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Marine pollution due to discharge of untreated waste water in Karachi coast

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Abstract

Karachi with population over 18 million is currently producing around 472 million gallons per day of industrial and municipal waste water. About 85% untreated wastewater discharged into the Arabian Sea. Except few, no industry has the pretreatment facility. The present study was conducted to assess the pollution load being received by the coastal waters. The chemical and microbiological analysis of waste water samples as well as environmental monitoring of Karachi coastal areas indicate a very high load of organic pollutant as BOD, nitrogenous compounds, suspended and dissolved solids, alkaline and acidic pH, and the presence of pathogenic bacteria. Moreover, the untreated industrial effluent, bring the heavy load of toxic metals, pesticides and lubricating oils. The presence of these toxic compounds not only affecting the marine environment, but also having its toll on the country's health as well as economy. The study findings may help authorities to develop an effective conservation plan.

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Introduction

Increased urbanization and industrialization in the country has given rise to serious water pollution and environmental problems. Globally the ocean and coastal areas are in a state of environmental crisis, facing a greater range of problems and dangers than ever before (Kennish, 1997). With over half of the world's population living along coastal areas, there has been unprecedented commercial and residential overdevelopment. Several researchers (Luker, M. and Brown, C. 1999, Tyrrel, 1999, Rabalais, 2002; Danulat *et al.* 2002, WHO, 2003) have reported that toxic pollution from cities and fields, anthropogenic waste disposal, excessive nutrients and oil spills, increasingly threatens lives and nonliving resources in the rivers, coastal and ocean environments - adversely impacting and fundamentally changing natural ecosystems, and even threatening human health.

Pakistan has a coastline of about 990 km. Out of this 960 km is relatively free of pollution, while 30 km of Karachi coastal water receives a heavy pollution load of both domestic and industrial origin. Karachi with population over 18 million and sixty percent of the country's industry, discharges around 472 million gallons per day of industrial and municipal wastewater. About 122 mgd generated by municipal sewers while 350 mgd is generated by industries in the area. About 26.5 % effluent reaches the coastal waters through Gizri-Korangi Creeks via Malir river and about 73.5 % reaches through Karachi Harbor via Lyari river. These effluents have a very high load of pollutants. According to an Environmental Protection Department, 9000 million gallons of wastewater having 20,000 tons of BOD_5 loading daily discharged into water bodies from the industrial sector (Saleemi, 1993). The environmental pollution by chemicals and heavy metals such as cadmium, nickel, zinc, lead, copper, etc., are accelerated dramatically during the last few decades (Mashiatullah *et al.* 2009, Qadri *et al.* 2011, Nergis *et al.* 2012).

It has been reported that total number of registered industries in the country is 6634, of which 1228 are considered highly polluting industries (Sial, *et al.* 2006). It is alarming that most industries in Pakistan are contributing relatively high quantity of problematic compounds in the environment, as most of them have either no treatment facilities or have grossly inadequate arrangement. These compounds may be toxic, mutagenic and carcinogenic and may be bioaccumulated or biomagnified by the biota (Hayes, 1984, Wagner, 1993, Groten and Vanbladeren, 1994, Khan, 2006). High levels of organic pollutant discharged in aquatic ecosystem cause an increase in biological oxygen demand (Kulkarni, 1997), chemical oxygen demand, heavy metals, total dissolved salts, total suspended solids and fecal coliform. Unlike sewage, pH values in an industrial effluent lie beyond the range of 6-9 and once disposed into the water body affects aquatic life. Overall, the discharge of untreated industrial effluent makes water unsuitable for its intended use (Beg, *et al.* 1975, Hari *et al.* 1994, Nergis *et al.* 2012).

