



## Assessment of Faecal Contamination in the Karachi Harbour Waters

Suraiya Jabeen†, Tariq Masood Ali Khan, Omme Hany, Amjad Husain Rajput, Uzair Saeed, Faisal Ahmed Khan and Kanza Abid

Institute of Environmental Studies, University of Karachi, Karachi 75270, Pakistan

†Corresponding author: Suraiya Jabeen

Nat. Env. & Poll. Tech.  
Website: [www.neptjournal.com](http://www.neptjournal.com)

Received: 29-03-2016

Accepted: 24-05-2016

### Key Words:

Harbour  
Faecal coliform  
Wastewater  
Resource management

### ABSTRACT

This paper gives the estimation of the bacterial density in the Karachi Harbour region. The study was conducted recently to determine the coliform pollution level of waters in the Karachi harbour. Twenty one stations were selected, analysis was conducted for pH, temperature, salinity, Total Dissolved Solids (TDS) and turbidity. The bacteriological quality was monitored by using Total Coliform Count (TCC) and Total Faecal Coliform (TFC). The excessive level of faecal indicators noticed in the harbour waters showed high contamination by indiscriminate discharge of crudely treated and non-treated wastewater of domestic and industrial origin. The flora and fauna is on threat by the faecal pollution, ultimately affecting the human health and economic situation. By proper resource management the grave marine pollution can be harnessed by implementation of stringent policies. The higher dilution rate in the offshore waters of Karachi can help to dilute and disperse sewage quickly and semidiurnal tidal behaviour transports the diluted sewage water to open sea without harming the coastal community.

### INTRODUCTION

**Study site:** The Karachi Harbour covers the lower part of Chinna Creek, and has been extended and divided into a lower and upper harbour because of commercial features found on both sides of the upper harbour. The entire harbour ranges about 3-1/2 n mi (6.5 km) north-northwestward and north-northeastward, and stretches from 250 to 500 yd (229 to 457 m) wide between the 20 ft (6.1 m) deep curves. The lower harbour starts from Manora Point to the southern ending of East Wharf, about 1-1/2 n mi (2.8 km); its steerable channel is shortened to about 300 yd (274 m) by the edges extending from all sides. The upper harbour covers northward and north-northeastward approximately 2 n mi (3.7 km) and has a navigable breadth of 300 to 400 yd (274 to 366 m) for maximum of its length.

A heavy load of pollution was observed (chemical and biological) in Karachi Harbour due to constant dumping in the sea. The main cause of pollution in the Karachi Harbour is through Lyari River, which conduits enormous volume of heavy loads of treated/untreated industrial and domestic wastewater (Waseem et al. 1997, Monawwar & Atiqullah 1999, Atif et al. 2009), including indicator pathogens into it. Roughly, throughout the tidal cycle nearly 50 billion cubic meter of seawater flows into and leaves the harbour (Sayied 2007).

The Karachi harbour waters and sediments are considered to be most polluted in the region, owing to the geographical location of the metropolis city harbour because

the marine contaminants are not entirely flushed out into the open sea making it hazardous dumping site, posing serious ecological imbalances in the marine biodiversity affecting both flora and fauna of the coastal waters. The faecal coliforms are bioindicators of severe health hazards especially when present in fishery products and other fauna, leading to the decline in the precious fishery export of the country.

Bacterial decay is generally the enumeration of T90, which is the time for bacterial population density decay to 90% of its original value. Faecal coliforms are non-conservative features. Their decay rate in marine environment is influenced by the bacterial species itself (strain and physiological condition). Other factors like physical and physicochemical characteristics such as sedimentation, photo-oxidation, temperature, salinity, hydrological status, pH and then biochemical-biological factors like organic matter including faecal material, predation, viruses and their competition (Fioravanti et al. 2011, Chamberlin & Mitchell 1978, USEPA 1985a, Rozen & Belkin 2001).

T90 establishes an essential parameter for water resources conservation as for outfalls design. The available data from enteric pathogen survival cannot be easily compared due to non-existence of suitable models or parameters (Gonzalez 1995).

