INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print), 2222-3045 (Online)
http://www.innspub.net
Vol. 6, No. 2, p. 208-214, 2015

RESEARCH PAPER OPEN ACCESS

Assessment of heavy metal pollution in Lyari river and adjoining coastal areas of Karachi

Seema Jilani

Institute of Environmental Studies, University of Karachi, Karachi, Pakistan

Key words: Heavy metals, coastal water, industrial waste, pollution, sustainability.

Article published on February 01, 2015

Abstract

The study objective was to determine the level and the distribution pattern of heavy metals in the coastal waters receiving a continuous discharge of untreated domestic and industrial effluent through Lyari river. In this research, the heavy metals in the surface water samples collected from Lyari river and adjoining coastal areas of Karachi namely; Fish Harbour, Netty Jetty, West Wharf, Naval Dockyard and Sandspit were analyzed using the atomic absorption spectrophotometer. The results of the analysis indicate that the mean concentrations of all metals (Cu, Fe, Mn, Ni, Pb & Zn) except for Cr, in Lyari river and Karachi fish harbor were significantly higher than the standard values. However, metal concentration decreased gradually as the distance from the discharged point increased and at the Sandspit point where no mixing of wastewater, the concentration was within safe limits. Moreover, the level of heavy metal concentration in the water samples were in following descending order Zn>Mn>Fe>Cu>Ni>Pb. Compare to other metal element, the Zn level was notably high and its main source of pollution could be the domestic and industrial waste as well as shipping activity. The study findings therefore suggest to incorporate quick remedial measures in order to combat pollution and to achieve socioeconomic sustainability in marine coastal environments.

***Corresponding Author:** Seema Jilani ✉ seemajilani@hotmail.com

Introduction

Marine pollution due to anthropogenic activities has now become a worldwide environmental concern (Kennish, 1997). Several researchers have reported that toxic pollution from cities and fields, discharge of untreated municipal and industrial effluent, excessive nutrients and oil spills, increasingly threatens lives and nonliving resources in the rivers, coastal and marine environments (Luger and Brown, 1999, Tyrrel, 1999, Rabalais and Nixon, 2002, Danulat *et al.*, 2002, WHO, 2003). Hence, monitoring of marine coastal environment is essential to understand the origin, distribution, fate and behavior of marine pollutants in order to formulate a viable management strategy [De Wolf *et al.*, 2005].

Metal contamination is considered as one of hazardous pollutants in natural environment due to their toxicity, persistence, risk to human, aquatic life and a long term damage to the environment (Wen *et al.*, 2007, Wcislo *et al.*, 2008). In general, the heavy metals are considered as a xenobiotic substance because of no beneficial role in body function and are very harmful even present in minor concentrations. Cadmium, beryllium, aluminum, uranium, mercury, lead, bismuth, barium, antimony, arsenic, and so forth are included in toxic metals. In addition to these, metals such as copper, manganese, iron, and zinc are important trace micronutrients. However, the presence of these metals in the atmosphere, soil, and water above the allowable limits, can cause a serious problem to all organisms. Moreover, the ubiquitous bioavailability of these heavy metals can result in bioaccumulation and biomagnification via food chain which especially can be highly dangerous to 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 origins. Karachi, a metropolitan city of Pakistan, with a 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 (WWF, 2002). About 26.5 % effluent reaches the coastal waters through Gizri-Korangi Creeks via Malir river and about 73.5 % reach through the Karachi Harbor via Lyari river. These effluents containing a very high load of pollutants. According to JICA report, about 20 percent of total annual wastewater produced in the city is treated and the rest is discharged without treatment into Karachi Harbor and adjoining coastal areas through Lyari and Malir river outfall (JICA Report, 2007). The industrial units which are discharging their waste into coastal water are mainly tanneries, textile, detergents, paints and dyes, pharmaceuticals, plastic, metallurgy, oil, food and beverages, lubricants, cement, auto engineering works etc. (Qureshi *et al.*, 1997).