The major industries in Karachi that are contributing relatively high pollution load include textile, pharmaceutical, chemicals (organic and inorganic), food industries, ceramics, steel, oil mills and leather tanning. It has been observed that except a few, no industry has the pretreatment facility and therefore untreated effluent from these industries flows into the municipal sewer system, from where the combined effluent through Lyari and Malir river outfall into and close to Karachi Harbor and adjoining coastal waters. The environmental assessment of Karachi coastal areas indicate a very high load of organic pollutant and the presence of heavy metals (Ali and Jilani, 1995, Akhter *et al.* 1997; Nergis *et al.* 2012). It is worth mentioning here that metals remain in contaminated sediments and they may accumulate in microorganisms and cause biomagnifications via food chain and eventually affect human well being (Shakeri and Moore, 2010). Overall the discharge of toxicant not only affecting

the health but also causing environmental and economic losses in the country (Hussain *et al*. 1996). With new regulations and a greater environmental concern, preventing marine pollution is critically important in order to achieve sustainability of the local development. The aim of this study is to assess the quality of municipal and industrial waste water being discharged into the coastal ecosystem and conclude its impact on the environment and health. The study findings may help in the sustainable development of the coastal ecosystem.

Materials and methods

The source for collection of water samples (influent) was at the inlet to the three existing treatment plants (trickling filters, aerated lagoons and oxidation ponds) receiving waste water of Karachi city, effluent samples of specific industries and water samples at different coastal areas of Karachi. The sewage samples were collected on a weekly basis and transported to the laboratory immediately in tightly sealed large plastic containers for physical and chemical analysis. Where as sterilized reagent bottle of 200 ml capacity were used for taking out samples for bacteriological examination. During collection every attempt was made to avoid the collection of debris, paper, twigs as well as silt. The samples were kept at 4^{o}C and were analyzed within 24 hours.

All parameters (pH, alkalinity, suspended solids, total dissolved solids, total solids, BOD, COD, ammonia nitrogen, phosphate phosphorus, Grease and oil and fecal coliform) were analyzed according to standard procedure laid down in APHA (1989), during 12 months period. Whereas, the heavy metals i.e., Cd, Cr, Cu, Pb, Ni and Zn in effluent samples of various representative industries were collected and determined by atomic absorption spectrophotometer after acid digestion of samples using the methods described in APHA (1998).

Results and discussion

Pollution Levels

The coastal zone, extended up to 135 Km has become the dumping ground of hazardous waste receiving huge quantities of toxic chemical waste. Lyari brings 122 mgd of municipal wastewater with an organic load of 20,000 tons of BOD/day. About 12000 tons i.e. 60% is contributed by the industries, textile having the major share of 90% followed by chemical industries (8%). The Malir river discharged 42 mgd, bringing 1500 tons of BOD/day, out of which industries contribute 1000 tons i.e. 66.6% and the rest is the contribution from municipal wastewater (ADB, 2007). In other study, it has been reported that 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 (JICA, 2007).

The average dissolved oxygen level of the receiving waters is less than 4 mg/L in contrast to unpolluted coastal water which varies from 4 to 6 mg/L. There is a considerable concentration of hydrogen sulfides in the bottom layers. Dissolved oxygen in deeper layers of the shallow coastal waters is less than 1.5 mg/L. The discharge of untreated municipal and industrial effluent further aggravates the lethal conditions for marine organisms, particularly fish and shellfish.

Since more than 70% sewage has been discharge untreated through Malir and Lyari river, the fecal coliform count $6.1x10^{5}$ and $4.9x10^{6}$ counts per 100 ml has been reported for Malir and Lyari rivers outfall. Whereas, the total bacterial count of $11.28x10^{6}$ MPN/100ml has been observed at the Malir river outfall (mixing zone), and for beaches away from the outfall, 3 to 4 MPN/100ml has been recorded.

Quality Characteristics of Municipal Waste Water

At present, about 70% sewage generated in Karachi city is drained untreated into the coastal waters creating severe environmental problems. There are only three wastewater treatment plants (two trickling filter plants and an aerated lagoon) which can treat less than 30% of the total wastewater and the rest discharged untreated into the municipal sewer system. Table 1, shows the characteristics of municipal wastewater received at three wastewater

treatment plants. The results of the influent sample indicate that the sewage under treatment is fairly strong and concentrated with BOD ranging from 155 mg/L in case of an oxidation pond to 360 mg/L in aerated lagoon. COD ranging between 357 to 777 mg/L. Suspended solids vary from 181 mg/L in trickling filter to 1244 mg/L in aerated lagoon. Ammonia nitrogen is 39 mg/L in an oxidation pond to 64 mg/L in aerated lagoon and the fecal coliform varies from $210x10^6$ MPN/100ml in trickling filter to $2400x10^6$ MPN/100ml in aerated lagoon. Overall the results indicates a high concentration of pollutants in water samples which are being received by coastal water as more than 70% untreated sewage is being discharged into water bodies continuously increasing the level of pollution.

