BACTERIOLOGICAL (FECAL AND TOTAL COLIFORM) QUALITY OF PAKISTANI COASTAL WATER

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The coliform bacteria group consists of several genera of bacteria belonging to the family *enterobacteriaceae*. These are harmless bacteria, mostly live in soil, water, and digestive system of animals. Fecal coliform bacteria, which belongs to this group, are present in large numbers in feces and intestinal tract of human beings and other warm-blooded animals which can enter into water bodies from human and animal waste. Swimming in water having high levels of Fecal coliform bacteria increases the chance of developing illness (fever, nausea or stomach cramps) from pathogens entering the body through mouth, nose, ears or cuts in the skin. The objective of the present study was to characterize the bathing quality of Pakistani coastal water with respect to coliform bacteria. Total and Fecal coliform bacteria were determined at seven (7) different locations along Pakistan coast using membrane filtration (MF) technique. 100 ml of water was passed through 0.45 micron (μ) filter paper. These filter papers were put on pads, soaked in Lauryle sulphate broth in petri-dishes and incubated at 44°C for Fecal and 37°C for Total coliform for 24 hours. Significantly high population of Fecal and Total coliform bacteria was recorded at Karachi harbour area and Indus delta region. Results indicate that a large amount of domestically originated waste is being discharged into these locations without any pre-treatment (e.g., screening, activated sludge, by using filtration beds etc.) resulting in a poor seawater quality making it unfit for bathing.

Keywords: Coliform, Bacteria, Pakistan, Fecal, Coast, Karachi, Seawater

1. Introduction

The term "Coliform" refers to rod shaped, non-spore forming, Gram negative bacteria, belonging to the family *enterobacteriaceae* (Figure 1).

These harmless bacteria mostly live in soil, water and digestive system of animals. Fecal coliform bacteria, which belong to this group, are present in large number in the feces and intestinal tract of human beings and other warm-blooded animals that can enter water bodies from human and animal waste. These organisms may be separated from the Total coliform group by their ability to grow at elevated temperatures and are associated only with the Fecal material of warm-blooded animals [1]. Fecal coliform bacteria can enter water reservoirs through direct discharge of waste from mammals, birds, agricultural and storm runoff, untreated human sewage. They can also enter through individual home septic tanks that can become overloaded during the rainy season allowing untreated human wastes to flow into drainage ditches and nearby water reservoirs [2]. If only Total coliform bacteria are detected in water, the source is probably environmental. Presence of Fecal coliform bacteria is an indication of sewage contamination and also the possible presence of other pathogenic organisms. These bacteria do not directly cause disease, however, large quantities are considered to be disease causing agents. Although not necessarily, Fecal coliform bacteria may indicate the potential presence of disease-carrying organisms, which live in the same environment as the Fecal coliform bacteria. [3, 4].

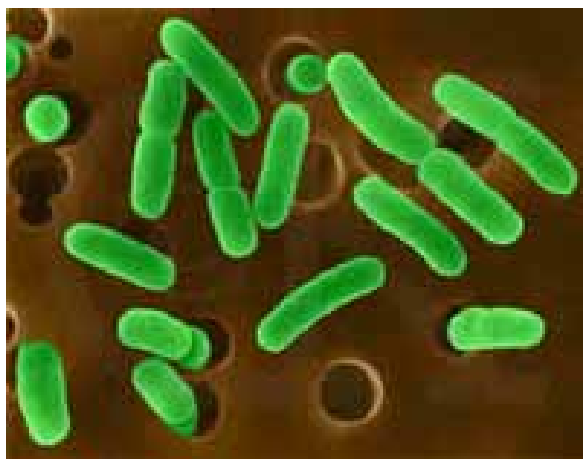* Corresponding author : azhar@pinstech.org.pk

Figure 1.   Coliform bacteria

The pollution of marine coastal water has its existence through river outlets [5]. These rivers contain rainwater, domestic wastewater, drowned animal, litters and trees which change composition of natural water. The sea has coped with this load since creation. Fecal coliform pollution is a serious environmental problem that has affected many coastal regions worldwide. Pathogens associated with Fecal coliform pollution can lead to human disease and economic losses in industries that depends upon coastal waters, such as shell fisheries [6]. Despite the efforts made to minimize Fecal input into coastal waterways, the problem persisted, possibly due to an inability to identify non point sources. These sources may include inefficient sewage treatment plants, leaking septic systems, agricultural runoff and wildlife [7]. Knowledge of contamination source is crucial for effective resource management.

