17	0.14	3.82	0.88	1.90	1.50	2.91	2.76
33	2.55	3.33	1.43	1.53	1.18	1.27	0.14	0.15	3.44	0.85	2.44	1.88	3.28	4.01

Geoaccumulation Index (I_{geo})

The Index of Geoaccumulation (I_{geo}) was first proposed by Müller (1969) [6] and described by Förstner [7] and has been used to calculate the enrichment of metal concentration above the background concentration in shale sediment [8]. It can be calculated by the following equation: $\mathbf{I_{geo} = \log_2[C_n/(1.5B_n)]}$ Where C_n is the concentration of the metal examined in the sediment and B_n is the concentration of the same metal in the shale [9]. . To reduce any possible variation in the back ground values of the metal, factor 1.5 is multiplied with it.

Forstner) has distinguished seven classes of geoaccumulation index: <0 practically unpolluted, 0–1 unpolluted to moderately polluted, 1–2 moderately polluted, 2– 3 moderately to strongly polluted, 3–4 strongly polluted, 4–5 strongly to very strongly polluted, and >5 very strongly polluted. The geoaccumulation index for the metals in the bed sediments of river Adyar are presented in Table 2 Geoaccumulation index values in the pre monsoon of the metals show that most of the stations are non polluted, few stations are very lightly polluted with the metal. In the post monsoon most of the stations are non polluted. The effect of dilution over in the post monsoon can be seen in the geoaccumalation index also. Few stations in the stretch of river Adyar shows I_{geo} shows moderate pollution indicating contamination through pollution either by antropogenic or geogenic factors.

