Pakistan Journal of Marine Sciences, Vol.1(2), 117-126, 1992.

HEAVY METALS POLLUTION IN THE COASTAL ENVIRONMENT OF KARACHI

Mirza Arshad Ali Beg, S.N. Mahmood and A.H.K. Yousufzai
PCSIR Laboratories Complex, Karachi-75280, Pakistan.

ABSTRACT: The marine environment near Karachi, particularly the Baba channel, Chari Kundi channel and Manora channel have been found contaminated with industrial effluents discharged by Malir and Lyari rivers, since they carry a high concentration of toxic heavy metals viz. Pb, Zn, Cu and Mn emanating from the industrial area and are received and discharged by the Lyari river. Out of 60 seawater samples collected from the above mentioned areas, Pb was present in 55 samples and Zn in 58 samples. The concentration of Pb was between 0.04 and 59.2 ppm and the concentration of Zn was between 0.05 and 1.9 ppm. Similarly all the 60 sludge samples collected from Lyari outfall and its adjoining area have been found to contain Pb and Zn in alarmingly high concentrations, which for Pb was between 15.4 and 3209.9 ppm while for Zn was between 87 and 111.3 ppm. Cu and Mn were also found in all the above samples.

KEY WORDS: Marine Pollution - heavy metals - Karachi coast.

INTRODUCTION

Degradation of the marine environment due to land based pollution has become a serious problem all over the world and is getting aggravated in the developing countries just as much as in the advanced countries. The marine environment endangered by land based pollution in Pakistan is located close to Karachi. There are three major areas viz. Manora channel/Karachi harbour, Hawkes Bay, and creeks and adjacent coastal areas which have been seriously exposed to the said situation. Manora channel serves as the main harbour and has vast areas forming western and eastern backwaters characterized by mud flats and mangroves. The Lyari river discharges untreated domestic and industrial effluents into Manora channel. Hawkes Bay, the semi-circular coastline between Cape Monze and Manora channel, is an important fishing ground for shrimp and fish. The creeks are located in the south of Karachi and their vast area is dominated by mangroves. These creeks and inshore areas serve as a spawning and nursery grounds for a number of commercially important sea animals. Almost all shrimp species available in Pakistan, that is, *Penaeus* spp. (Jaira), *Metapenaeus* spp. (Kalri) and *Parapenaeopsis* spp. (Kiddi) breed in coastal waters and their larval stages migrate to inshore creek water to complete part of their life cycle (Mohammad, 1963).

The effluents from Lyari and Malir rivers have degraded the marine environment considerably. Lyari discharges the highly contaminated admixture of sewage and industrial effluents into Manora channel where Karachi Port and fish harbour are located. Malir river discharges into Gizri creek which is linked to Ibrahim Hyderi fish harbour. Throughout the year, Manora channel receives an unending supply of untreated industrial effluent from SITE (Sindh Industrial Trading Estate) area, and garbage from north western areas of Karachi.

It was pointed out earlier (Beg *et al.*, 1975) that Lyari discharges 376.2 metric tons of total dissolved solids and 34.2 tons of suspended solids per day into the channel, creating dredging problems for the Manora channel. It has also been reported (Karachi Development Authority, 1972) that Karachi coastline is receiving more than 1200 tons of BOD daily, including the wastes from domestic sewage (12%) and industrial waste (84%) from industrial areas of the Karachi city.

Ryther and Menzel (1965) reported that the waters of Arabian Sea off the coast of Pakistan are very productive. Zupanovic (1971) estimated that the potential yield of demersal organisms from Pakistani waters was of the order of 5.8 g/m^3. Qureshi (1975) pointed out that the shrimps and fish which were abundant near Manora and Hawkes Bay were receding into deep waters. Since marine fishery is responsible for a considerable amount of foreign exchange, it was considered desirable to quantify the pollution and its sources. The methodology adopted for this purpose was monitoring heavy metal concentration in seawater, industrial waste water and sludge at different locations and the results are being reported here.