Coliform testing is one of the important water quality test needed for overall water-quality rating used by the Environmental Protection Agency (EPA). This test requires a very careful set of sterile procedures [8].

Like other coastal regions of the world, Karachi coast, especially Manora Channel/Karachi harbour, is heavily polluted due to untreated industrial wastewater and Metropolitan municipal sewage which are indiscriminately discharged through Layari and Malir rivers [9]. Only 20 percent of the total annual wastewater produced in Metropolitan Karachi is treated and the rest is discharged directly into coastal water [10]. This situation demands the characterization of the coastal water in order to determine its bathing quality. Hence the objective of study was to monitor its microbiological water quality along Pakistani coastlines to assure bathing quality of the beaches.

2.   Sampling Locations

Figure 2 shows sampling stations along the coast of Pakistan. At the Sindh coast, sampling was performed at Indus Delta, Manora Channel, North West Coast, Karachi and South East Coast, Karachi. Along Baluchistan coast, sampling was performed at Gadani, Somiyani, Ormara, Pasni, Gwadar and Jiwani coasts. 250 ml of seawater sample was collected in sterilized plastic bottles from each site. The bottles were stored in ice box while transporting to laboratory. Samples were analyzed within 3-4 hours after collection From each sampling location 3-11 samples were collected. All samples were taken in triplicate. Sampling was done in low tidal condition. The location of sampling points was determined with the help of a Garmin GPS-100 Personal Navigator^{TM} (M/S Garmin, 11206 Thompson Avenue, Lenexa, KS 66219).
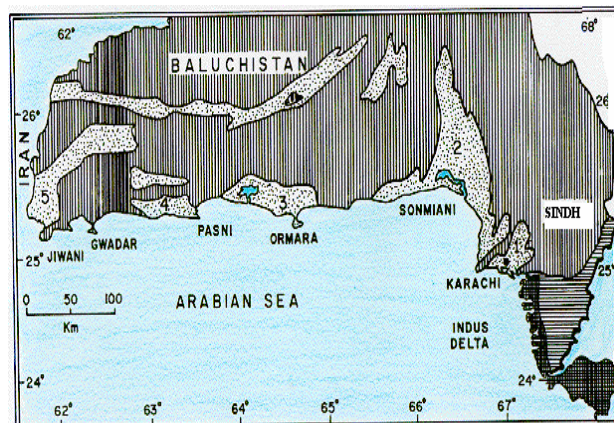
Figure 2.   Sampling locations along Pakistan Coast

3.   Materials and Methods

Coliform population was measured by Membrane Filtration (MF) Technique [11]. The MF method is more rapid as compared to MPN (Most Probable Number) method.

Coliform bacterial population analysis was performed through membrane filtration technique using a Paqualab^{TM} incubator. For the measurement of coliform bacterial population, water samples (100ml each) were filtered through nitrocellulose membrane filter paper (0.45 μ) to

Table 1.   Bacteriological analysis   of seawater at Indus Delta

Code	Sample Location	Geographical location Lat/Long*	Total Coliform /100ml	Fecal Coliform /100ml
KS--25	Keiti Bandar	24-04-78 67-34-69	300 ± 5	196 ± 2
KS-26	Mitho Pani	24-11-35 67-37-56	324 ± 6	224 ± 5
KS-27	Baharo Bridge (Indus Water)	24-27-95 67-35-22	356 ± 1	250 ± 4
Ranges			300-356	196-250

