The Nucleus, **46** (1-2) 2009: 53-59

The Nucleus
A Quarterly Scientific Journal of Pakistan
Atomic Energy Commission
NCLEAM, ISSN 0029-5698

PHYSICO - CHEMICAL AND BIOLOGICAL WATER QUALITY OF KARACHI COASTAL WATER

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(Received January 27, 2009 and accepted in revised form April 13, 2009)

Physiochemical and biological techniques have been applied to investigate Karachi Coastal water pollution due to Layari and Malir rivers, which mainly carry Karachi Metropolitan domestic and industrial wastewater. In Manora channel, which receives domestic sewage through Layari river, pH and electrical conductivity (E.C.) of seawater were less in low tide conditions as compared to high tide condition, and except for Manora Lighthouse all sampling stations exhibit E.C. below normal values of seawater, indicating fair proportion of Layari river water mixing in seawater. Coliform contamination ranged from 156 – 542 per 100 ml (high tide) and 132- 974 per 100 ml (low tide) with increased levels observed in sampling sites close to Layari river outfall zone. Along Southeast coast, a decrease in EC was recorded at Ghizri area and Ibrahim Haideri fish harbour in low tide which indicated Malir river water input. Coliform bacterial counts at these locations were also above WHO guidelines for seawater bathing. pH and electrical conductivity values of Northwest coastal water indicated that this coast is marginally polluted. The study revealed that Karachi Metropolitan domestic sewage and industrial effluents are main source of coastal water pollution.

Keywords: Electrical conductivity, pH, Turbidity, Coliform, Manora channel, Southeast, Northwest coast

1. Introduction

Marine pollution due to anthropogenic activities has now become a worldwide environmental concern [1]. Several researchers [2-5] have reported the influence of indiscriminate discharge of untreated industrial effluent and municipal waste water on the marine environment in terms of danger to habitants, serious risk to marine life, deterioration of aesthetic values and limited access to coastal areas. Hence, monitoring of marine coastal environment is essential to formulate a viable management strategy [6].

Like other coastal regions of the world, Karachi coast, especially Manora channel, is heavily polluted due to untreated industrial wastewater and Metropolitan municipal sewage which are indiscriminately discharged into coastal waters through Layari and Malir rivers [7]. According to a report [8], only 20 percent of total annual wastewater produced in Metropolitan Karachi is treated and rest is discharged directly into coastal waters. This situation demands to characterize the coastal water in order to determine pollution load, its extent and type.

Metropolitan municipal sewage and industrial effluent are two major sources of coastal water pollution. The untreated effluent of more than six thousand industrial units scattered in six big industrial estates alongwith 300 Million Gallon per Day (MGD) municipal and industrial wastewater is discharged into Karachi coastal waters through Malir and Layari rivers [9]. Layari river empties into Manora channel while Malir river joins sea at the Ghizri creek lying on Southeast of Karachi Coast. Industrial units pouring their waste into sea through these rivers are mainly tanneries, textile, detergents, paints and dyes, pharmaceuticals, plastic, metallurgy, oil, food and beverages, lubricants, cement, auto engineering works etc. [10]. It is reported that an estimated BOD load of 1,500 tons/day is added into sea by these industries in addition to inorganic pollutants [11].

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Layari river passes right through the centre of the Karachi Metropolitan while Malir river flows mainly through eastern part of the city. Both rivers act as an open sewage drain, receiving highly polluted wastewater of industrial and domestic origin. In accordance with a report [8], the Layari river discharges 130,000 tons of solid nitrogen, 160,000 tons of organic matter, 800 tons of nitrogen compounds, 90 tons of phosphate compounds and 12,000 tons of suspended solid every year in Manora channel.

In the present study, physico-chemical and coliform bacteria were used to assess marine coastal pollution along Karachi coast.

2. Materials and Methods

2.1 Sampling

For sampling, Karachi coast was broadly divided into three zones such as (i) Manora channel (ii) Southeast coast and (iii) Northwest coast (Figure 1).

Figure 1. Location map of Karachi coast.