MATERIALS AND METHODS

The selection of the sampling stations was based on convenience and accessibility and was so arranged as to make the samples the most representative of that area, taking due cognizance of industrial pollution. The six sampling stations so selected were as follows:

(1) The confluence of Lyari river and sea adjacent to Gulbai Salt Works.
(2) Near the railway bridge over Lyari river, about 1 km upstream of the first station.
(3) Kala Pani (the spot has been designated 'black water' because of its colour), at the fish harbour near the mangrove swamps, where seawater recedes during low tides. The water here contains a good proportion of industrial effluents and untreated sewage and is greyish black in appearance, hence the name.
(4) Near the fish harbour jetty where launches and boats are anchored for repairing.
(5) Near shipyard on the left of fish harbour.
(6) Near the mouth of Baba channel, close to China creek.

In addition to the above mentioned stations, samples were also collected from other localities affected by pollution such as Hawkes Bay, Sandspit and stagnant pools in the Chari Kundi channel. Few samples were also collected from Lyari, Shershah bridge and Dhobi Ghat.

SAMPLE COLLECTION:

The first set of samples was collected in December 1984 and the second in January 1985. Four samples each of seawater and of sludge were collected from the water edge at station 1-4. Later on, when the number of stations was increased, the number

of samples was also increased accordingly. There was a collection every month, starting from December 1984 to November 1985. Eight samples were collected monthly from the above mentioned stations from December 1984 to May 1985 and twelve samples from June 1985 to November 1985. In addition to the routine collection, samples were also collected from various points, located on the beaches and Lyari river.

ESTIMATION OF HEAVY METALS:

The samples were analysed by atomic absorption for heavy metals viz. Pb and Zn, in all the samples throughout the year; for Pb, Cu and Zn in water samples from June to November and for Pb, Zn, Cu and Mn in sludge samples also from June to November. Estimation of heavy metals in seawater and sludge sediment required special treatment for the destruction of organic matter from the samples. A preliminary treatment was essential to destroy organic matter present in the samples and to prevent it from interfering with the specific tests. The treatment was also necessary to ensure that metals present in the samples were brought into solution for estimation.

Perchloric acid method was used for the preliminary treatment of the samples. After preliminary treatment, the samples were subjected to solution preparation for the estimation of heavy metals. Colorometric estimation for the determination of heavy metals was carried out using a Spectronic-21 Spectrophotometer.

RESULTS AND DISCUSSION

Samples of water and sludge were subjected to analysis for the estimation of heavy metals viz. Pb, Zn, Cu and Mn. In all, 24 samples were collected during the months of December 1984, January and February 1985 from 4 stations. None of the collected samples contained As and Cd perhaps because their concentration was not within the detectable limit of the method applied for their estimation. The methods employed were, however, quite sensitive and could determine concentrations of Cd and As in the range of 0.0025 to 0.025 mg/l in solution.

Lead was found in all the samples excepting three water samples, collected in January. The concentration of Pb in those three samples was possibly not within the range of sensitivity of the instrument. Zn was found in all the 12 samples collected during this period. Pb and Zn were present in every sample of sludge and seawater collected from the 4 stations during March, April and May 1985. The concentrations of As and Cd could again not be estimated in these samples.

Table-I lists the concentration of heavy metals in the samples of sludge and seawater collected during June, July and August 1985. The number of stations was increased from June to cover a larger segment of the affected area under study and Cu and Mn were also determined. Cu was found in all the 18 samples of sludge and seawater. Mn was not found in any seawater sample whereas it was present in all the sludge samples except sample No.38. Pb was present in all the sludge and seawater samples excepting seawater samples No.37 and 39. Sludge samples No.37, 39 and 40 and seawater samples No.38 and 40 did not contain Zn, whereas all the other sludge and seawater samples contained this element.

Table-I: Analytical data on concentration of heavy metals in seawater and sludge samples at various sampling points during June, July and August, 1985.

