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PHYSICO-CHEMICAL CHARACTERISTICS OF WATER AND SEDIMENTS OF CHINNA CREEK AND THE ASSOCIATED BENTHIC BIOTA ON ITS FRINGES

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ABSTRACT

Chinna Creek is about 5.0 km long, 300 to 500 m wide with a depth ranges from 1 to 3 m situated at the south east of Karachi. The concentrations and spatial distributions of different pollutants, including ammonia, Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Cyanide, Dissolved Oxygen (DO), oil and grease (n-Hexane extract), Phenol, and Heavy metals (As, Cd, Cu, Cr, Hg, Pb and Ni) were investigated in water and sediment samples collected from eight stations at Chinna Creek. The concentration of many of these pollutants was quite alarming except Cr, Pb and Ni in water and sediment samples. A total of 47 species of flora and fauna were recorded from 8 different sampling sites of Chinna Creek. Ecological survey of the benthic communities revealed that the pollutants are responsible for the degradation of natural ecosystem of the Creek, which has consequently resulted in reduced biodiversity of the ecosystem.

Keywords: Pollution, Chinna Creek, ecology, NEQS (National Environmental Quality Standard)

INTRODUCTION

Karachi is the largest and the highly populated metropolitan centre of Pakistan. It is situated near the coast, which makes it a focal centre of industrial development, education and multi-culturalism. The coastal zone of Karachi is about 135 km long and it is reported that it is one of the most affected areas along the coast of Pakistan (Haq, 1976; Beg, *et al.*, 1984; Iqbal and Jilani, 1995; Beg 1997, Khan, *et al.*, 1999a; Khan, *et al.*, 1999b). East south east of Karachi lies the Indus delta, which covers an area of 5,000 square kilometers. This area is provided with an intense network of creek System.

Chinna Creek also known as Eastern Breakwater had two entrances, one at Manora point and other at Clifton foreshore, prior to 1873 before the construction of Karachi Port. This natural arrangement had a good water circulation. In 1873 the Clifton entrance was artificially closed with a view to use the Western Breakwater as intertidal water reservoir so that the water stored here during high tides leaves Manora channel at high velocity during ebb keeping the channel bed clean and dredged. With the passage of time, a thick growth of mangrove developed in the area that promoted situation to the extent that the water reservoir capacity was drastically reduced resulting in loss of natural dredging effect.

The sizeable addition of various chemicals in the creek of industrial and domestic origin and the waste oil from various motor boats further aggravates the problem. In view of significant marine pollution, a pollution survey was conducted to investigate the quantities of various pollutants in the creek and the effect of such pollutants on the benthic communities of Chinna Creek.

MATERIALS AND METHODS

The study was conducted during February and March 2003. Water and sediment samples were collected from 8 different sampling stations along the Chinna Creek at a distance of at least 400 m apart. At different sampling stations the depth of water varied significantly from 1.0 to 3.0 m. From each sampling station three samples were collected. Samples were brought to the laboratory within two hours of collection, processed accordingly and analyzed for the parameters mentioned below. Fig. 1 represents the sites of sample collection of Chinna Creek.

Collection of water samples

The samples were collected using Nelson bottle from the surface (approx. 5 cm), mid point and at the bottom of total depth. The samples were mixed in equal proportion (approx. 1 litre) to make one composite sample. For the collection of water samples for physical and chemical parameters white plastic containers of 2-litre capacity were used. The sample was collected to avoid floating materials. Some portion of the sample was appropriately preserved

for later studies according to the procedures as mentioned in Standard Methods for the Examination of Water and Wastewater (APHA, 1995).

Collection of sediment samples

The sediment samples from the Creek were collected from the locations given in Fig. 1. These samples were collected in sterile plastic bags using Patterson grab. Temperature and pH of the sediment samples were recorded on the spot. These samples were brought to the laboratory within two hours of collection. The samples were analysed in accordance with the procedures outlined in Standard Methods for the Examination of Water and Wastewater (APHA, 1995).

Fig. 1. Map showing Chinna Creek in the south of Karachi City.

Physical parameters

The physical parameters tested were pH, salinity and temperature. pH and salinity of the samples were determined on site using HACH sensation 156 multi parameter dissolved oxygen meter. Temperature (^{o}C) measurements were conducted using Zeil thermometer by immersing it in the sample.

Biochemical and Chemical Parameters

These parameters include (i) ammonia NH_3-N (ii) Biochemical Oxygen demand BOD_5 (iii) Chemical Oxygen demand COD (iv) cyanide (v) dissolved oxygen (DO) (vi) oil and grease (n-Hexane extract) and (vii) phenol. These parameters were determined according to the methods mentioned in the Standard Methods for the Examination of Water and Wastewater (APHA, 1995).