The Karachi Harbour area is now considered to be the most heavily polluted marine sites in Pakistan due to receiving a continuous discharged of domestic and industrial waste. The waste is further supplemented with oil spills from cargo ships and oil tankers in the area. It has been documented that due to various kinds of pollutants such as heavy metals in the coastal water, not only the depletion of Oyster beds occur but also the shrimps and fishes which were abundant in the Manora Channel/Karachi Harbour migrated to the deeper waters (Quraishee, 1985, Khan, 1995). Nevertheless, in spite of very high pollution levels in the Karachi Harbour, it is still being used for bathing by tourists and the local population. The fish habitat and the mangroves in the harbor and backwater areas are now under considerable stress due to metal contamination.

The coastal 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). Previous investigations showed that point and non-point sources of pollution have affected the coastal water quality (Baig, *et al.*, 1975).

In the late nineties, the environmental assessment of Karachi coastal areas indicates a very high load of organic pollutant and the presence of heavy metals (Ali and Jilani, 1995, Akhter *et al*., 1997). Comparison of earlier studies clearly showing 4-10 times increased in pollution level. Overall, the discharge of untreated domestic and industrial effluent not only affecting the health but also causing environmental and economic losses (Hussain *et al*. 1996). As fishing, boating and tourism is being affected badly. It is time to take necessary step in order to prevent massive ocean extinctions and loss of marine biodiversity. Due to lack of regular monitoring, most of the coastal areas become deteriorated and causing a serious risk to marine life (mangrove forests, marine food chain etc.). With new regulations and a greater environmental concern, preventing marine pollution along Karachi Coast, is critically important in order to ensure safety, protect health, environment and to achieve socio economic sustainability. The present study objective was to determine the concentrations and spatial distribution of metals in lyari river and adjoining costal areas. The study findings may help to conserve and manage the marine ecosystem receiving untreated wastewater.

Materials and methods

Description of Study Area

Manora Channel is a navigational channel along the Karachi coast. It spreads over an area of 7.17 km and hosts the Karachi Fish Harbor, Naval Jetty, West Wharf, Naval Dockyard (Fig. 1). The tides are diurnal and about 3.4 million cubic meters of seawater enter and leaves the channel during each tidal cycle. The status of Lyari River derived sediment input load into the channel is so bad that the channel has to be dredged year round by the Karachi Port Trust (KPT). Due to continuous inventory of domestic and industrial waste matter from Lyari River, the Karachi Harbor/Manora Channel area is now severely polluted. In spite of its highly filthy conditions, the channel is routinely used by Pakistan Navy, Karachi Port Trust, and Karachi Fisheries for navigational purposes and by tourists and inhabitants of the adjoining Islands for bathing and fishing purposes.

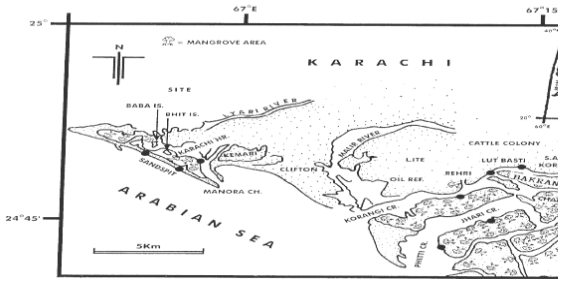

Fig. 1. Map showing study area (Manora Channel).

Water Sampling and Preservation

Sea water samples were collected on a monthly basis (April, May, June and September, 2014) from (i) pollution receiving body namely Lyari river outfall zone, Karachi Fish Harbor, Netty Jetty, MS Jetty, West Wharf and Pakistan Naval Academy and (ii) the non-polluted Karachi-sea water (Sandspit area). The sampling points are indicated in Fig.. 1. In this study, Karachi Fish Harbor and adjoining coastal areas were selected as it is semi-enclosed bay covering an area of approximately 5 Km^2 and is the recipient of Lyari river. This river act as an open sewage drain, receiving highly polluted wastewater of industrial and domestic origin.