Sample No.	Stations	Seawater (conc. in mg/lit)						Sludge (conc. in mg/kg)					
		Pb	Zn	Cd	As	Cu	Mn	Pb	Zn	Cd	As	Cu	Mn
JUNE													
25	1	8.60	1.20	ND	ND	0.23	ND	950.0	55.6	ND	ND	35.3	78.0
26	2	1.50	0.80	"	"	0.21	"	1159.0	69.6	"	"	198.4	26.5
27	3	0.34	0.50	"	"	0.46	"	135.8	18.0	"	"	35.3	201.9
28	4	0.88	0.40	"	"	0,84	"	162.6	25.0	"	"	198.4	248.4
29	5	1.72	0.05	"	"	0.07	"	517.3	32.7	"	"	301.0	82.1
30	6	1.21	0.06	"	"	0.09	"	989.1	20.6	"	"	51.2	206.0
JULY													
31	1	6.20	0.90	"	"	0.18	"	887.8	46.3	"	"	32.5	66.2
32	2	0.95	0.70	"	"	0.20	"	1008.9	61.3	"	"	172.5	21.1
33	3	0.15	0.59	"	"	0.38	"	115.6	16.0	"	"	43.0	190.6
34	4	0.96	0.40	"	"	0.68	"	154.3	10.8	"	"	118.5	224.3
35	5	1.42	0.00	"	"	0.09	"	589.1	37.6	"	"	351.1	62.7
36	6	0.09	0.06	"	"	0.10	"	1085.0	23.1	"	"	55.0	185.1
AUGUST													
37	1	-	0.29	"	"	0.17	"	108.4	-	"	"	27.2	65.0
38	2	0.08	-	"	"	0.17	"	175.0	10.8	"	"	172.8	-
39	3	-	0.35	"	"	0.22	"	60.0	-	"	"	24.0	1450.0
40	4	0.41	-	"	"	0.44	"	133.7	-	"	"	112.0	231.0
41	5	1.07	0.07	"	"	0.11	"	621.5	39.0	"	"	370.2	60.2
42	6	0.07	0.09	"	"	0.12	"	1129.0	27.1	"	"	61.1	151.1

ND = Not detectable in ppm.

Samples were also collected from different locations along the Lyari river for which a typical analysis is shown in Table II. It would be noted from the table that Pb was invariably present in all the samples of water and sludge. Zn was found in only one water sample whereas all the sludge samples had it. Cu was found in all the samples of water and sludge while Mn could not be found in water samples but it was present in high concentration in all the sludge samples.

Samples collected from stagnant pools located at or near the Chari Kundi channel were also analysed for heavy metals. Table III lists the typical concentration of these metals. The seawater is stagnant at most of these stations except at station 3 (opposite jetty) and is contaminated with Lyari effluent. Pb, Zn and Cu were present in all the samples of seawater and sludge collected. Mn was not found in any seawater

Table-II: Analytical data on concentration of heavy metals in water and sludge samples collected along the Lyari river.

Sample No.	Stations	Water (conc. in mg/lit)						Sludge (conc. in mg/kg)					
		Pb	Zn	Cd	As	Cu	Mn	Pb	Zn	Cd	As	Cu	Mn
1.	Lyari	0.40	ND	ND	ND	0.07	ND	222.7	140.5	ND	ND	66.8	242.0
2.	Shershah	1.00	1.9	"	"	0.70	"	19.3	103.7	"	"	104.0	162.0
3.	Dhobi Ghat	0.22	ND	"	"	0.07	"	11.7	230.2	"	"	32.7	300.0
4.	Lasbella bridge	0.20	"	"	"	0.03	"	17.6	65.9	"	"	21.5	317.0

ND = Not detectable in ppm.

Table-III: Concentration of heavy metals in samples of seawater and sludge collected from stagnant pools at or near the Chari Kundi channel

Sample No.	Stations	Seawater (conc. in mg/lit)						Sludge (conc. in mg/kg)					
		Pb	Zn	Cd	As	Cu	Mn	Pb	Zn	Cd	As	Cu	Mn
1.	Hut S.50	0.5	0.02	ND	ND	0.21	ND	0.22	51.03	ND	ND	3.20	9.20
2.	Jetty	0.3	0.26	"	"	0.09	"	0.43	20.00	"	"	3.00	4.30
3.	Opp. Jetty (Beach)	0.0	0.02	"	"	0.03	"	0.06	0.12	"	"	0.32	0.10
4.	Opposite P.N.S. Himmalya	12.0	0.14	"	"	0.32	"	1.81	12.54	"	"	0.92	5.50

ND = Not detectable in ppm.

sample, although, it was present in every sludge sample. As and Cd could again not be estimated at these sampling points.