Total coliforms (TC), faecal coliforms (FC), and enterococci (EC) are assumed to be beneficial bioindicators of faecal pollution as they are present in the faeces of human

and warm blooded animals. They indicate occurrence of other detrimental pathogens in marine waters. Greater the number of indicator bacteria present, there is a greater likelihood of presence of infectious organisms. The U.S. EPA 1986 revealed that gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases spread through pathogen polluted recreational waters. Therefore, the focal purpose of the current study was to determine to accentuate the significance of routine assessment and monitoring of water along the coastal areas to the deep waters.

## MATERIALS AND METHODS

Sampling was done in the third week of January, 2015. Fig. 1 shows sampling stations in the study area. The sampling sites, S1- S2 are Machcher colony stations, S3 is close to Treatment Plant (TP3), S4-S8 stations are near to the Karachi fish harbour, S9 is located at the confluence of Kemari and Chinna creek waters., whereas the stations S11 to S21 are located on the navigational channel Karachi harbour. The navigational channel connects open sea water to Karachi port. The Stations S16, S17 and S18 are at the mouth of harbour. The mixing and dilution at these stations depict in the analysis of samples. The sampling was started during maximum high tide condition and later on the boat followed the ebbing and flooding currents during the tidal cycle (high-low-high). At sampling site S16, the maximum low tide condition was observed. As the flooding started (high tide) again the boat followed the water currents direction and moved into Karachi harbour area through mouth of

navigational channel near Manora breakwater. The samples S19, S20 and S21 were collected during high tide condition. For microbiological analysis the Most Probable Number Technique (Total Coliform Count (TCC)) was performed aseptically in the boat. After collection samples were brought to the laboratory of Institute of Environmental Studies, incubated at 37°C for 24 hours. Next day test for Total Faecal Coliform (TFC) was performed after getting results of TCC using EC broth and incubated at 44.5°C. The confirmatory test was performed on Eosine Methylene Blue Agar (EMB).

Total Dissolved Solids (TDS), temperature and salinity were determined by WTW Multiple parameter series Cond 720, pH was determined by Jenway 3505 pH meter, and turbidity by Eutech TN 100 turbidity meter.

## RESULTS AND DISCUSSION

The field data of this study were analysed to enumerate the coliform in the harbour waters. Pathogenic bacterial load is a dire alarm for optimization and suitable management of water resources in many regions of the world (UNO-Water 2007) due to indiscriminate discharge of partially treated and non-treated waste. The high load of coliform bacteria in sewage and urban runoff has been notoriously known to stipulate a high risk of diseases in humans (Haile et al. 1999, Kay et al. 1994, Fleisher et al. 1998). However, several research studies have been performed in the past to scrutinize rates of indicator bacteria. Karachi harbour since long is thought to be the profoundly contaminated nautical site of

