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Pollution Profile of Malir River

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Abstract. This study was aimed at determining the physical (pH, TDS, TSS) and chemical (ammonia, BOD_5, COD, chloride, cyanide, detergents, phenols and sulphate) parameters as well as heavy metals (As, Cd, Cu, Cr, Pb, Ni, and Zn) present in Malir river water, so as to identify the extent of pollution. The average results of each parameter of 10 different sites were compared with National Environmental Quality Standards (NEQS). It was found that Malir river water quality meets only some of the NEQS. Variable quantities of different heavy metals were also found. It can be concluded that the continuous discharge of Malir river at Gizri creek plays an important role resulting in reduced biodiversity.

Keywords: Malir river, effluent, pollution, industrial, water quality

Introduction

Karachi is situated on the southwestern part of Indus delta. It is the largest and the most industrialized city of Pakistan. There are more than 5000 registered industrial units (and many unregistered ones) producing oil, steel, paints, chemical, fabric, pharmaceuticals, paper and pulp, food products, etc. Apart from a few multinational companies, which have installed waste treatment facilities, virtually none of the industrial unit has any waste treatment facility. Most of the industrial and domestic wastewater is discharged untreated into the Arabian sea through Malir and Lyari rivers.

Karachi basin is drained by two major rivers namely Malir and Lyari with catchments areas of 2051 and 7045 Km^2, respectively (ACE, 1994). These rivers play an important role in the natural drainage of Karachi city. At present, Lyari and Malir rivers are being used for (i) dumping of garbage and industrial waste, (ii) cattle yard waste, (iii) laundry effluent, (iv) waste from unauthorized factories, (v) agriculture wastes and, (vi) domestic wastewater from human settlement. Throughout the year Malir and Lyari rivers serve as dumping places for the discharge of liquid and solid waste of industrial and domestic origin. These rivers instead of giving a pleasant look become an eye sore for the population (Beg, 1997).

Malir river topography can be divided in two parts: (1) upper portion that is hilly, undulated and without any vegetation, (2) lower portion that consists of a 48 Km strip from confluence of Mol and Khadeji to sea, and occupies about 133, 333 Km^2. The ground level ranges from 0.0 to 106 m above the mean sea level (ACE,1994). The Malir river has a wide bed with a narrow strip of flood plains along its bank. Most of the area is covered with fine to coarse sand occasionally mixed with gravels and boulders. However, silty sand and silt beds are also found in patches. Apart from Mol and Khadeji the other tributaries of Malir river are Thaddo, Sukkan, Turi, and Jarendo nallas. Malir river travels a distance of 18 km approximately within the city limits. Large scale unauthorized agricultural activity is taking place along the Malir river bed causing alteration in the river water flow. In addition a number of cattle dens are also present along the riverbed that is a continuous source of pollution of the river water. At present there are two road bridges, one railway bridge and five road causeways built on Malir river. There are presently eight inlets discharging untreated industrial and domestic wastewater into it.

The present study was aimed at collection and analysis of wastewater samples from the Malir river so as to determine the extent of pollution load that is a continuous threat to inland and coastal ecosystems.

Materials and Methods

Water samples were collected from 10 different predesignated sampling sites along the Malir river, as indicated in Fig. 1. The description of these sites and the associated activities indicated in Table 1. The present study was conducted from January to December, 2002.

Sampling technique. At different sampling sites the river water depth varied from 0.1 to 0.3 m. Care was taken to collect the sample from the mid depth of the flow. At each sampling site (M-1 to M-10) 12 samples were collected from January to December, 2002, with monthly interval. The present study is, therefore, based on the analysis of 120 samples from 10 different sites. Flow proportionate samples were collected