Table 1. Characteristics of municipal wastewater received at the three wastewater treatment plants.

Parameters	Trickling Filters	Aerated Lagoons	Oxidation Pond	NEQS
pH	7.42	7.66	6.97	6.5-9.5
Alkalinity (mg/L)	465	584	283	-
Suspended solids (mg/L)	381	244	352	150
Total Dissolved solids (mg/L)	1592	1756	461	3500
BOD_5 (mg/L)	227	360	180	80
COD (mg/L)	580	777	357	150
Ammonia Nitrogen (mg/L)	40	64	39	40
Nitrate Nitrogen (mg/L)	0.12	0.31	0.2	50
Phosphate (mg/L)	4.0	11.56	5.7	1.0
Total Coliform (MPN/ml)	$1100x10^6$	$240x10^9$	$689x10^6$	< 400
Total Fecal Coliform (MPN/ml)	$210x10^6$	$209x10^8$	$540x10^6$	< 200
Total Fecal Streptococci (MPN/ml)	$93x10^5$	$155x10^7$	$114x10^5$	< 200

*Each value is the average of 24 samples
*NEQS=National Environmental Quality Standards for municipal and industrial effluents in Pakistan.

Quality Characteristics of Industrial Effluent

There are more than six thousand three hundred industries located at four different sites of Karachi are Sindh Industrial Trading Estate (SITE), Landhi Industrial Area (LIA), Korangi Industrial Area (KIA) and West Wharf Industries (WWI) and one at the Hub near Karachi. Most of them have no pretreatment facility and drain their untreated effluent into municipal sewers.

Table 2. Characteristics of effluents from various industries in Karachi (Korangi Site Area).

Parameters	Pharma-ceutical	Tannery	Industries Textile (Silk)	Paper Mill	Beverages	Refinery	NEQS
pH	*5.15*	9.76	11.83	3.98	13.0	7.65	6.1
Suspended Solids (mg/L)	848	4756	466	2648	63	833	150
TDS (mg/L)	3236	36228	5280	12146	18244	16920	3500
BOD_5 (mg/L)	3000	12000	4000	34000	2000	8000	80
COD (mg/L)	4612	38828	6010	54696	1872	4670	150
Grease & Oil (mg/L)	158	1444	618	10644	163	484	10
Cadmium (mg/L)	6	1083	14	917	20	8	0.1
Chromium (mg/L)	1052	3087	100	400	400	360	1.0
Copper (mg/L)	129	500	200	3942	107	53	1.0
Lead (mg/L)	75	1333	117	1083	780	75	0.5
Nickel (mg/L)	100	1143	300	2000	364	100	1.0
Zinc (mg/L)	812	1383	724	1217	4386	343	5.0

**Each value is the average of 12 samples*
**NEQS = National Environmental Quality Standards* for municipal and industrial effluents in Pakistan.

The level of water-pollution due to the release of effluents from various industries in Korangi Industrial Area (KIA) was investigated. The data regarding five different types of industries, along with NEQS, is recorded in table 2. These values explain the extent of the pollutants being received by the coastal waters of Karachi as the amount of pollutants presents in the effluent samples are much higher than the permissible limits. The average value of COD of the effluent from paper mill is 34000 mg/L and tannery waste touches 12000 mg/L. The paper mill effluent is highly acidic with a pH of 3.98. This value is beyond the sustainable limit of any receiving waters.

Table 3. Metals and organic carbon content in the sediment samples of Karachi coastal areas (Nergis, *et al.*, 2012).