* Lat: Latitude, Long: Longitude

collect the coliform bacteria. Thereafter, the membrane filter papers were carefully put on pads soaked in Lauryle Sulphate bacterial broth in aluminium petri-dish. The petri-dishes were placed in the Paqualab^{TM} incubator for 16- 24 hours. One group of petri-dishes was incubated at 44°C for determination of the Fecal coliform bacterial population, while the other set of petri-dishes of same samples were incubated at 37°C for determination of the Total coliform bacterial population. Afterwards, the petri dishes were removed and the membrane filters were examined by a magnifying glass for presence of yellow spot colonies which confirm the presence of Coliform bacteria in water samples [12].

4.   Results and Discussion

Tables 1-10 show coliform bacterial population at different locations. Results of different locations are discussed in proceeding sections:

4.1   Indus Delta

At Indus Delta sampling was performed at three different locations namely: Keiti Bandar, Metho Pani and Baharo Bridge (Table 1). The average mean range of Fecal coliform in these sites was 196-250 coliform colonies per 100 ml while for Total coliform was 300-356 colonies per 100 ml. Maximum concentration was observed at Baharo Bridge (River Indus water), due to direct discharge of animal and human feces into the river water along its path. However, concentration at each location was above permissible limits of recreation water (100 Fecal coliform colonies per 100 ml) set by EPA [13].

4.2   Karachi Harbour

Karachi harbour is considered to be the most heavily polluted marine site in Pakistan. Disposal of sewage waste through Layari River is causing serious biological contamination in the harbour. At Karachi harbour, sampling was performed at nine locations.   The locations include, Manora light House, Pakistan Naval Academy (PNA), Boat Club, Bhit Island, Bhabba Island, Shamspir, Naval Harbour Store Depot, Naval Dockyard and Shipyard. Table 2 presents results of coliform analysis at these sampling locations. Total and Fecal Coliform bacteria were 204-988 and 136 – 740 colonies per 100 ml, respectively. Significantly high values of Coliform bacterial colonies were observed at Bhit Island, Bhabba Island and Shamspir area.   The presence of high number of coliform organisms in these locations indicates that large amount of domestic waste is drained in the area. The sewage waste generation in Karachi is dumped into the Karachi sea via Malir River (Ghizri-Korangi Creek area), Layari River (Manora Channel/Karachi Harbour area), and small waste drains mainly along Clifton Coast and Korangi Coast. In general coliform bacterial counts were above the permissible limits set by US EPA [13] (< 100 coliform bacterial colonies per 100 ml) and is not found to be suitable for swimming. Although, high pollution level has been recorded in the Karachi Harbour area, but still it is being used for bathing by tourists and the local population.

4.3   North West Coast, Karachi

The North-West Coast of Karachi faces open sea and is extended from Manora Light-House (sea side) to Paradise/Sunehry Point area. Sampling was performed in North West coast at three locations namely: Paradise Point, Hax Bay

Table 2. Bacteriological analysis of seawater at Karachi harbour /Manora Channel

Code	Sample Location	Geographical location Lat/Long	Total Coliform /100 ml	Fecal Coliform /100 ml
KS-10	Light House	24-47-83 66-58-75	204 ± 3	136 ± 6
KS-11	Pakistan Naval Academy (PNA)	24-48-29 66-58-50	396 ± 1	216 ± 3
KS-12	Boat Club	24-58-67 66-58-13	420 ± 5	388 ± 1
KS-13	Bhit Island	24-49-18 66-58-00	540 ± 6	446 ± 4
KS-14	Bhaba Island	24-49-43 66-57-91	988 ± 7	680 ± 2
KS-15	Shamspir	24-50-46 66-55-96	950 ± 3	825 ± 3
KS-16	Naval Harbour Store Depot	24-49-69 66-58-05	824 ± 4	604 ± 5
KS-17	Naval Dockyard	24-50-14 66-58-07	820 ± 4	616 ± 2
KS-18	Shipyard	24-50-47 66-58-09	988 ± 5	740 ± 1
Ranges			204-988	136 -740