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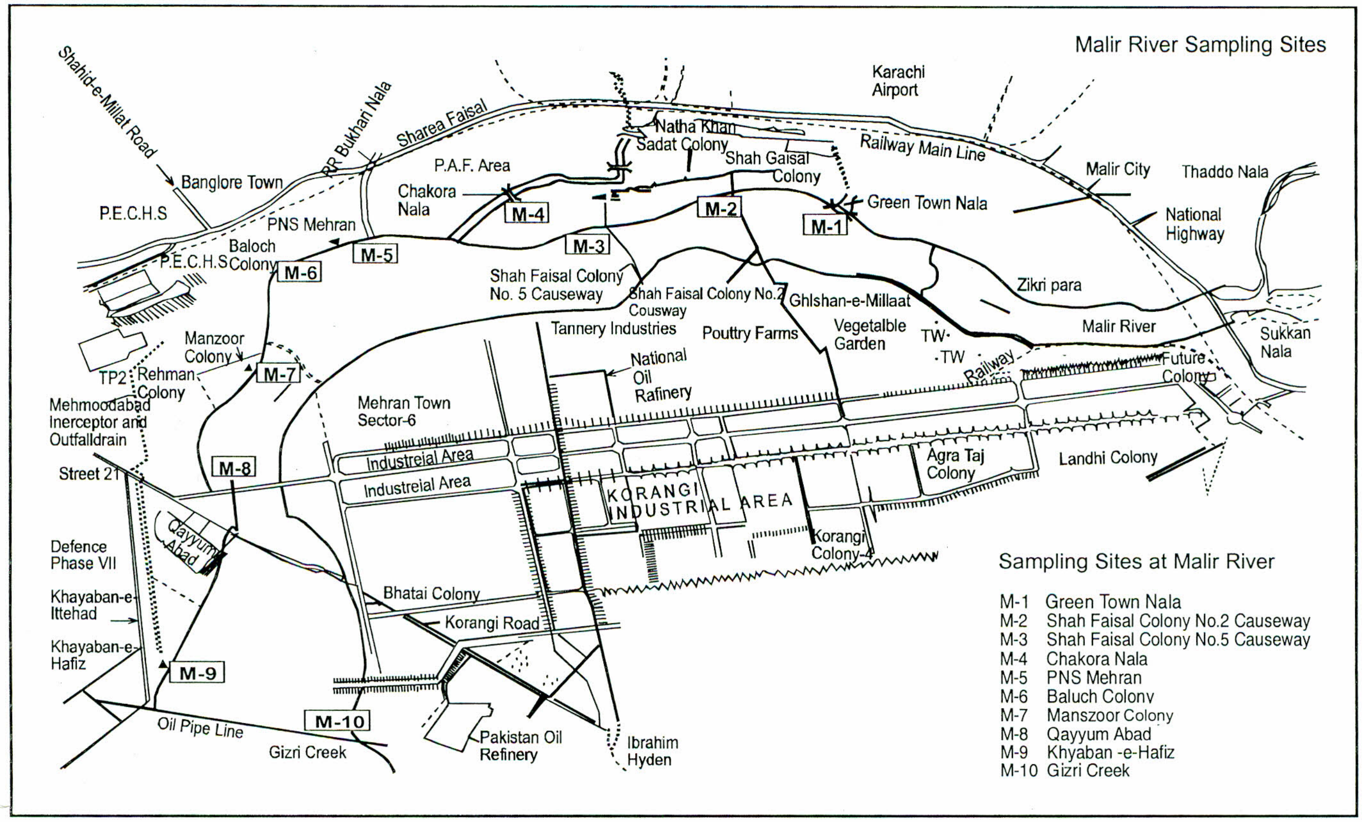

Fig. 1. Malir river sampling sites.

and pooled to obtain one composite sample. The composite sample representing a given sampling site was brought to the laboratory within two hours of collection and processed accordingly for the analysis of following parameters.

Physical parameters. The physical parameters tested were (i) pH (ii) total dissolved solids (TDS) and (iii) total suspended solids (TSS). The pH of the samples was determined by using Orion pH meter. The other two parameters (TDS and TSS) were measured by the methods described in APHA (2003).

Biochemical and chemical parameters. These parameters include (i) ammonia, (ii) BOD_5 (biochemical oxygen demand), (iii) COD (chemical oxygen demand), (iv) chloride, (v) cyanide, (vi) an-ionic detergents, (vii) phenols, (viii) sulphate, which were measured according to the methods described in APHA (2003).

Metal analysis. Metal contents of the samples were measured with the help of atomic absorption spectrophotometer (Pye Unicam, SP-2900) using standard techniques as mentioned in the APHA (2003).