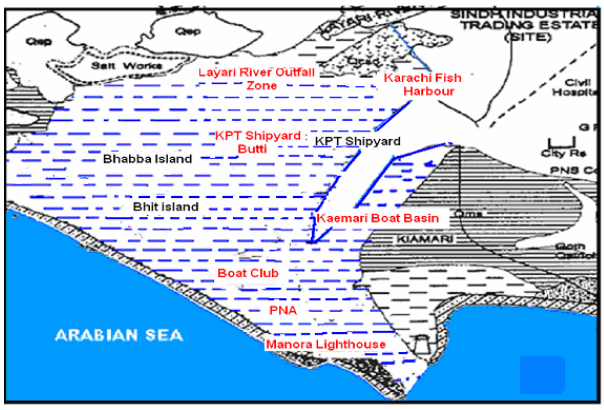

Figure 2. Location of sampling sites of Manora channel.

Manora channel is semi-enclosed bay covering an area of approximately 5 Km^2 and is recipient of Layari river. Southeast and northwest are open coast. Malir river empties at southeast coast. Sea water from Manora channel was sampled from several sites, including Layari river outfall zone, Fish harbor, KPT Shipyard butti, KPT Shipyard, Kaemari boat basin, Bhaba island, Bhit island, Boat club, Pakistan navel academy and Manora lighthouse (Figure 2). Sampling sites along 10 km long Southeast coast included Marina plaza, Casino, Naval jetty, Marina club, Ghizri area and Ibrahim Haideri fish habour whereas sampling sites along Northwest coast, which stretch over a strip of 15 Km, included Manora island sea side, PNS Himalaya, Kakka pir, Buleji , Power house and Sunari point (Figure 3) shows the locations of these sites. The sampling was carried out from 7 - 14 Feb. 2007. Water samples were collected during the last hour of low and high tide regime. All samples were collected during the day time. The location of sampling points was determined with Garmin GPS-100 Personal Navigator™ (M/S Garmin, 11206 Thompson Avenue, Lenexa, KS 66219). The polluted rivers downstream areas prior to fallout in Karachi Manora channel and Ghizri Creek were approached by road whereas sampling in the sea was performed using conventional mechanized tourist boat hired from the Keamari Boat Basin. The rivers were tapped during the low tide period and at a point much beyond the influence of high tide so as to assure that the channel contained only the representative municipal waste water/ sewerage/ industrial effluents. Sea water samples for coliform analysis were collected in sterilized plastic bottles and stored in ice box below 8°C before laboratory analysis.

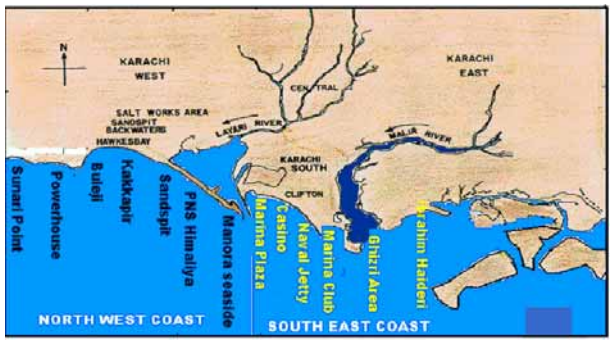

Figure 3. Location of sampling sites southeast and northwest coast.

2.2 Physico-chemical analysis

Samples of seawater, and river water were characterized in terms of electrical conductivity (E.C.), turbidity and pH. These measurements were made in field with potable meters. Turbidity was measured with a portable turbidity meter (Model 6035, JENWAY). E.C was measured with a portable conductivity meter (Model HI 8633, M/S HANNA Instruments). pH was determined using a portable pH meter (Model: PS-19 M/S Corning, Canada). Each instrument was duly calibrated before use as described in respective manuals.

2.3. Coliform analysis

Standard procedures [12,13] were followed to determine coliform bacteria in sea water. A sample of 100 ml sea water was filtered through 0.45 μm pre-sterilized membrane filter (Gelman Sciences, USA). Filters were carefully transferred onto pads soaked in Lauryle sulphate bacterial broth (ELE International Limited, U.K.) and placed in pre-labeled sterilized petri dishes. The dishes were then placed in Paqualab^{TM} incubator (Paqualab Standard System 50, ELE International Limited, U.K.) at 44^{o}C for 24 hours. After that the dishes were removed and filters were thoroughly examined with a magnifying glass to identify and count the colonies of coliform bacteria. For determination of fecal coliform in polluted rivers water, serial dilutions upto 10^{-4} (final volume 100 ml) were made from the collected samples using sterilized water. 100 ml of final dilution was processed as described above for coliform estimation and colonies number counted was multiplied with dilution factor (10^{4}).