Table 2 Geoaccumulation index for trace element of River Adyar bed sediments

	Cr		Cu		Fe		Mn		Ni		Pb		Zn	
	Pre	post	Pre	post	pre	post	Pre	post	pre	post	pre	post	pre	post
1	0.51	0.27	-0.21	-0.64	-0.31	-0.63	-2.74	-3.16	-0.69	-1.08	-0.36	-0.88	0.36	0.03
2	0.75	0.63	-0.21	-0.66	-0.21	-0.47	-2.73	-3.10	-0.46	-0.81	-0.28	-0.80	-0.20	-0.54
3	0.88	0.71	-0.11	-0.53	-0.09	-0.35	-2.44	-3.12	-0.50	-0.71	0.06	-0.56	1.10	1.01
4	-0.46	-0.66	-0.29	-0.61	-0.43	-0.90	-2.12	-2.95	-0.71	-1.08	0.15	-0.12	0.48	0.26
5	-0.36	-0.49	-0.21	-0.98	-1.08	-1.52	-1.63	-1.93	-1.34	-1.27	0.42	-0.34	-0.11	-0.24
6	-0.06	-0.33	-0.39	-1.06	-0.57	-1.05	-1.03	-1.46	-0.96	-1.22	0.49	-0.07	0.21	0.00
7	-0.07	-0.47	-0.64	-0.71	-0.39	-0.61	-0.85	-3.37	-0.37	-1.27	0.56	0.15	0.58	0.38
8	-0.53	-0.82	-0.29	-0.48	-0.23	-0.47	-1.30	-1.87	-0.73	-0.86	0.15	0.01	0.33	0.24
9	0.08	-0.73	0.19	-0.58	-0.12	-0.36	-1.93	-2.30	-0.64	-1.22	-0.50	-0.49	0.03	0.00
10	0.47	-0.03	0.18	-0.37	-0.43	-0.89	-1.75	-2.28	-0.35	-1.02	-0.42	-0.07	0.48	0.28
11	0.51	0.45	-0.12	-0.77	-1.14	-1.53	-1.94	-2.25	-0.71	-0.93	0.27	0.01	1.00	0.90
12	0.73	0.59	0.45	-0.32	-1.05	-0.80	-1.03	-1.30	-0.43	-0.84	0.50	0.17	0.88	0.76
13	0.45	0.17	0.64	0.32	-0.09	-0.33	-1.44	-1.86	-0.69	-1.14	0.15	0.01	0.86	0.70
14	0.38	0.11	0.74	0.14	0.08	-0.27	-2.33	-2.71	-0.49	-0.94	0.17	-0.01	1.13	0.97
15	0.32	0.00	0.35	0.04	-0.07	-0.33	-2.36	-2.75	-0.12	-0.68	-0.49	-0.48	0.95	0.65
16	0.35	0.09	0.27	0.02	-0.18	-0.36	-2.27	-2.73	-0.54	-0.88	-0.13	-0.19	0.43	0.16
17	0.40	0.21	0.29	-0.02	-0.28	-0.54	-2.40	-2.97	-0.71	-0.91	0.01	-0.54	0.07	-0.20
18	0.55	0.37	0.01	-0.18	-0.62	-1.05	-2.51	-2.96	-0.64	-0.72	-0.23	-0.83	0.77	0.65
19	0.73	0.48	-0.37	-0.71	-0.16	-0.38	-2.70	-3.16	-0.71	-1.31	0.36	-0.62	1.28	1.19
20	0.84	0.73	0.05	-0.29	-0.07	-0.21	-2.95	-3.25	-0.52	-0.88	-0.43	-0.78	1.31	1.15
21	0.93	0.69	0.40	-0.11	-0.23	-0.41	-2.95	-3.12	-0.21	-0.76	-0.97	-1.14	1.25	1.27
22	0.80	0.71	0.21	-0.11	-0.21	-0.52	-2.87	-3.05	-0.26	-0.91	-0.49	-0.97	1.35	1.18
23	0.65	0.41	-0.28	-0.63	-0.33	-0.59	-2.59	-2.95	-0.36	-0.99	-0.08	-0.91	1.13	1.01
24	0.84	0.72	0.02	-0.37	-0.33	-0.57	-2.32	-2.58	-0.52	-0.88	-0.30	-0.56	0.98	0.88
25	1.30	1.21	0.02	-0.44	-0.51	-1.03	-2.27	-2.81	-0.54	-0.91	0.01	-0.07	1.11	0.98
26	1.13	1.13	0.60	0.02	-0.27	-0.66	-2.47	-2.75	-0.26	-0.68	0.36	0.17	0.68	0.65
27	0.96	0.82	0.54	-0.16	-0.16	-0.42	-3.24	-3.64	1.84	-0.76	0.56	0.32	1.20	1.02
28	0.79	0.47	0.02	-0.61	-0.10	-0.33	-2.27	-2.61	-0.24	-0.79	0.77	0.42	1.22	1.02
29	1.49	1.22	0.45	-0.05	-0.16	-0.43	-2.09	-2.40	-0.38	-1.02	0.63	0.35	1.33	1.28
30	1.02	1.01	0.97	0.60	-0.11	-0.44	-1.57	-1.91	-0.14	-0.57	0.46	-0.30	0.96	0.90
31	0.84	0.46	0.53	0.32	-0.18	-0.61	-1.90	-2.31	0.09	-0.42	0.06	-0.05	0.65	0.37
32	0.70	0.50	0.39	-0.20	-0.15	-0.44	-3.01	-3.43	-0.26	-0.76	0.50	0.01	1.11	0.89
33	0.84	0.84	0.00	-0.29	-0.28	-0.55	-3.30	-3.64	-0.50	-1.14	0.77	0.01	1.20	1.10

Biological effects

Long et al. [10] have studied the biological adverse effects of the trace metals in sediments. They proposed two guideline values: the effects range-low (ERL) and effects range-medium (ERM) for nine trace metals. Lower 10th percentile of the effects data for each metal was determined and the values were referred as ERL. 50th percentile (median) of the effects data of the each metal were taken as ERM. The ERL and ERM values are guidelines used to evaluate whether sediment chemical concentrations were within ranges that have been reported to be associated with biological effects. These guidelines were generated from a large national sediment data base and are currently the most widely used and accepted sediment guidelines available. ERMs are the concentration at which 50% of the studies for a particular chemical showed biological effects and ERLs are the concentration at which 10% of the

Table 3 The guideline values and biological effects of the studied metal

Guideline (mg/kg)			Adverse effects(%)		
	ERL	ERM	<ERL	ERL~ERM	>ERM
Cu	34	270	9.4	29.1	83.7
Ni	20.9	51.6	1.9	16.7	16.9
Pb	46.7	218	8.0	35.8	90.2
Cr	81	370	2.9	21.1	95
Zn	150	410	6.1	47.0	69.8