Table 3. Bacteriological analysis of seawater at Karachi Northwest Coast

Code	Sample Location	Geographical location Lat/Long	Total Coliform /100ml	Fecal Coliform /100ml
KS-19	Paradise point	24-51-42 66-50-00	100 ±2	60 ±1
KS-20	Hax Bay	24-51-66 66-50-23	72 ± 6	23 ±4
KS-21	Sandspit	24-51-68 66-51-33	80 ± 3	30 ± 5
Ranges			72-100	23-60

and Sandspit during low tidal condition. Table 3 presents the results of coliform analysis. The pollution scenario along the North West Coast is much better than Karachi harbour. Maximum Fecal and Total coliform bacterial count recorded at Paradise point were 60 and 100 coliform colonies per 100 ml of sample, respectively. At Hax bay and Sandspit, Total and Fecal coliform bacteria were 72 and 23 & 80 and 30 bacterial colonies per 100 ml, respectively. At all the locations the level of coliform bacteria is less than the recommended levels. North west coast is relatively less polluted.

4.4   South East Coast, Karachi

The South-East Coast of Karachi faces open sea and is extended from Clifton beach near KPT Oil terminal to Ibrahim Haideri Fish Harbour in Korangi Industrial area. Samples were taken from three locations that include: Bhutto Casino, Ghizri Creek and Ibrahim Haideri fish harbour. Results are presented in Table 4. Total and Fecal coliform counts at Bhutto casino, Ghizri Creek and Ibrahim Haideri were found to be in range of 170 and 70, 220 and 142 and 390 and 226 coliform colonies per 100 ml respectively. Heavy coliform pollution along this coast is an indication of domestic waste discharge along the coast.

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Table 4.   Bacteriological analysis of seawater at Karachi Southeast Coast .

Code	Sample Location/ collection point	Geographical location Lat/Long	Total Coliform /100ml	Fecal Coliform /100ml
KS-22	Bhutto Casino	24-48-05 67-00-85	170± 5	70 ± 1
KS-23	Ghizri Creek	24-47-32 67-05-11	220 ± 3	142 ± 5
KS-24	Ibrahim Haideri	24-47-04 67-08-75	390 ± 2	226 ± 4
Ranges			170-390	70-226

Table 5.   Bacteriological analysis of seawater at Gadani .

Code	Sample Location/ collection point	Geographical location Lat/Long	Total Coliform /100ml	Fecal Coliform /100ml
GD-1	Gadani Picnic Point	25-07-07 66-43-37	740 ± 3	590 ± 5
GD-2	Ship Breaking Area (Plot 80)	25-03-36 66-42-66	90 ± 6	75 ± 4
Ranges			90- 740	75- 590

Table 6. Bacteriological analysis of seawater at Somiyani .

Code	Sample Location/ collection point	Geographical location Lat/Long	Total Coliform /100ml	Fecal Coliform /100ml
SD-1	Open Sea	25-25-46 66-32-18	Nil	Nil
SD-2	Opposite Damb	25-27-33 66-32-43	370 ± 7	334 ±3
SD-3	Start of Mangrove Channel	25-27-95 66-31-75	190 ± 2	94 ± 5
SD-4	End of Mangrove Channel	25-28-34 66-31-64	220± 4	154 ±1
SD-5	Middle of two Channel	25-28-44 66-31-39	150 ± 3	104 ± 6
SD-6	End of Channel	25-28-79 66-31-34	Nil	Nil
Ranges			0-370	0-334

4.5   Gadani Coast

Gadani Coast is situated about 100 km away towards East of Karachi. It is famous for ship breaking industry. Two sampling points namely, picnic point and ship breaking area facing plot 80 were selected for sampling. Results are presented in Table 5. At picnic point significantly high concentration of Fecal coliform colonies (740) and Total coliform colonies (590) were observed in 100 ml of sample due to public activity at this point. At ship breaking area, relatively less number of Total as well as Fecal coliform colonies (90 and 75 per 100 ml, respectively) were recorded. The picnic spot is used for bathing activities by tourist despite of high coliform population than the recommended levels.