To investigate the seawater quality, surface water samples were collected in a clean plastic bottle (2.5 Liter) during slightly rough sea conditions prevailing in early summer monsoon periods (April-May,June) and a slightly calm period (September). For metal analysis, 500 ml of each water sample was preserved by adding few drops of HNO_3 in accordance with standard procedure laid down in APHA (1987).

Sample digestion and metals analysis

Each water sample (100 ml) was evaporated almost to dryness at moderate temperature 65-70 C^o on the hot plate under the clean air-fuming hood. Finally, the samples were diluted up to 25 ml with 2% nitric acid (FAO, 1975).

In order to assess the level of heavy metal pollution along the Karachi coast, the toxic metals such as Cu, Fe, Mn, Ni, Pb, Zn and Cr in the water samples were analyzed by atomic absorption spectrophotometer (Hitachi-Model Z-8000) after acid digestion using the methods described in APHA (1998). Results are reported in mg/L (ppm).

Results and discussion

The average concentrations of heavy metals in the water samples collected during summer 2014 from Lyari river and five stations at Karachi Coastal areas namely: Karachi fish harbor, Netty Jetty, West Wharf, Naval Dockyard and Sandspit area are recorded in Table 1. Sanspit location at northwest coast was deliberately selected for comparison of heavy metal pollution as Sandspit is substantially a low pollution area because of no mixing of municipal and industrial effluent.

It may be noted that significantly higher concentrations of all tested metals i.e., Cu (0.093 pprn), Fe (0.107 ppm), Mn (0.183 ppm), Ni (0.027 pprn), Pb (0.024 pprn) and Zn (0.548 pprn) are present in Lyari River and its out fall zone i.e. Karachi Harbor. Higher levels of metal elements in the Harbor and adjoining areas may be attributed to the untreated domestic and industrial waste drained through Lyari river. The present situation further aggravate due to fishing trawler and shipping activity (such as repairing, fueling, greasing and painting of ships), oil spills from cargo ships and oil tankers.

Table 1. Average results of heavy metal in the coastal waters of Karachi.

S. No.	Parameters N= 08	Unit	Sample Locations						
			Lyari River	Fish Harbor	West Wharf	Netty Jetty	Naval Dockyard	Sandspit (Typical Ocean	Concentration in Seawater
1	Cu	mg/L	0.093	0.025	<0.001	0.015	0.010	0.008	NA
2	Fe	mg/L	0.107	0.038	0.050	0.041	0.030	0.019	0.001-0.003
3	Mn	mg/L	0.183	0.065	0.017	0.036	0.053	0.049	0.0004-0.01
4	Ni	mg/L	0.027	0.030	0.007	0.012	0.008	0.008	NA
5	Pb	mg/L	0.024	0.008	<0.001	< 0.001	< 0.001	< 0.001	0.000002-0.00003
6	Zn	mg/L	0.548	0.488	0.157	0.062	0.085	0.039	0.0006-0.005

NA= Not Available

Table 2. Marine water quality guidelines for metals.

Parameters (ppm)	US EPA	*ANZECC/ ARMCANZ (2000) Guidelines
Cu	0.0031	0.0013
Fe	-	NA
Mn	-	NA
Ni	0.01	0.007
Pb	0.0081	0.0044
Zn	-	0.0015

*Australian and New Zealand Environment and Conservation Council (ANZECC).

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

The comparative results of heavy metals as shown in Fig. 2, clearly indicate that metal contents in the Lyari river and Karachi fish harbor is considerably higher as compared to Australian guidelines (Table 2) and thus may adversely affect the marine ecosystem. Higher concentrations of Zn and Cu in the water samples might be due to the influx of wastewater from industrial units such as electrical appliances, electroplating, textile and glass. However, elevated levels of Ni and Mn in the harbor area owe to the inflow of untreated effluents from automobile batteries, electroplating, car painting, dying, and glass

industries [WWF, 2002]. Although no specific guidelines set by WHO or USEPA for the discharge of heavy metal into sea. For comparison purpose, Australian and Swedish guidelines have been used in this study.