Metal Analysis

The metal contents in the sample were measured with the help of Perkin Elmer Atomic absorption Spectrophotometer–3100 using standard techniques (APHA, 1995).

Collection and Processing of Sample for Benthic Communities

Benthic sample were collected using Patterson grab from the designated sampling sites. At each site a quadrate of 1.0 m^2 was placed at random and the sediment along with benthic organisms and were collected and transferred in the plastic bags. Formalin (10%) was added to the sample to ensured adequate fixing of all the material. Rose Bengal (1% solution in distilled water) was also added to the sample so as to stain the benthic organisms, which made sorting much easier.

Sieving and Sorting

In laboratory, each plastic bag containing biotic sample was carefully opened and the contents were transferred on a sieve of 0.5 mm mesh. The bottom of the sieve was gently dipped several times in sink containing water. The sediment remained on the sieve was transferred to Petri plates and the benthic organisms were handpicked, mostly under a stereomicroscope. Care was taken to pick up all the organisms present in the sediment sample. These organisms were put in suitable containers and fresh formalin solution (10%) was added. The containers were properly labeled.

Identification of biota

Attempts were made to identify all the biota present in the samples up to species level, but it was not always possible to do so. Hence several specimens were identified only up to various taxonomic categories. This was mainly due to the condition of the preserved specimens, which sometimes lacked those parts of the body that bear species specific characters.

Temporary slides of microscopic organisms were made in glycerol jelly, which is a mixture of gelatin (10g), distilled water (60ml), glycerol (70ml) and phenol (0.25g) (Peacock 1966). Lactophenol (Amann's medium) was used to clear the specimens, especially nematodes and polychaetes. The lactophenol was prepared by adding 20g of phenol to 20 ml of distilled water, when the phenol dissolved completely, 16.8 ml of lactic acid (glacial) was mixed and finally 33.3 ml of glycerol was added (Peacock 1966).

The references which were used for the identification of biota include: Dendy (1916), Gardiner (1916), Wesenberg-Lund (1949), Mohammad (1970a,b,c, 1971, 1972a,b, 1973, 1974a,b), Dance (1974), Oliver (1975), David and George (1979), Bemert and Ormond (1982), Burukovskii (1982), Tirmizi and Zehra (1984), Davaney *et al.* (1987), Campbell (1989), Fish and Fish (1989), Allen (1997), Mustaquim (1997) and Shameel (2001).

RESULTS AND DISCUSSION

The data collected during the course of study is presented, discussed and compared with National Environmental Quality Standards.

Physical parameters

Physical profile of marine water samples from different locations of Chinna Creek is shown in Table 1. pH values of Chinna Creek water at different sampling stations ranged between 7.7 to 9.1 whereas, the pH of sediment ranged between 7.8 to 8.8. pH of the entire Creek was towards alkaline side which favours the growth of flora especially algae (Smith and Smith 1998). The salinity of the Creek water ranged from 20 to 30 parts per thousand.

Biochemical and Chemical Parameters

The results of above biochemical and chemical parameters are reported in Table 2. NH_3-N is an important parameter in the pollution of marine and terrestrial environments. The average minimum and maximum concentration of NH_3-N in Creek water ranged between 2.6-5.7 mg/L. In marine environment NH_3-N is produced as a result deamination activity by microorganisms. Accumulation of NH_3-N beyond 1.5-2.5 mg/L becomes toxic to growth of marine vertebrates and invertebrates (Bond and Straub,1973; Pearson-Le *et al*.,1995).

The BOD_5 values of the creek water ranged between 108-144 mg/L whereas the sediment values varied from 135-290 mg/L. The values are significantly greater compared to the NEQS (P at the most 0.05), which represents the maximum permissible limit of 80 mg/L. High BOD_5 interferes with aquatic life and harmful to fishes as it tends to deplete dissolved oxygen. BOD_5 generating compounds such as hydrocarbons are toxic to fish beyond 10-20 mg/L (ACE, 1994).

Table 1. Physical profile of marine water at different locations of Chinna Creek

S.No.	Sample	Depth (m)	Parameters					
			pH		Salinity ppt		Temperature (^{o}C)	
			W	S	W	S	W	S
1.	1	1.5	7.7	7.8	28	-	20	21
2.	2	1.0	8.2	8.3	25	-	21	22
3	3	1.5	8.3	7.9	19	-	22	21
4.	4	2.5	9.1	8.8	21	-	20	20
5.	5	3.0	8.1	8.0	27	-	21	22
6.	6	3.0	8.1	8.2	27	-	20	19
7	7	2.5	8.2	8.2	30	-	21	20
8	8	4.4	8.1	8.3	28	-	20	21
	Range	1.0-5.0	7.7-9.1	7.8-8.8	29-30	-	20-22	19-22

The results reported are mean of 3 replicates. W=Water, S=Sediment, ppt=Parts per thousand