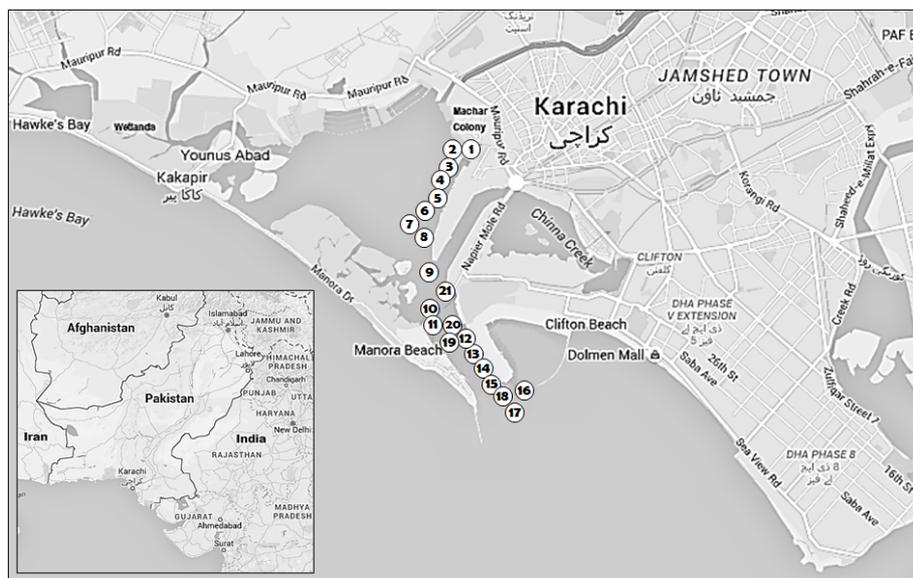


Fig. 1: Study area and sampling stations in the Karachi Harbour area.

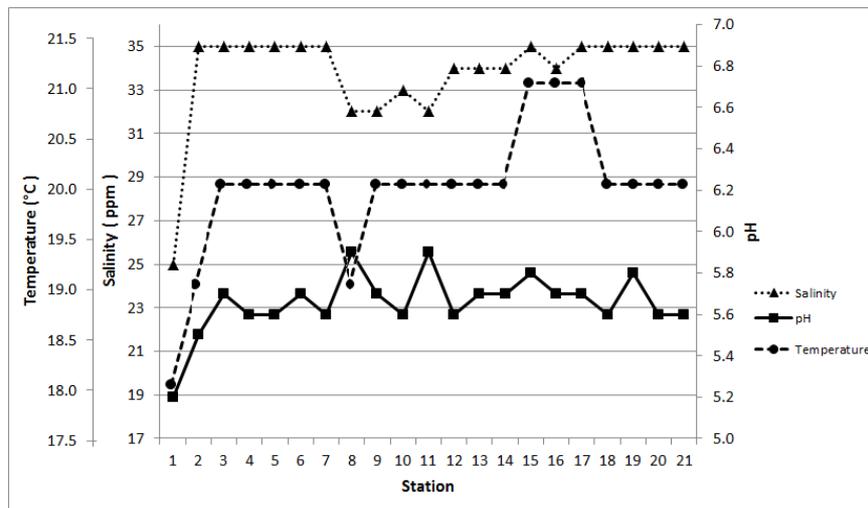


Fig. 2: Temperature (°C) and pH values observed at different sampling stations in the Karachi harbour area.

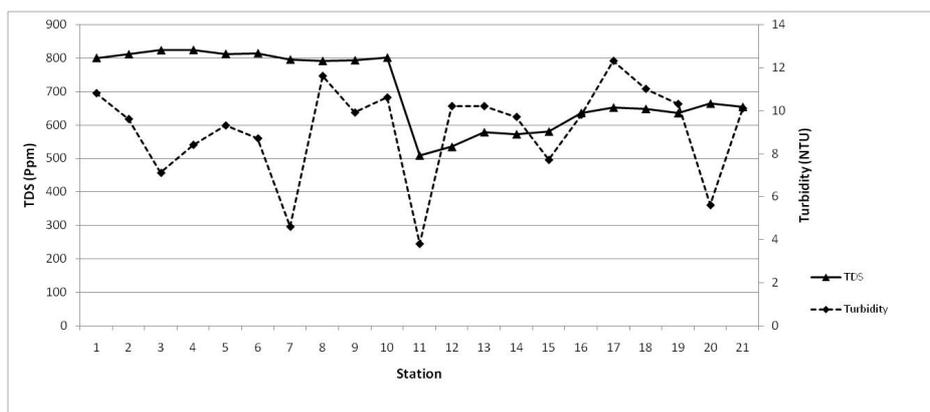


Fig. 3: TDS (ppm) and Turbidity (NTU) observed at different sampling stations in the Karachi harbour area.