Hydrological regime of Malir river. Since Karachi, gets very little rain therefore, Malir river remains dry almost through out the year. During dry season, and in the absence of rain the river acts as an open sewer receiving domestic, industrial and trade wastewater through different tributaries, overflowing gutters and storm water drains transformed into and acts as open sewerage network (Khan and Khan, 2001; Khan *et al.*, 1999). Due to variations in industrial production and in the use of water by different communities, a large variation in the

Table 1. Malir river sampling sites along with the associated activities

Sampling stations	Sampling sites	Associated activities
M-1	Green town nallah	solid waste dumping
M-2	Shah Faisal colony No.2: Causeway	agricultural activities, cattle farming
M-3	Shah Faisal colony No.5: Causeway	vegetable farming
M-4	Chakora nallah	no activity was seen
M-5	PNS Mehran	no activity was seen
M-6	Baloch colony	no activity was seen
M-7	Manzoor colony	cattle farming, agricultural activities, squatter settlements
M-8	Qayyumabad	cattle farming, solid waste dumping
M-9	Khyaban-e-Hafiz	no activity was seen
M-10	Gizri creek	solid waste dumping

hydraulic flow regime and hence the concentration of pollutants was observed at different sampling stations from M-1 to M-8 (Khan *et al.,* 2001). Flow measurements were carried out before noon and after noon and then averaged out for all the sites. The flow measurement was carried out using a pin pong ball that was allowed to float for a known distance.

Results and Discussion

River flow, bed slope and subsurface conditions. The upper portion of Malir river is undulating whereas the lower portion comprises flat land, which is nearly level plain. The area is covered with fine to coarse sand whereas, silty sand and silt beds are also found. The catchment area mostly is occupied with unauthorized agricultural activities, which altered the flow of water. The river water is typically dark grey with high suspended solids, floatable solids, and high nutrients (nitrogen and phosphorus).

There is no significant variation in the flow during day time. However, considerable difference was observed during nighttime. The average flow is summarized in Table 2.

From Fig. 2 it can be seen that the flow in the river gradually increases as the river approaches the sea. The maximum flow was found at M-8 (271 mld) and M-10 (312 mld). M-8 is one of the major inlets receiving industrial wastewater from the Korangi industrial town and draining into the Malir river. Discharge from Mehmoodabad treatment plant into the Malir river is also received at this point. At Gizri creek (M-10) the wastewater is coming from Korangi nalla mixes with Mehmoodabad outfall drain and Defence society inlet and finally drains into the sea at Gizri creek. The catchment area of Green town nalla

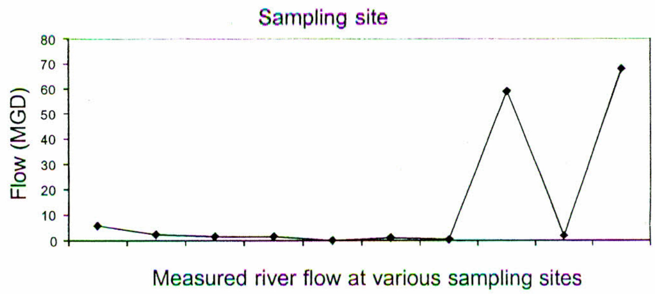

Fig. 2. Flow in Malir river (MGD).

(M-1) is small and constitutes a major source of domestic wastewater, which is used for agricultural activities on the Malir River bed covering an area approximately 40 Km^2. At M-1 the average flow recorded was 25.74 mld. From M-2 to M-7 relatively less flow was recorded. From Green Town nalla up to Baloch colony the wastewater is mostly of domestic origin. However, from Manzoor colony onwards the industrial wastewater also started mixing with the river effluent. The industrial wastewater from the Korangi industrial estate, and National oil refinery, are the major sources of industrial wastewater pollution.

Physical parameters. The pH of Malir river effluent fluctuated between 7.2 to 8.1, indicating that the river effluent is quite basic (Table 3).