Table 2. Biochemical and chemical profile of Gharo Creek

Sam-ple	Parameters (W=mg/L, S=mg/Kg)													
	Ammonia NEQS=40		BOD_5 NEQS=80		COD NEQS=150		Cyanide NEQS=2.0		DO		Oil and grease NEQS=10		Phenol NEQS=0.1	
	W	S	W	S	W	S	W	S	W	S	W	S	W	S
1	4.8	-	138	262	10178	12794	3.56	6.71	3.2	_	432	48	4.89	6.21
2	5.7	-	144	273	1305	2100	4.51	7.60	3.9	_	535	744	5.54	5.73
3	5.3	-	142	276	1240	2230	4.86	8.28	2.2	_	527	593	6.70	6.89
4	5.5	-	135	290	745	1870	3.36	5.46	4.8	_	579	632	4.32	5.51
5	4.5	-	115	191	262	1650	3.32	3.31	2.9	_	351	430	3.96	4.93
6	3.5	-	120	180	252	1340	3.51	6.71	3.3	_	154	325	4.22	3.73
7	2.6	-	132	135	248	794	3.28	3.39	5.5	_	226	220	3.56	3.50
8	2.8	-	108	150	267	1225	3.49	5.78	4.5	_	329	433	3.59	3.56
Min Max	2.6-5.7	-	108-144	135-290	248-1305	794-2230	3.28-4.86	3.31-8.28	2.2-5.5		154-579	223-744	3.59-6.70	3.50-6.89

The results reported are means of 3 replicates.

The COD values represent both biologically and chemically oxidisable substances. The COD values of water and sediment samples ranged between 248-1305 mg/Land 794-2230 mg/Kg respectively. These values are significantly greater that that of NEQS ($P<0.001$). The high values represent the presence of high concentration of chemically oxidisable matter of industrial origin that may be toxic to marine life forms.

The concentration of cyanide in Creek water and sediment as compared to NEQS was quite alarming. The values of Creek water ranged between 3.28- 4.86 mg/L and in sediment ranged between 3.31 8.28 mg/Kg. The maximum allowable limit of cyanide as compared to NEQS is 2.0 mg/L. Presence of cyanide indicates contamination due to industrial waste, which is mainly attributed to electroplating industry, metal treating industry, steam electric power plants, etc.

Although, DO is not considered to be the pollutant parameter however its concentration represents the extent of pollution. The values of DO in Creek water ranged between 2.2 to 5.5 mg/L. However, this level of oxygen would not be enough to efficiently control the natural purification system of water in the Creek, which would result in reduced biodiversity.

Table 3. Heavy metal profile of Chinna Creek.

Sample	Parameters (mg/L)													
	As NEQS=1.0		Cd NEQS=1.0		Cr NEQS=1.0		Cu NEQS=1.0		Hg NEQS=0.01		Pb NEQS=0.5		Ni NEQS=1.0	
	W	S	W	S	W	S	W	S	W	S	W	S	W	S
S-1	T	T	T	T	0.28	1.18	T	T	T	T	0.48	0.68	<0.002	1.80
S-2	T	T	T	T	1.09	0.84	T	0.003	T	T	0.38	0.53	0.004	1.96
S-3	T	T	T	T	0.48	0.81	T	0.005	T	T	0.41	0.90	T	1.86
S-4	T	T	T	T	1.21	1.63	T	<0.002	T	T	0.32	0.93	<0.003	1.64
S-5	T	T	T	T	0.43	0.62	T	T	T	T	0.27	0.53	<0.002	1.32
S-6	T	T	T	T	1.26	1.35	T	T	T	T	0.39	0.42	T	1.56
S-7	T	T	T	T	0.33	0.45	T	<0.008	T	T	0.24	0.46	<0.002	0.32
S-8	T	T	T	T	0.38	1.31	T	<0.005	T	T	0.28	0.47	T	0.37
Min-Max					0.28-1.26	0.45-1.63		T <0.008			0.24-0.48	0.42 0.93	T-0.004	0.52-1.96

The results reported are mean of 3 replicates; T: Traces.

Oil and grease in any amount hampers the dissolution of atmospheric oxygen in the water thereby creating anoxious condition detrimental to marine life form. The concentration of oil and grease in water varied between 154 to 579 mg/L where as, in sediment ranged 220-744 mg/Kg. These values represent significant extent of oil pollution in the Creek. The values are alarming (highly significant $P<0.001$) when compared with NEQS where the standard value is 10.0mg/L.

Phenols are usually present in the discharges from petroleum refinery, steam and electric power plants, rubber processing, glass and asbestos manufacturing. The concentration of phenol in Creek water ranged between 3.59-6.70 mg/L and that of sediment ranged from 3.50 to 6.89 mg/ Kg. These values are significantly higher when compared with NEQS and indicates a heavy pollution load entering into the Creek from the industries near by.