Pakistan. The Fig. 1 shows the location of Karachi harbour and sampling sites inside harbour stretches from mouth of Layari River to mouth of harbour connected to open sea. The temperature was 18-21°C, the pH ranges 5.2-5.9 that is maximum at site 8 which is a small jetty of fish harbour, the lowest is at site 1 near Macchar colony, this slightly acidic pH is tolerable for *E.coli*. The average pH is 5.6 that is slightly acidic as the water coming from industrial discharges. National Environmental Quality Standards (NEQS) for Municipal and Liquid Industrial Effluents for pH is 6-9. The TDS ranges 508- 825mg/L which is within the range given by NEQS. The highest TDS is on site 4 which is Karachi fish Harbour. The turbidity ranges 3.8-12.3 NTU, and salinity is 25-35 mg/L. The variation of temperature, salinity and pH observed at different stations is shown in Fig. 2. Similarly, analysed TDS and turbidity of water sample collected at

different stations are shown in Fig. 3.

The results of the current study reveal that untreated domestic and industrial wastewater through the Liyari River is responsible for pollution of Karachi Harbour waters. The pH is decreased by approximately 0.5-1 pH unit than the normal range, it is also related with less values of TDS and salinity. All sites showing occurrence of indicator organisms in maximum that is  $\geq 2400$  MPN Index/100 mL of each sample except sites 17 and 18. Samples of these stations were taken when the high tide changing into low tide leading to dilution towards Arabian Sea, while station 21 is also less polluted due to slightly acidic pH, on average it was 5.6 at these less contaminated sites. Samples from these tubes separately inoculated in E.C medium, sites 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20 gave positive indication of faecal coliforms, the indicator pathogens. (Table 1).

This area receives high faecal pathogen load dispersing in the coastal area depending completely on the mercy of marine environment.

The confirmatory test on EMB, showed positive result. It means that Machhar colony, Hijrat colony, Karachi Fish Harbour, small jetty of fish Harbour, Chinna Creek dumping site, some of the sites of Kemari all are highly contaminated with the faecal pollution. S17 and S18 the sites from Kemari to Manora heading towards Arabian Sea reveal less contamination owing to the fact of dilution in the open sea.

Their survival or die off rates hinge on nutrient presence in form of organic load, sunlight penetration, temperature turbidity and sediments (Pommepey et al. 1992) predation, osmotic stress, particulate levels, oxygen concentrations, and microbial community composition, all these factors facilitate the inactivation of bacteria (Mancini 1978, Davies-Colley et al. 1994, Fujioka et al. 1981, Kapuscinski & Mitchell 1980, Auer & Niehaus 1992, Johnson et al. 1997). All harbour sampling sites were highly contaminated with faecal pollution except area near to TP3, only two sites from Kemari to Manora (sites 17 and 18) because this polluted area in the Karachi harbour and the Manora Channel is responsible for mixing of Liyari River water with the Arabian Sea water.

The coliform bacterial counts were above the allowable limits given by US EPA 1986 (< 100 coliform bacterial colonies per 100 ml). Hence, not appropriate for swimming of local inhabitants and tourists, also supported by a previous study Mashiatullah et al. 2010).

In various developing countries the discharge of untreated or partly treated wastes into water systems has been a routine practice. The marine wastewater pollution is a rising challenge which signifies a risk to natural resources and has major socio-economic influence. Human health can be adversely affected by the consumption of harvestable resources. Even though there are three treatment plants in Karachi but they are not working adequately and sometimes when the sewage treatment plants are working properly, the drainage network is not operative always. So, the recreational activities like bathing or drinking water close to the discharge points may lead to the infectious diseases in humans and animals due to bacterial pollution. The sewage of the municipal wastewater contains human excreta, consequently contributing to high loads of enteric pathogens. The conventional treatment plants typically remove up to 3 log units of enteric bacteria, but the microbial mass of the effluent can in spite of that be very huge (Mugglestone et al. 2001, Kocasooy 1995).