	Results			
Parameters	Location1	Location 2	Location 3	Location 4
Cadmium (mg/Kg)	1108	987	1060	1240
Chromium (mg/Kg)	517	428	706	654
Lead (mg/Kg)	930	1230	987	1020
Mercury (mg/Kg)	197	118	204	242
Zinc (mg/Kg)	1380	1260	1276	1410
Organic Carbon (%)	4.28	3.96	4.49	2.84

Another area of concern is the heavy metals causing toxic pollution. Table 2 shows typical values from different industries. Due to lack of pretreatment and recycling, the Cr level in tannery effluent is 3.08 g/L which is very high. Similarly other metals like Pb, Cd, Ni, Cu and Zn are 1.3, 1.1 1.1, 0.5 and 1.4 g/L respectively. There are approximately 160 tanneries of varying capacity located in Karachi, with effluent discharge of 2.5 mgd. The effluent from paper industries contain a very heavy load of toxic element i.e. Cd 0.9, Cu 3.9, Pb 1.1, Ni 2.0 and Zn 1.2 g/L and is highly acidic with a pH of 3.98. The other metal industries located along the coast like Karachi Shipyard and Engineering Works discharge untreated effluent into the coastal waters carrying 11.75 mg/L of Pb and 1300 mg/L of Zn. The net contribution of Cr from tanneries to the coastal waters range from 225 to 300 tons/year.

Table 4. Heavy metals in marine organisms.

Marine Organisms	Heavy Metals (mg/Kg)		
	Mn	Fe	Zn
Fish (*Leiognathus* specie)	9.61	208	0.09
Shrimp (Metapenaeus specie)	207	946	152

Pollution Impact in Coastal Ecosystem

The impact of high organic loading and toxic elements may have caused oxygen depletion resulting in the near elimination of marine life and high toxicity in coastal waters.

The analysis of the sediments from Korangi creek sea bed (Saleem and Kazi 1995, Saleem and Kazi 1998) shows a very high deposition of Zn, Cu and Fe ranges between 87.5 to 172.5, 12.1 to 40.1 and 15.0 to 17.5 mg/Kg respectively. Moreover, the results of the chemical analysis of Lyari River and harbor surface sediments as shown in Table 3 indicate highly elevated concentrations of Cd, Cr, Pb, Zn and Hg (Nergis, *et al.* 2012). It is evident from these results

that heavy metal pollution is significant along the industrialized Karachi coast.

It is worth mentioning here that the distribution of nutrients is affected by the movement of the currents. During November to March, the winter monsoon (NE monsoon) results in the seawater currents moving away from the coast and greater dilution rate for pollutants is expected in the coastal water. Whereas in summer months, summer monsoon (SW monsoon) sets in reversal of winds and current pattern. These changes influence the nutrient circulation accordingly. In Karachi Harbor, 50 billion cubic meters of water flow in and out and the dilution rate is more or less constant over the year. However, even the lowest pollution levels for various parameters but the heavy metals remain significantly high.

Because of above mentioned facts, the various parameters in marine ecosystem disperse in the following manner:

- Remain suspended in waters close to the coast.
- Partly washed away and diluted to harmless levels in the deep sea.
- Partly settled down to the bottom of a shallow sea along the coast.
- Partly picked up by the marine organisms which through the food chain end up in sea food consumers.

It is the last one which is more significant than others as far as the impact on human health is concerned. The Table 4 below gives some of the heavy metals found in the fishes and shrimps from the Korangi creek (i.e. close to the Malir river outfall). The results indicate that the manganese and iron concentration in fish and shrimp samples are significantly high. However, the concentration of zinc in shrimps is quite high when compared with the fishes. This may be due to metabolic processes of the marine organisms as the body metal concentration is affected by the changes in body weight due to growth and reproduction, storage or depletion of energy reserves, etc. (Bryan *et al.* 1980). Moreover, similar results of high metal concentration in the fishes and shrimps present in the creeks were also reported by other researchers (Rizvi *et al.* 1986, Tariq *et al.* 1993, Itrat *et al.* 2003).

Conclusions

The discharges of untreated municipal and industrial effluents into the water-bodies are adversely affecting the water quality. Overall the impact arising from coastal pollution in and around Karachi harbor can be summarized as:

(1) Depletion of bottom fauna in polluted areas.

(2) Depletion of water quality.

(3) Loss of the aesthetic value of the polluted area.

(4) Contamination of marine organisms with pathogenic micro-organisms from untreated sewage of Karachi flowing into the sea.

(5) Bioaccumulation of heavy metals in fishes and through food chain into human beings.

(6) The moralities of marine organisms and loss of aesthetic value in oil polluted areas.

It is time that a marine pollution control program must be launched and to start with, must be focused on the 30 miles sector of the Karachi coast which is most affected.

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