The concentrations of heavy metals (As, Cd, Cu, Cr, Fe, Hg, Pb, and Ni) are reported in Table 3. From the standpoint of metallic pollution the Creek water is not significantly polluted. All the heavy metals were below detectable (<0.001 mg/L) limit except Pb and Ni where in the Creek water and sediment samples show concentrations above the standard.

The high concentrations of Cr, Ni and Pb are mainly attributed to the industrial activities. Cr is reported to be toxic only in hexavalent form (Misra and Mani, 1992). The concentration of Cr in Creek water varied from 0.28-

1.26 mg/L where as in sediment raged between 0.45-1.63 mg/Kg. The high concentration of Cr in Creek water is mainly attributed to tanneries. The values of Cr in sediment samples were insignificant from the environmental point of view. The concentration of Lead ranged between 0.24 to 0.48 mg/L in water and in sediment from 0.42-0.93 mg/Kg, which might come from plumbing material, batteries, and paint manufacturing plants. Lead exhibits low toxicity potential to plants but a high potential fro toxicity to animals including marine life forms (Bushnel and Joeger, 1986).

The concentration of nickel in water is insignificant (P at the most 0.05) but relatively high in sediment samples (0.52-1.96 mg/Kg) compared to NEQS.

Table 4. Frequency of occurrence of biota of Chinna Creek

Taxa	Sampling sites									
	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	Number of species (ni)	% Abundance (ni/N)
Flora										
Monocot (Graminae)	1	1	2	1	1	1	1_	1	2	4.25
Dicots	1	2_	1	1	2	1	1	1	2	4.25
Algae	5	4	5	3	6	3	4	4	6	12.76
Total number of plant species	7	7	8	5	9	5	6	6	10	
Fauna										
Porifera (Sponges)	___	___	1	___	__	__	__		1	2.12
Nematoda (Round worm)	4	5	4	3	3	4	1	2	6	12.76
Mollusca										
Gastropoda (Snail and Sea slugs)	3	2	4	2	3	2	2	1	6	12.76
Pelecypoda (Bivalves)	2	3	2	1	1	2	3	2	4	8.51
Annelida (Polychaeta)	3	1	3	2	2	1	2	2	5	10.63
Crustacea										
Copepoda	1	1	__	1	1	2	3	__	3	6.38
Ostracoda	1	1	2	2	1	3	1	__	4	8.51
Egg mass/eggs	2	4	3	3	___	3	2	__	4	8.51
Unidentified specimen	2	4	3	___	3	___	4	__	4	8.51
Total number of species	25	28	30	19	23	22	24	13	N= 47	

In general, the biodiversity of the creek is low.

Benthic Communities

During present investigation biota sample from benthic deposits were collected from 8 sampling sites as described above. The number of species of various taxa recorded and the distribution of species across sampling sites are reported in Table 4. A total of 47 species of flora and fauna were recorded from the samples collected at 8 different sampling sites of Chinna creek. The number of angiospermic plant species (monocots and dicots) were low in all the sampling sites because of the brackish water at the sites. The number of algal species recorded were substantially higher than the angiosperms recorded at Chinna creek. Among the algae the most abundant species

were *Enteromorpha* and *Ulva* (Chlorophyta). The blue-green algae (Cyanophyta= Cyanobacteria) were also recorded. These included *Phormedium*, *Calothrix* and Nostoc. Like the flora, fauna was also poorly represented. Only one species of sponge (Porifera) was recorded. Marine (benthic) nematodes were represented by 6 species. The most prominent group (phylum) was Mollusca, which constituted 21.27 % of the total organisms collected from all the sampling sites. Within Mollusca, Gastropods were represented by 6 species and bivalves by 4 species. Crustacea had low species richness and constituted 14.89 %. Egg mass, unidentified specimen, empty mucous tubes were also recrded. Annelida were represented by 4 species (8.51%). In Crustacea the most abundant group was Ostrocoda (8.51%).

CONCLUSION

The heavy metals profile of Chinna Creek shows that most metals (As, Cd, Cu, Hg) are generally being added to the creek in low amounts and are within safe limits from environmental viewpoint except Cr, Pb and Ni that are significantly greater than those of NEQS (P at the most 0.05). High BOD and COD of channel water and the accumulation of heavy metals such as chromium, lead and nickel in the sediments are inimical to growth and development of flora and fauna. Thus reduced biodiversity can easily be attributed to increased levels of pollution of the sediments. Heavy metals are being added constantly as a result of the discharge of industrial effluents, their continuous accumulation in marine deposits is a potential threat to aquatic life. It is suggested that a more extensive ecological survey of the creek need to be undertaken to elucidate the impact of above mentioned pollutants on the biotic communities of the Creek.

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