Samples of seawater were collected from those areas which have been affected by pollution and mixed with industrial effluents from Lyari. Surveys carried out earlier (Beg *et al.* 1975, 1978, 1979 and 1984) to assess the extent of pollution caused by the discharge of industrial and municipal effluents into the coastal areas of Karachi have established that Lyari river is the major source of pollution in the Manora channel which receives organic nutrients from Lyari effluents and is a possible reason for the healthy growth of mangroves there. The tidal action spreads the pollutants and

contaminants all over the channel and to the adjacent beaches.

Sindh Industrial Trading Estate (SITE) has the largest conglomeration of industries, such as, food and beverages, paper and paper products, tobacco, textiles, rubber products, machinery, chemicals, non-metallic minerals, basic metals, metal products and products of petrol and coal. All of them contribute substantially to industrial pollution by discharging their effluents into the Manora channel through the Lyari river.

Table I lists the concentration of toxic heavy metals viz. Pb, Zn, Cu and Mn found in the samples collected during June to August 1985. Out of 60 seawater samples, Zn was found in 59 samples and Pb in 55 samples. Out of the 36 samples of seawater analysed during the six months for Cu and Mn, the former was found in all the samples whereas Mn could not be detected.

Maximum concentration of 59.1 ppm Pb in seawater was found at station 4 in March while the minimum concentration was 0.04 ppm, estimated at station 3 during November. Maximum concentration of 1.87 ppm Zn in seawater was noted at station 1 in October 1985 whereas the minimum concentration of 0.05 ppm Zn was found at station 6 in June 1985. Maximum Cu concentration in seawater samples was 0.08 ppm, determined at station 4 in June, while the minimum concentration, 0.03 ppm was recorded also at station 4 in September.

A total of 60 sludge samples were collected from the same localities where seawater samples were collected. Pb and Zn were present in every sludge sample while Mn and Cu were present in all 36 samples analysed for the same.

Maximum concentration of Pb in the sludge samples was 3209.9 ppm, which was recorded at station 5 in November while the minimum concentration was 15.4 ppm noted at station 2 also in November. The maximum concentration of 111.3 ppm Zn was found at station 1 during September whereas the minimum was 8.7 ppm estimated at station 4 in August. Cu was maximum at 454.4 ppm in October at station 5 while a minimum concentration of 1.6 ppm was recorded at station 2 in November. The concentration of 1450 ppm Mn was maximum at station 3 during August and a minimum of 5.0 ppm was also noted at station 3 during October.

The above mentioned analytical results are completely different from municipal waste water and hence they suggest that presence of heavy metals was due to industrial effluents of Lyari. Since Manora channel has only one outlet, the polluted water from Lyari is not easily flushed out of it and remains almost stagnant during low tides. But atleast for the three months during North East monsoon when the currents move anticlockwise, the out-going water may be carried towards Manora island, Sandspit, Hawkes Bay and Paradise Point.

High concentration of the heavy metals in the seawater as well as sludge samples is due to the cumulative effect resulting from stagnation in the channel. It should, therefore, be a point of great concern that the effluents from Lyari carrying the high pollutant load of heavy metals are discharged into the coastal waters.

In order to identify the source of heavy metals, samples were collected from various points located at Lyari river. Table II shows the concentration of heavy metals at localities where most of the industrial effluents from SITE area are discharged. For example, Pb was present in water in all the collected samples, but it was maximum at Shershah bridge. It is, therefore, possible to say that the main bulk of this pollutant is