Table 4 Biological adverse effect of the trace metals in the bed sediments of River Adyar

	Cr		**Cu**		**Ni**		**Pb**		**Zn**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
1	21.1	21.1	29.1	29.1	16.9	16.7	8	8	47	6.1
2	21.1	21.1	29.1	29.1	16.9	16.9	8	8	6.1	6.1
3	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
4	21.1	21.1	29.1	29.1	16.9	16.7	8	8	47	47
5	21.1	21.1	29.1	29.1	16.7	16.7	8	8	6.1	6.1
6	21.1	21.1	29.1	29.1	16.9	16.7	8	8	47	47
7	21.1	21.1	29.1	29.1	16.9	16.7	8	8	47	47
8	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
9	21.1	21.1	29.1	29.1	16.9	16.7	8	8	47	6.1
10	21.1	21.1	29.1	29.1	16.9	16.7	8	8	47	47
11	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
12	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
13	21.1	21.1	29.1	29.1	16.9	16.7	8	8	47	47
14	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
15	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
16	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
17	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
18	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
19	21.1	21.1	29.1	29.1	16.9	16.7	8	8	47	47
20	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
21	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
22	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
23	21.1	21.1	29.1	29.1	16.9	16.7	8	8	47	47
24	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
25	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
26	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
27	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
28	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
29	95	21.1	29.1	29.1	16.9	16.9	8	8	47	47
30	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
31	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
32	21.1	21.1	29.1	29.1	16.9	16.9	8	8	47	47
33	21.1	21.1	29.1	29.1	16.9	16.7	35.8	8	47	47

studies showed biological effects. Since sediment chemical concentration below ERL are interpretated as having rarely associated with adverse effects exceedence of ERM values and maximum baseline values were used to identify chemical of potential concern. The adverse for the metals in the bed sediments of river Adyar are presented in **Table 3**. During pre-monsoon and post monsoon the concentration of the Cr is between ERL~ERM and the adverse effect for most of the station during these period were given as 21.1. Only one station (30) showed value >ERM and this station had a adverse effect of 95% indicating high toxicity. The concentration of the Copper in the sediments during both pre monsoon and post monsoon are in between 34 and 270. The adverse effect with respect to this metal is 29.1 for all the station. No station in the Pre monsoon or post monsoon showed value greater than ERM or lesser than ERL. During pre-monsoon all the samples showed Ni concentration more than ERM having an adverse effect of 16.9 except station 5 which had concentration in between ERL and ERM with an adverse effect of 16.7.

During post monsoon station 1, 4 to 7, 9, 10, 13, 19, 23, 33 showed Ni values in between ERL and ERM having an adverse effect of 16.7 and rest of the stations showed value more than ERM with an adverse effect of 16.9%. Pb concentration in the sediment for the pre monsoon is less than ERL with an adverse effect of 8% except for station 33 with an adverse effect of 35.8%. During post monsoon all the sediment showed values less than ERL having an adverse effect of 8%. Zn concentration in the pre monsoon are in between ERL and ERM with an adverse effect of 47.00 except for the station 2 and 5 showing Zn concentration of lesser than ERL with an adverse effect of 6.10%. In the post monsoon station 1, 2, 5, 9 showed values less than ERL with an adverse effect of 6.10% and the rest of the stations having concentration of the above metal in between ERL and ERM having an adverse effect of 47.00%

Conclusions

The study of various indices in the sediment of water indicates that the contamination of the water in the sediment of River Adyar with respect to various heavy metals is moderate to heavy. The contamination is mainly anthropogenic with Cr, Ni and Zn being the most. Dyeing industries and dumping of the waste in and around the river course is the main factor which attributes the heavy metal pollution. In the Post Monsoon the expected dilution takes place which suggests that the equilibrium between the heavy metal in water and sediment shifts to the water and subsequent removal of the metal from the sediment is seen. The biological effect of Zn, Cu, Cr heavy metals is alarming high warranting speedy action for the removal of those metals.

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