Approximately 75 % of the municipal suspended solids are organic in nature and nearly half of which are settleable. Therefore, the distribution of these solids is not uniform. The variations in the amount of TDS and TSS at various stations are given in Table 3. The values of TDS range from 1012 to 3130 and those of TSS from 102-358 mg/l. TDS concentration

Table 2. Malir river flow at different sampling stations

Months	Hydraulic flow (MGD approx.)									
(2002)	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9	M-10
Jan.	6.00	2.47	1.45	1.51	0.07	0.08	0.52	42.23	1.27	64.94
Feb.	6.25	2.21	1.56	1.65	0.09	1.12	0.48	56.45	1.67	78.42
Mar.	6.11	2.32	1.58	1.75	0.085	1.11	0.52	58.95	2.20	76.54
Apr.	5.47	2.33	1.34	1.82	0.076	1.65	0.45	67.56	1.89	89.90
May.	6.22	2.00	1.36	1.34	0.07	0.85	0.47	68.45	1.95	62.78
Jun.	6.27	3.65	1.78	1.75	0.07	1.00	0.43	72.42	2.21	71.25
Jul.	6.54	2.87	1.89	1.46	0.08	1.23	0.40	52.34	1.43	78.65
Aug	4.33	2.11	1.65	1.63	0.065	1.45	0.38	52.45	1.56	45.67
Sept.	6.12	2.52	1.45	1.47	0.081	1.34	0.57	54.34	1.85	62.35
Oct.	5.32	2.63	1.64	1.78	0.09	1.56	0.62	51.25	1.91	58.90
Nov.	4.54	1.19	1.32	1.23	0.075	1.24	0.52	67.48	2.13	56.75
Dec.	5.47	1.67	1.43	1.75	0.067	1.17	0.41	63.22	2.18	68.75
Average	5.72	2.33	1.53	1.59	0.076	1.15	0.48	58.92	1.85	67.90

MGD = million gallons/day; total flow (mgd) = 141.54.

Table 3. Pollution profile of Malir river

Parameters mg/l (except for pH)	Malir river sampling sites										
	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9	M-10	Min-Max
pH (6-10)	7.6	7.6	8.0	7.4	7.2	7.5	7.9	7.8	8.1	7.2	7.2-8.1
TDS (3500)	1352	1618	3130	1012	1353	1897	2687	2957	2044	2777	1012-3130
TSS (150)	235	119	102	256	193	168	198	189	194	358	102-358
NH_3-N (40)	10.27	9.35	4.95	9.11	9.02	4.74	7.03	7.66	7.38	9.94	4.74-10.27
BOD_5 (80)	270	241	522	320	235	280	369	255	303	426	235-426
COD (150)	619	567	1316	777	644	703	1174	640	739	1497	567-1497
Chloride (1000)	440	500	1052	281	359	547	876	825	721	1074	281-1074
Cyanide (2.0)	0.084	0.05	0.044	0.032	0.046	0.016	0.019	0.469	0.029	0.104	0.016-0.469
An-ionic detergents (20)	1.21	4.74	11.33	5.95	4.38	10.97	12.33	12.77	17.40	2.20	11.21-17.40
Phenols (0.1)	0.07	0.03	0.05	0.26	0.09	0.04	0.03	0.45	0.13	0.32	0.03-0.45
Sulphates (400)	171	238	425	133	162	185	291	156	252	247	133-425
Arsenic (1.0)	0.03	0.108	0.061	0.036	0.06	0.065	0.046	0.05	0.025	0.087	0.025-0.08
Cadmium (0.1)	0.011	0.011	0.013	0.014	0.006	0.002	0.013	0.003	0.014	0.012	0.011-0.014
Copper (1.0)	0.093	0.123	0.143	0.142	0.117	0.117	0.23	0.43	0.357	0.223	0.093-0.43
Chromium (1.0)	0.003	0.415	0.001	0.002	0.003	0.002	0.002	0.002	0.004	0.001	0.001-0.415
Lead (0.5)	0.155	0.080	0.124	0.404	0.001	0.100	0.207	0.667	0.287	0.348	0.080-0.667
Nickel (1.0)	0.348	1.153	0.228	0.025	0.705	0.210	0.35	0.28	0.067	0.448	0.025-1.153
Zinc (5.0)	0.365	0.268	0.528	0.28	0.348	0.103	0.24	0.587	0.35	0.45	0.24-0.587

(Mean of 12 samples). Figures in the parenthesis are National Environmental Quality Standards (NEQS, 1993).

increases gradually as the river passes through the city but no significant change in TSS concentration was observed. This indicates that the effluent from the industries contains solids mostly in soluble from rather than in the suspended form (Khan and Khan, 2001; Khan *et al.*, 1999).