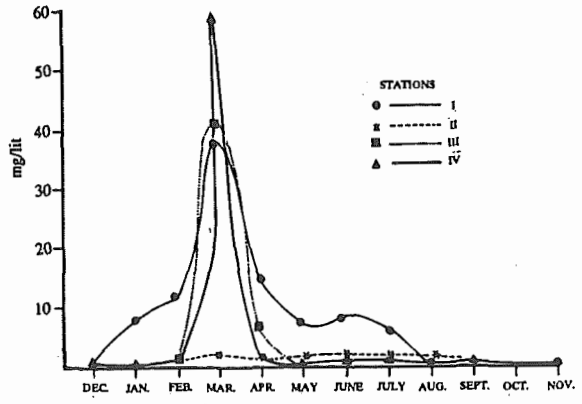


Fig.1. Concentration of lead in water

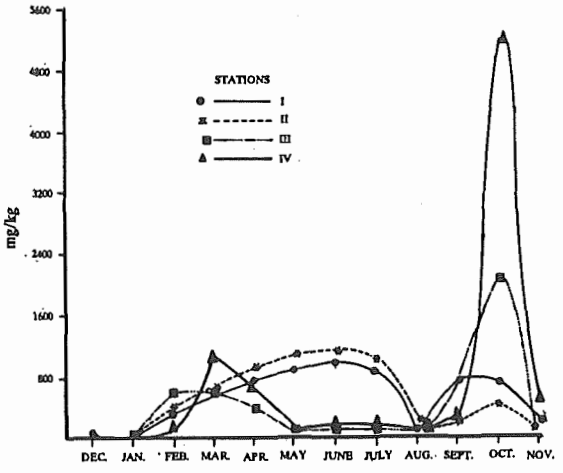


Fig.2. Concentration of lead in sludge.

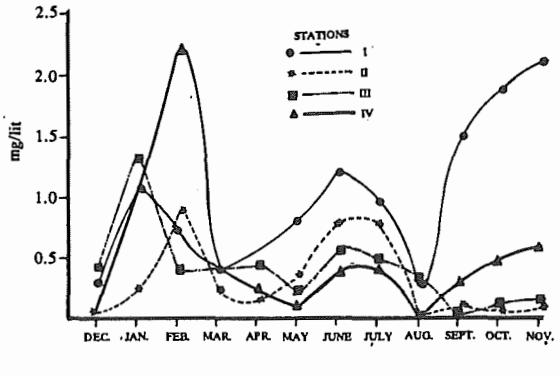


Fig.3. Concentration of zinc in water.

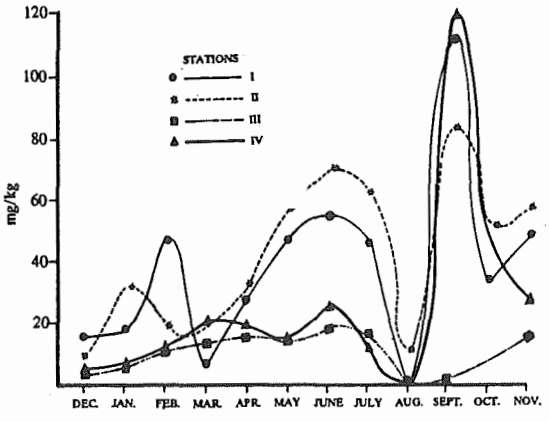


Fig.4. Concentration of zinc in sludge.

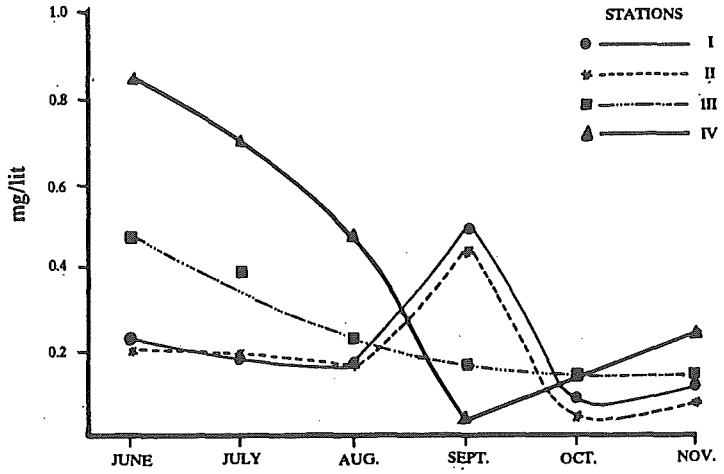


Fig.5. Concentration of copper in water.