3 Results and Discussion

3.1 Polluted rivers

Layari and Malir rivers are natural streams which drain industrial effluents and domestic sewerage of Metropolitan Karachi into sea. Table 1 shows the characteristics of the stream waters. Biological pollution appears to be the predominant pollution type in terms of fecal coliform (6.1×10^{5} and 4.9×10^{6} counts per 100 ml for Malir and Layari rivers water respectively). Malir river appears to be relatively less polluted because of type and quantity of influx waste water.

Table 1. Characteristics of Layari and Malir rivers water.

Name of Stream	Parameters			
	pH	E.C. (mS/cm)	Turbidity (NTU)	Fecal Coliform per 100 ml
Layari river	7.8 ± 0.2	2.5 ± 0.2	64 ± 1	4900,000 ± 50
Malir river	7.3 ± 0.1	4.7 ± 0.2	68 ± 1	610,000 ± 50

Each value is an average of five samples.

3.2. Manora channel

Table 2 summarizes the characteristics of Manora channel water. In Manora channel, during high tidal conditions pH values were in the range of 7.8 to 8.0 while Electrical Conductivity values were in the range of 43.3 to 50.6 mS/cm. A considerable decrease in electrical conductivity values were observed upto Bhaba Island. Lowest values were recorded at Layari river outfall zone in low tide i.e., 43.3 mS/cm which indicated fair proportion of Layari river water in this area. Except for Manora lighthouse all sampling stations exhibit E.C. below normal seawater values showing impact of Layari river water. Turbidity levels ranged from 19.7 NTU at Manora lighthouse to 77 NTU at Layari river outfall zone. Fecal coliform population was found to be in range of 156 - 542 per 100ml. During low tidal conditions maximum turbidity levels were observed at Layari river outfall zone (97.1 NTU) and minimum at Manora lighthouse (30 NTU). Coliform contamination ranged from 132 - 974 per 100 ml with increased levels observed in sampling sites close to Layari river outfall zone and does not meet the standard set for sea water bathing (180 coliform /100 ml) [14].

3.3. Southeast coast

Table 3 represents the characteristics of Southeast coastal water. pH values during high and low tide were 8.0 - 8.2 and 7.8 to 8.1 respectively. E.C. ranged 47.4 to 50.7 mS/cm in high tide regime and 40.5 to 50.6 mS/cm in low tide. A decrease in electrical conductivity was recorded at Ghizri area and Ibrahim Haideri fish harbour in low tide. Turbidity levels were higher in low tidal conditions as compared to high tide. Maximum turbidity levels were observed at Ibrahim

Table 2. Characteristics of Manora channel water.

Sampling sites (coordinates)	Characteristics							
	High Tide				Low Tide			
	pH	E.C. (mS/cm)	Turbidity (NTU)	Fecal Coliform (per 100 ml)	pH	E.C. (mS/cm)	Turbidity (NTU)	Fecal Coliform (per 100 ml)
Layari river outfall zone N 24-51-26, E 66-58-01	7.8 ± 0.2	43.3 ± 1.0	77± 2.6	542 ± 18	7.8 ± 0.2	31.8± 1.2	97.1 ± 3.2	974 ± 32
Fish harbor N 24-51-01 E 66-58-25	8.0 ± 0.1	47.5 ± 1.2	67.7± 2	537 ± 14	7.8 ± 0.2	37.2 ± 1.1	83.9 ± 2.5	766 ± 28
KPT Shipyard N 24-50-15, E 66-58-01	7.9 ± 0.2	47.6 ± 1.1	55.1 ± 2.1	376 ± 13	7.7 ± 0.2	34.8 ± 1.3	75.1± 3.1	482 ± 32
KPT Shipyard (butti) N 24-49-59, E 66-58-02	8.0 ± 0.2	46.5 ± 1.0	316 ± 2.9	312 ± 11	7.8 ± 0.2	36.1 ± 1.2	68.2± 2.8	436 ± 27
Bhaba island N 24-49-26, E 66-58-00	8.0 ± 0.2	48.6 ± 1.4	43± 1.9	377± 15	7.8± 0.2	43.5± 1.3	74.4 ± 2.7	500 ± 28
Kaemari boat basin N 24-49-02, E 66-58-29	7.8 ± 0.1	48.4 ± 1.0	58 ± 2.1	364± 12	7.6 ± 0.1	46.3 ± 1.2	74.0 ± 2.3	476± 22
Bhit island N 24-49-00, E 66-58-03	8.0 ± 0.2	48.9 ± 1.2	57 ± 1.9	421 ± 16	7.7 ± 0.2	45.7 ± 1.1	74.1 ± 2.7	379± 21
Boat club N 24-48-43, E 66-58-08	8.0 ± 0.1	49.9 ± 1.6	26.4 ± 1.3	167 ± 15	7.7 ± 0.2	48.2 ± 1.3	46.2 ± 2.2	267± 19
Pakistan navel academy N 24-48-03, E 66-58-28	8.0 ± 0.2	50.0 ± 1.8	21.1 ± 1.6	179 ± 14	7.9 ± 0.1	48.2 ± 1.3	40.2 ± 2,3	136 ± 6
Manora lighthouse N 24-47-34, E 66-58-52	8.0 ± 0.2	50.6 ± 1.2	19.7 ± 1.1	156 ± 13	8.0 ± 0.2	49.0 ± 1.3	30.0 ± 1.9	132 ± 7