4.6   Somiyani Coast

Somiyani Coast is situated about 150 km East away from Karachi. Five sampling points namely open sea, opposite Damb, Start of Mangrove Channel, End of Mangrove Channel, Middle of two channel, End of Channel were selected for sampling. Results are presented in Table 6. High Fecal (334) and Total coliform (370) colonies per 100 ml of seawater at opposite Dhomb (picnic point) may be due to public activity at this point.

Table 7.   Bacteriological analysis of seawater at Ormara .

Code	Sample Location/ collection point	Geographical location Lat/Long	Total Coliform /100ml	Fecal Coliform /100ml
OR-1	Open Sea	25-11-42 64-42-23	Nil	Nil
OR-2	Opposite RU Tank	25-12-15 64-39-60	96 ±2	58 ± 3
OR-4	Opposite Mosque &Middle School	25-12-48 64-38-35	290 ± 5	134 ± 4
OR-5	End of Village	25-12-89 64-38-35	156 ± 2	78 ± 3
Ranges			0-290	0-134

Table 8. Bacteriological analysis of seawater at Pasni .

Code	Sample Location/ collection point	Geographical location Lat/Long	Total Coliform /100ml	Fecal Coliform /100ml
PS-1	Opposite Mosque	25-15-65 63-28-68	98 ± 2	24 ± 7
PS-2	Fish Harbour Mouth	25-15-05 63-28-68	225 ± 5	105 ± 6
PS-3	Opposite Coast Guard Building	25-16-00 63-29-30	68 ± 3	42 ± 2
PS-3	Opposite Weather Station	25-16-35 63-29-12	64 ±1	26 ± 4
PS-5	Open Sea	25-15-97 63-30-03	24 ± 3	Nil
Ranges			24-225	0-105

Mangrove area sampling points (sampling locations SD-3 and SD-4) also had high number of Fecal and Total coliform bacteria. Open sea was found to be free of coliform contamination.

4.7   Ormara Coast

Ormara coast is situated about 250 km East of Karachi. Ormara is small town with a population of about 5,000. Five sampling points namely Open Sea, Opposite RU Tank, Opposite Mosque and Middle School, End of Village were selected for sampling. Results are presented in Table 7. Maximum number of Total and Fecal coliform bacteria per 100 ml of sample (290 and 134 respectively) were determined in samples collected at the centre of the village. Ormara Coast is relatively free of pollution due to population and lack of industrial activity.

4.8   Pasni Coast

Pasni is situated on Baluchistan coast line. Five sampling locations were selected for monitoring of coliform bacteria namely: Opposite Mosque, Fish Harbour Mouth, Opposite Coast Guard Building, Opposite Weather Station and Open Sea. Table 8 presents results of coliform bacterial analysis per 100 ml of samples. Fecal coliform was not found in open sea, while 24 Total coliform colonies per 100 ml of water were observed at this point. Fish harbour mouth area was observed to be the most polluted zone with Total (225) and Fecal (105) coliform bacteria per 100 ml of sample. The remaining sampling points also had coliform contamination above permissible limits. The pollution in Pasni coast is attributed due to untreated domestic waste which is poured directly into the sea.

4.9   Gwadar Coast

Gawdar is the second largest coast of Pakistan. The coast line of Gwadar extends in an East - West direction. Samples were collected from nine locations i.e., 5 sampling points on East Coast, 3 sampling points on west coast and one sample from deep sea. Results are presented in Table 9. Out of three sampling locations on West Coast, no

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Table 9.   Bacteriological analysis of seawater at Gwadar .