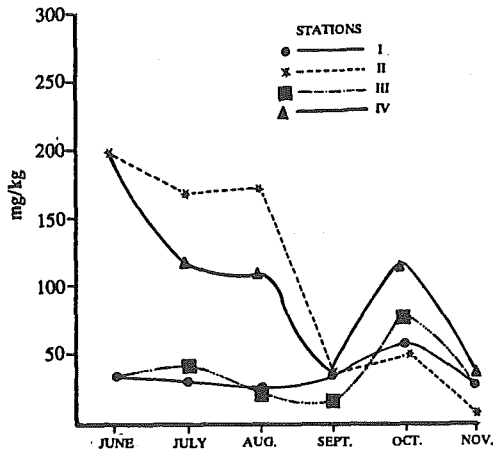
emanating from industries based in Shershah. Sludge samples collected at the same locality similarly showed the maximum concentration of Pb (1800 ppm) and Zn (230 ppm).

Heavy metal concentration at other points on the Lyari river suggests that the maximum level is at present located adjacent to the discharges of industrial effluents from SITE. It may be noted from Table II that although Lyari is being diluted near the confluence it carries a high load of toxic elements which in the long run may become quite unmanageable since industries are being sited indiscriminately in the entire area.

The extent of heavy metal pollution may also be observed from the typical analytical results presented in Table III. Most of the samples collected were located at Chari Kundi channel. The water here is stagnant and, therefore, is highly polluted as well as concentrated with soluble matter. It has been noted from the results that every collected sample from this area is contaminated with Pb, Zn, Cu, and Mn. The sampling spot located opposite the jetty on the beach contains comparatively lower concentration of pollutants. This observation suggests that the pollution load is gradually spreading all over the coastal areas. High concentrations of Zn could be observed in September and October; perhaps because of the effect of concentration due to dry winds and high temperatures.

Figures 1 and 2 show the variation of concentration of Pb in seawater and sludge during the 12 months. From this it can be seen that the concentration of Pb in seawater is alarmingly high during March, possibly due to some industrial activity. An average of 0.2 to 0.9 ppm of Pb is recorded throughout the year, most of it being noted at stations 1 and 2 in Table II which further indicates that the main source of pollution is Lyari.

The variation of concentration of Zn in seawater may be noted from the figure 3 and of the sludge in figure 4. The variation of concentration of Pb and Zn in sludge follow the same pattern. In both cases it was very high in October. It may be noted from figure 3 that Zn is present in the range of 0.02 to 2.5 ppm throughout the year, that is, December 1984 to November 1985 at all the sampling localities while in the



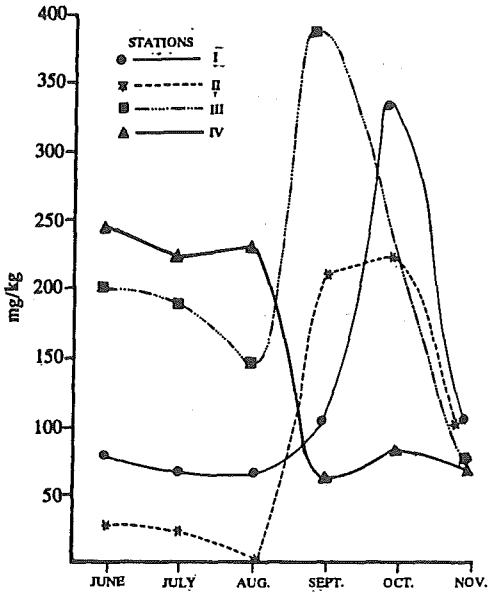


Fig.6. Concentration of copper in sludge. Fig.7. Concentration of mangnese in sludge.

sludge it varies from 0.01 to 120 ppm.

Figures 5 and 6 show that variation of concentration of Cu in seawater and sludge samples during the period of the survey. The maximum concentration in seawater is at station 4. An average of 0.2 to 0.5 ppm of Cu was found at all the localities. Station 4 is near the repair area of boats and launches close to the fish harbour, which may be the reason for the high concentration. Cu in sludge is also quite high at station 4. The concentration both in seawater and sludge is high in June, July and August.

Manganese was not found in the seawater but in the sludge it was found at all localities throughout the year. At stations 3 and 4 it was found to be maximum in concentration in the months of June to August, but higher concentration of Mn was also found at stations 1 and 2 in the months of September to November (Fig.7).

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