Biochemical and chemical parameters. The ammonia concentration at different sampling sites of Malir river, ranged between 4.74 to 10.27 mg/l. No significant change in ammonia concentration was observed except at sites M-3 and M-6. These are the sites where the effluent was mostly of domestic origin. Ammonia in the wastewater, is produced by the hydrolysis of urea and by the biological degradation of organic compounds. High concentration of ammonia depletes oxygen in wastewater as a result of microbial activity. The concentrations of ammonical nirogen at all sites were below the NEQS (1993) (Table 3). However, even this much concentration is toxic to some of the marine life forms.

One of the important indicators of the pollution potential of wastewater is BOD_5. The variation of BOD_5 at different sampling sites is shown in Table 3. BOD_5 level of Malir river ranges between 235 to 426 mg/l, indicating the presence of heavy organic load. The environmentally acceptable level of BOD_5 is <50 mg/l. However, at high range (> 50 mg/l) BOD_5 tends to reduce dissolved oxygen and causes the development of obnoxious odour.

The variations of COD at different sampling sites are shown in Table 3. The COD level ranged from 567 (Shah Faisal colony No. 2) to 1497 mg/l (Gizri creek). The high COD level in the samples indicates the presence of industrial compounds that are resistant to biological oxidation.

Chloride and sulphate contents of the river water were also higher as compared to NEQS (1993) (Table 3). However, chloride is not an important pollutant as that of sulphate. High sulphate level could be attributed to the reduction of sulphates to hydrogen sulphide (Bond and Straub, 1974). Thus the presence of sulphates in river water may create odour problems in the absence of oxygen.

The use of detergents has led to concerns about persistence of foaming when they are released to water bodies. The traditional soaps are biodegradable but the branched chains of sulphonates are resistant. Detergents occupy a dominant place in the market but the use of detergents is wide spread in industry and home. The variation in detergent levels of Malir river is reported in Table 3. The detergent level of the river is quite low as compared to NEQS (1993). A high level of detergents is toxic to marine life.

Cyanides are used in different industries like metal treating industry, coke and gas manufacturing. The later two are the major sources of cyanide in the wastewater. The trend of cyanide is reported in Table 3. Though the cyanide level is still not alarming however, such levels if maintained over long periods may be toxic to some of the fish species and other aquatic fauna (Bond and Straub, 1974).

The variation in phenol level is indicated in Table 3. Phenols are usually present in discharges from petroleum refining, steam power plants, rubber processing plants, glass and asbestos manufacturing. The phenol concentration is relatively higher (0.45 mg/l) at M-8, which receives wastewater from national refinery and other industries. Higher concentrations of phenol are reported to be carcinogenic if enters into the food chain (George *et al.*, 1994). Moreover, their presence in wastewater increases the chlorine demand for disinfection.

Metals in different states and in different situations have been found to be essential and toxic (Fischer, 1985; Nelson, 1982; Hambridge *et al.,* 1981; Davis and Beckett, 1978; Martin and Coughtry, 1975). The extent of damage done to the physiological system of living beings depends upon bioavailability and absorbability of metals (Misra and Mani, 1992; Bushnell and Joeger, 1986; Catlado *et al.,* 1983).

The ranges of metal content at different sampling sites of Malir river are presented in Table 3. Variable quantities of different metals were present in all the sampling sites. In general the concentrations of heavy metals were within the permissible limits of the NEQS (1993). The sensitivity of organisms to metal toxicity varies widely with species of flora, fauna, and genotypes within the species and several factors can modify the response to the toxic dose of metals. Although the concentration of these heavy metal is low but their continuous deposition in marine environment is a constant threat to the coastal, and inland ecosystem.

Conclusion

The Malir river meets only some of the NEQS (1993). BOD_5 and COD values are exceptionally high. It is concluded that the unpleasant character of the river will not be changed till the industries do not stop dumping untreated wastewater. It is noticeable and alarming that the river effluent is used for irrigation. The civic bodies should take immediate steps to impose ban on this unhealthy activity. About 650 mld of untreated wastewater from Malir river enters into the sea at Gizri creek, which is responsible for the degradation of natural ecosystem of the creek and resulting into reduced biodiversity.

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