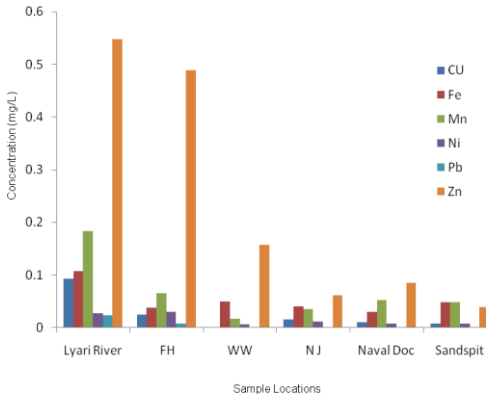

Fig. 2. Average values of Heavy metals in the coastal water of Karachi.

It is worth mentioning here that the comparatively higher concentration of heavy metals in the sea and harbor waters was reported by several researchers of the world (Patel, 1985; Harper, 1991; Brugman, 1998; and Zingde *et al*., 1987; Ven *et al*., 2007). In Pakistan, many researchers also attempted to evaluate the heavy metal elements in Karachi coastal water (Saleem and Kazi, 1998, Beg *et al*., 1992, Saleem and Khan, 1999, WWF, 2002). As shown in Table 1, heavy metal distribution pattern in coastal water of Karachi has a strong association with pollution load (mainly municipal sewage and industrial effluent) added by Lyari rivers into the sea. It has been observed that the level of metal elements in coastal waters decreased gradually as the distance of the sampling site from Lyari river out falls increased. The highest concentrations of metals are recorded close to the Lyari river (Karachi fish harbor, West Wharf) as evident from Table 1. Results showing the markedly high level of Zn in all the samples as compared to other analyzed metal elements and its sources could be the domestic and industrial waste as well as the shipping activity. From the study findings, it can be concluded that the water quality at Lyari and its outfall zone i.e. the Karachi harbor in terms of heavy metal is quite poor as the level in these areas were higher than the Australian and Swedish guidelines (Moss and Constanza, 2007, Naturvårdsverketa, 2001). However, at other sampling stations, the analyzed metal concentrations were significantly less and at Sandspit area, it is more or less within safe limits.

It is important to mention here that marine sediments are generally the endpoints for trace metals as metal in aquatic ecosystem bound to suspended particles and sink causing several environmental problems. Now a day, contamination of marine sediments becomes an important environmental issue as when ports are dredged, the coastal water become polluted, causing human health risk via eating contaminated or diseased fish. Further, the contaminated dredged materials when dumped on the land cause immense environmental problems. The study therefore suggests the governmental departments and industrialists to incorporate quick remedial measures in order to combat pollution, to protect health and to achieve socioeconomic sustainability in the coastal areas of Karachi.

Conclusions

A safe and healthy environment is important for sustaining coastal and marine ecosystems, commercial and recreational fisheries, and an economic growth in the country. The present results indicate the poor water quality in terms of heavy metal along Karachi coastal areas due continuous discharge of untreated domestic and industrial waste, deposition of atmospheric particulate, harbor activities, the dumping of ship waste and other coastal activities. The increased pollution level specifically the metal element will have an adverse effect on marine organisms and increase toxicity in the environment through the food chain, cause corrosion of cargo ships and naval vessels; and a significant ill effect on the health of coastal communities. Overall, the environment and the economic health of marine and coastal waters are linked at the individual, community, state, regional, national and international levels. Government agencies

and industries in joint collaboration should adopt technologies to prevent and reduce pollution and its impacts.

Acknowledgments

The authors greatly acknowledge the Deans research grant provided by University of Karachi, to conduct this research study.

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