Values are an average of five samples

Haideri fish harbour. Turbidity variation in high and low tide was 22–68.5 and 50–92.5 NTU respectively. Coliform bacterial population ranged from 182 – 678 per 100 ml during high tide and 341 – 895 per 100 ml during low tide. Maximum counts were observed at Ibrahim Haideri followed by Ghizri area which may possibly be due to mixing of local sewage in addition to input from Malir river. High coliform at other sampling locations indicated off shore pollution due to recreation activities.

3.4. Northwest coast

Table 4 shows the characteristics of Northwest coastal water. pH values in both tidal conditions did not show any fluctuation. Electrical conductivity and turbidity levels also followed similar trends. pH values range from 8.1 to 8.2 (high tide) and 8.0 to 8.1 (low tide). Electrical Conductivity was in the rang of 50.1 to 52.2 mS/cm (high tide) and 50 – 52.7 mS/cm (low tide) which is near normal sea values . Turbidity levels were quite low 1.1 – 2.2 NTU (high tide) and 1.3 to 4.2 NTU (low tide). Physiochemical values during low and high tide did not fluctuate much which indicate pollution free

Table 3. Characteristics of southeast coastal water.

Sampling sites (coordinates)	Characteristics							
	High Tide				Low Tide			
	pH	E.C. mS/cm	Turbidity (NTU)	Fecal Coliform per 100 ml	pH	E.C. mS/cm	Turbidity (NTU)	Fecal Coliform per 100 ml
Marina plaza N 24-48-19, E 67-00-46	8.2 ± 0.1	50.7 ± 2.2	22.0 ± 1.1	182 ± 10	8.1 ± 0.1	50.6 ± 1.4	50.0 ± 2.7	341 ± 10
Casino N 24-47-43, E 67-01-40	8.1 ± 0.1	50.0 ± 2.8	34.0 ± 1.6	256 ± 12	8.1 ± 0.1	50.4 ± 1.7	54.5 ± 2.4	432 ± 14
Naval jetty N 24-45-23, E 67-03-37	8.1± 0.1	49.7 ± 2.1	29.0 ± 1.3	387 ± 14	8.0 ± 0.1	50.4 ± 1.4	55.0 ± 2.3	521± 17
Marina club N 24-45-23, E 67-03-37	8.1 ± 0.1	47.6 ± 1.4	24.0 ± 1.2	398 ± 12	8.0 ± 0.1	46.6 ± 1.5	58.5 ± 2.2	421 ± 16
Ghizri area N 24-45-23, E67-03-37	8.0 ± 0.1	47.4 ± 1.2	58.7 ± 2.8	489 ± 16	7.8 ± 0.1	40.6 ± 1.1	69.7 ± 2.2	850 ± 25
Ibrahim Haideri fish harbour N 24-47-03 E 67-08-39	8.0 ± 0.1	49 ± 1.3	68.5 ± 2.6	678 ± 20	7.8 ± 0.1	46.5 ± 1.4	92.5 ± 2.7	895 ± 23

Values are an average of five samples

coastal water along this coast. Levels of coliform bacterial population ranged from 115 – 200 per 100 ml during high tide and 95 – 204 per 100 ml during low tide.