#### **Dispersion and dilution of marine pollutants through sub-**

Table-1: MPN Test Result (TCC & TFC)

S.No.	Sampling Sites	TCC	TFC
1	1	+	+
2	2	+	+
3	3	+	+
4	4	+	+
5	5	+	+
6	6	+	+
7	7	+	+
8	8	+	+
9	9	+	+
10	10	+	+
11	11	+	+
12	12	+	+
13	13	+	-
14	14	+	-
15	15	+	-
16	16	+	-
17	17	-	-
18	18	-	-
19	19	+	+
20	20	+	+
21	21	+	+

**marine outfall Hawkes bay area:** Since, the addition of sewage into the near shore waters causes perturbation in the coastal ecosystems, the better alternative for coastal cities is to discharge wastewater into deep ocean far away from the coast through submarine outfall (Chandramohan & Jayakumar 1997). When the wastewater releases from the submerged pipe it undergoes basic processes of mixing with ambient seawater. The diluted waste is carried with the ocean water either to the surface or bottom of the sea depending on the density stratification of the ocean. The mixing and spreading of effluent horizontally establishes sewage field. The current speed and natural turbulence of the sea help in the large scale mixing and spreading of the wastewater.

A feasibility study of marine outfall to dump Layari river sewage water into offshore water of Hawkes Bay was conducted (Rizvi et al. 1993, Khan et al. 2013). The variables which affect wastewater spread such as initial, minimum and maximum dilutions under different tidal conditions and bathymetry of the sea were estimated. The study reveals that the off Hawkes Bay outfall site is one of the potential marine outfall sites for Lyari River sewage discharge.

In continuation of feasibility study, in another study, some more parameters were calculated by using USEPA spread sheet (Khan et al. 2015, USEPA 1985(b)). The calculated moving water dilution in the offshore area of Hawkes Bay is 175. The estimated high dilution values depict that the offshore area of Karachi is suited for wastewater disposal with a high capacity of dilution and mixing. The large

Table 2: A typical relationship between the discharge, Froude number and moving water dilution at offshore of Hawkes Bay.

Location	Discharge (m <sup>3</sup> /s)	Depth (m) spring	Froude number	Moving water dilution
Offshore Hawkes Bay/Manora	12.928	23.0	12.6745	175

Froude Number depicts no seawater intrusion into the outfall pipe as higher exit velocity of sewage from the outfall into the sea bed prevents outfall pipe chocking. The typical relationship between the discharge and estimated Froude number and moving water dilution at offshore of Hawkes Bay is shown in Table 2.

The diluted values of waste depict that waste would mix throughout depth more quickly. Thus, the disposal area offers more favourable conditions for diluting liquid wastes so that the negative effects on the ecosystem are dubious. Moreover, the semidiurnal tides in Karachi help spreading of outfall effluent away from the coast with strong dispersion and dilution process including rapid FC-coliform die off rate (Khan et al. 2013, Lakshmi & Sapna 2007).

## CONCLUSION

Karachi coastal area, especially the harbour waters, is highly polluted with faecal pathogens, they can become part of the food web through bioaccumulation in the marine ecosystem and aquatic fauna and flora is at high risk. There is a substantial concern regarding the protection of the public health, not only for the local residents but for foreign tourists as well.

The most efficient option can be dumping of sewage water through marine outfall in the offshore area of Hawkes bay. Thus marine outfall can be an efficient and economical way of dumping wastewaters into deep ocean, so that estuaries around Karachi may probably be conserved. The ocean is stirred and mixed by turbulent processes associated with winds, waves, currents and buoyancy (density differences). A water column is stably stratified if the density increases with depth. The estimated stability shows that the offshore water of Karachi is suitable for marine outfalls. The natural turbulence of ocean waters helps in dispersion and dilution of waste. The semidiurnal tidal behaviour favours spreading of outfall effluent towards open sea with rapid FC-coliform decay rate.

Karachi coastal and marine ecosystems should be sustained by maintaining the better environmental quality not only for supporting the economic status but for promotion of replenishing the marine health that would raise the ecotourism as well. It is expected that this study could help to accentuate the importance of regular monitoring of coastal

belt, and furthermore emphasizing the betterment of wastewater treatment policies and ensuring them as an integral part of water quality monitoring which in turn definitely going to establish the economic backbone of the country.

## ACKNOWLEDGEMENT

The support of Dean Faculty of Science, University of Karachi is gratefully acknowledged.

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