Code	Sample Location / collection point	Geographical location Lat/Long	Total Coliform /100ml	Fecal Coliform /100ml
GW-0	Open Sea	25-07-03 62-22-63	156 ±1	58 ± 5
GW-1	Boat Making Area West Bay	25-07-38 62-19-11	232 ± 4	80 ± 3
GW-2	Opposite Girls School West Bay	25-00-09 62-19-19	Nil	Nil
GW-3	Opposite Governor House West Bay	25-09-33 62-19-39	Nil	Nil
GW-4	Coast Guard East Bay	25-09-29 62-19-39	Nil	Nil
GW-5	Opposite PIA Office East Bay	25-08-62 62-19-49	80 ± 6	20 ± 2
GW-6	Btw PIA office and T&T East Bay	25-07-91 62-19-58	60 ± 3	24 ± 5
GW-7	T & T Exchange East Bay	25-07-76 62-19-69	436 ±4	108 ± 3
GW-8	Fish Harbour East Bay	25-06-82 62-19-87	496 ±1	460 ± 6
Ranges			0-496	0-460

Table 10.   Bacteriological analysis of seawater at Jiwani

Code	Sample Location/ collection point	Geographical location Lat/Long	Total Coliform /100ml	Fecal Coliform /100ml
JW-1	Start of city back of WWF Office	25-03-23 61-44-68	156± 5	68 ± 1
JW-2	Opposite Fish Workshop	25-03-21 61-44-60	105 ± 4	95 ± 2
JW-3	Infront of mosques	25-02-82 61-44-51	95 ± 6	60 ± 3
JW-4	Back of Rest House (End of City)	25-02-82 61-44- 32	Nil	Nil
Ranges			0-156	0-95

coliform colony per 100 ml of water sample was detected, while boat making area (GW-1) was heavily contaminated. This is possibly due to industrial and human activities near this point. Other sampling points at West Coast were relatively clean and had coliform bacteria within permissible limits (<100 coliform colonies per 100 ml). East Coast was found much polluted as compared to West Coast. As the East Coast faces the city, all the domestic waste is being drained on East Coast. At Coastal Guard area no coliform colony was detected. These points are out of the city and relatively clean. The two sampling points, i.e., near T & T Tower and at fish harbour were heavily polluted with coliform bacteria due to domestic drain. Most of population at Gwadar is expanding on East Coast without any planning and domestic/industrial waste is drained directly into sea.

4.10   Jiwaini Coast

Jiwaini is a small town at the border of Iran. It is the last coastal city of Pakistan in the East. It is relatively clean beach due to less population and industrial activities. Samples were collected from four locations namely: Start of city, opposite fish workshop, in front of mosque and back of rest house. The results are presented in Table 10. The

domestic drain of city falls directly into the sea, which is reflected by the count of coliform bacteria at sampling points near the city. No bacterial colonies were detected at the end of city, near rest house (JW-4). Three points near the city were contaminated with coliform but their number was within permissible limits.

5. Conclusions

Fecal coliform bacteria have been used as an indicator of the possible presence of pathogens in surface water. Contact with contaminated water can lead to ear or skin infections, and inhalation can cause respiratory diseases. The pathogens responsible for these diseases can be bacteria, viruses, protozoa's, fungi, or parasites that live in the gastrointestinal tract and are shed in the feces of warm-blooded animals. On the basis of the difficulties in analyzing and detecting the many possible pathogens or parasites, Fecal bacteria are used as the primary indicators of Fecal contamination in seawater.

The presence of high number of Coliform bacteria in Indus delta, Karachi harbour and some areas in Gwadar port indicates that large amount of domestic waste is drained in the sea without any treatment. There is an urgent need for community participation to upgrade remedial strategies and to make these procedures effective for improvement in water quality of coastal waters. The key to resolve the wastewater problems can be controlled by management planning, enforcement of national standards, licensing and policing of discharges, following approved procedures in wastewater management and environmental awareness. In industrialized countries, many types of water born diseases have been effectively controlled through the general introduction of innovative methods of water treatment and improved means of sewerage collection, treatment and disposal methods.

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