4. Discussion

The results indicated that the pollution level along Karachi coast is higher at zones directly affected by urban and industrial effluents at confluence point of Malir and Layari rivers with sea (Layari river outfall area and Ghizi area). The mixing pattern of polluted rivers water with sea water appears to be dependent on high/low tide and distance of the sampling sites from the confluence points of polluted water bodies (Layari river) with the sea. It is evident that high tide conditions retard the mixing of polluted water with seawater and low tide environment facilitates the mixing of pollutants. Due to semi enclosed nature of Manora channel, Layari river pollution is not completely flashed out during high tide condition, which results in increasing pollution levels in this area. It is also evident that pollution load of Malir diffuses quickly into seawater along southeast coast. Level of pollution appears to be gradually decreased as the distance of sampling sites is increased from the entrance point of polluted streams into sea with slight deviation at some sites which is due to locally added pollution load . The EC (51 mS/cm) and pH (8.2) values of seawater at sites like Pakistan Naval Academy (PNA) and Manora Lighthouse are in agreement with as recommended for normal sea [15]. Although no guideline regarding permissible limit for turbidity of coastal water is yet available, many countries follow maximum level of 50 NTU as bathing water quality criteria [16]. At some places (mostly near to the points where river joins the sea such as Layari outfall, fish harbor, Ghizri area and Ibrahim Haideri), turbidity is above the recommended threshold and renders the sea water unfit for bathing and may adversely affect the benthic life as well. It is also evident from the results that quality of seawater in terms of fecal coliform is quite poor and does not meet the standard set for seawater bathing [14]. Riffat et al. [17] also reported that electrical conductivity and turbidity

Table 4. Characteristics of northwest coastal water.

Sampling sites (coordinates)	Characteristics							
	High Tide				Low Tide			
	pH	E.C. (mS/cm)	Turbidity (NTU)	Fecal Coliform (per 100 ml)	pH	E.C. (mS/cm)	Turbidity (NTU)	Fecal Coliform (per 100 ml)
Manora sea side *N 24-47-26, E 66-58-14*	8.1 ± 0.2	50.2 ± 1.5	1.9 ± 0.3	200 ± 13	8.1± 0.2	50 ± 1.4	4.2 ± 0.5	204 ± 14
PNS Himalaya *N 24-48-30, E 66-56-29*	8.1 ± 0.1	50.1 ± 1.2	1.7 ± 0.1	150 ± 12	8.0± 0.2	50.1± 1.4	3.0 ± 0.2	176± 16
Sandspit *N 24-49-15, E 66-55-23*	8.1 ± 0.2	50.6 ± 1.4	2.0 ± 0.2	175 ± 12	8.0± 0.1	51.0± 1.3	2.3± 0.2	143 ± 7
Kakka pir *N 24-49-55, E 66-53-55*	8.1 ± 0.1	50.6 ± 1.6	2.1 ± 0.1	165 ± 4	8.0± 0.2	50.7± 1.3	2.1± 0.3	147 ± 12
Buleji *N 24-49-04, E 66-50-41*	8.2 ± 0.2	51.0 ± 1.4	2.2 ± 0.2	123 ± 8	8.1± 0.1	50.7± 1.2	1.6± 0.2	159 ± 10
Power house *N 24-50-12, E 66-47-56*	8.1 ± 0.1	52.2 ± 1.3	1.9 ± 0.2	125 ± 7	8.1± 0.2	52.7± 1.4	1.6± 0.2	134 ± 5
Sunari point *N 24-50-52, E 66-45-46*	8.1± 0.2	51.7 ± 1.3	1.1 ± 0.1	115 ± 10	8.1± 0.2	51.8± 1.2	1.3± 0.2	95 ± 6

Values are an average of five samples

values were lower in high tide environment and their levels were decreased as the distance was increased from the Layari river out fall.

A comparison of data given in Tables 2 to 4 reveal that pollution level in northwest coast is far below as compared to pollution level of Manora channel and southeast coastal water. The characteristics shown in Table 4 indicate northwest coastal water as normal seawater. This owes to the fact that North-west coast is not highly populated and industrialized. Also, pollution load of small villages on Northwest coast is mostly drained to backwaters of Manora channel. Also, there is no influx of either municipal wastewater or industrial effluent into the northwest coastal water.

5 Conclusions

Physico-chemical (pH, electrical conductivity and turbidity), biological (fecal coliform), characteristics of Layari and Malir rivers water, Karachi coastal waters showed that Karachi Metropolitan domestic sewage and industrial effluents were the main sources of coastal water pollution and coastal water of Manora channel was heavily polluted as compared to water of southeast coastal area of Karachi. However, the northwest coastal water was marginally polluted. Turbidity and fecal coliform population levels in sea water of Manora channel and some locations along southeast coast (Ghizri area and Ibrahim Haideri) were found above the WHO recommended threshold limits set for seawater bathing.

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