

Prevalence of pollution indicators in Palk bay coastal zone, Southern India

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Abstract

In this study, the sea water and sediment samples of four different locations were collected from Palk bay regions during 2014 for pollution indicators study. All the bacterial parameters were higher during the rainy season compared to summer season in all the sampling locations of the Palk bay regions. In the water samples, among the pollution indicator bacterial groups, TC and TS counts were highest $0.67 - 10.3 [\times 10^3] \text{ ml}^{-1}$ and $0.8 - 10.8 [\times 10^2] \text{ ml}^{-1}$ during monsoon, and the least $0.54 - 8.5 [\times 10^3] \text{ ml}^{-1}$ and $0.7 - 9.0 [\times 10^2] \text{ ml}^{-1}$ were noticed during summer. In monsoon sediment sample, the higher VC count was observed in Thondi (2100 g^{-1}) followed by Mimisal (1700 g^{-1}), Manamelkudi (960 g^{-1}) and Devipattinam (200 g^{-1}). The pollution index (PI) of each location was calculated and was showed a remarkable microbial contamination was observed in sediment sample than water sample. The order of PI observed were Thondi > Mimisal > Manamelkudi > Devipattinam. The highest PI ratio (15.5) was observed in Devipattinam sediment sample at monsoon season while lowest (2.5) was noticed in Devipattinam water sample at summer season. The results indicated that the coastal environment is highly exposed to human excreta that suggesting to avoid direct contact. Hence, throughout impoundment is needed to protect coastal environments.

Keywords: Pollution indicators, Palk bay, Fecal coliforms, Pollution index, Thondi

1. Introduction

Recreational water generally contains a mixture of pathogenic and non-pathogenic microbes derived from different waste such as rural/ urban sewage effluents, industrial and farming activities and other sources. The presence of such microorganisms in recreational seawaters and sea sediments leads to a high risk of waterborne and airborne illnesses to beach users. Human health risks associated with microbial vectors are a serious problem in coastal zones, and these risks may increase dramatically in the near future. These microbes can present a hazard to bathers where an infective dose of pathogen colonizes a suitable growth site in the body and leads to disease. Billions of people worldwide suffer from diseases that are linked to water pollution, and most of the victims are children in developing countries [1]. Because, approximately three billion people live worldwide within 200 kilometers of a coastline. Hence, now a day, rapid development of industries and human population is occur in the coastal cities that are responsible for diffuse pollution in the aqueous environment. At the same time, the ocean contains

enormous bioactive compounds in both living and non-living things [2] [3].

Discharges of sewage effluents have generally a negative impact on the coastal environment and tourism/ aquaculture activities are increasing significantly which make it less attractive for recreation/ economic usages. Fecal material from beach users, domestic animals (dogs, cattle, and horses), as well as birds/ waterfowl (geese, gulls, and ducks), all lead to increases in bacterial loading in coastal areas [4]. Watershed studies should address potential pollution risks from sediments, which can serve as a reservoir for coliform bacteria and are attached to the surfaces of runoff solids [5]. Generally, fecal indicator concentrations are higher in sediments than in the overlying water column [6]. The microbiological quality of sediments at the sediment-water interface in bathing water received particular attention [7]. Detection and enumeration of indicator organisms are of primary importance for the monitoring of sanitary and microbiological quality of water [8].

The survival of enteric bacteria on the surface of dry sand may essentially be of short duration, the bacteria being destroyed mostly by environmental pressure. But in the wet sand, enriched with organic substances, provides a favorable environment for enteric bacteria, which enables them to survive longer than in seawater [9]. Various factors have been proposed as encouraging the survival and dispersion of fecal index microorganisms and pathogens on beach sand. These include the nature of the beach, tidal phenomena, sewage outlets, the season, the presence of animals and the number of bathers. Water movement, for example, causes erosion, transportation and deposition of beach sediment and redistribution of associated microorganisms [7]. The particular objective of the present study is to scrutinize the seasonal and temporal variations of pollution indicators and to find which source is highly influence the marine environmental contaminations.

2. Materials and methods

2.1 Study area

In India, the Palk Bay has landmarks between the Point Calimere and Rameshwaram island as northern and southern borders, respectively. The eastern part of the bay is connected with Srilanka whereas the western part of the bay is the border of the Indian subcontinent. The 130 km long stretch between Pamban and Athiramapattinam in the Palk Bay coast has a treasure of luxuriant living and non-living things. There are no major river discharges expect that of a small rivers, which brings water along with waste materials only during the rainy/ monsoon season

(September – December). Fishing activities are carried out on a small and large scale using wooden dugout canoes, and mechanized boats. Active aquaculture is noticed all along the Kattumavadi coast, discharging effluents directly in to the sea in many areas. The indirect land-based threats included increase in sediment loads, waste water discharges/ non-point sources, high levels of increased ions/ metals from different wastes and cultivation of exotic seaweed, sea grass and etc. Many numbers of fish landing centers (fishing harbor) were situated along the Palk bay regions and nearly few lakhs fishermen depend on the ocean for their livelihood. The seasons were divided into four groups: post monsoon (January – February), summer (March - May), premonsoon (June - August) and monsoon (September - December).

2.2 Sampling and processing

We collected a total of 16 samples (water and sediment) from 4 different locations in two different seasons (summer and monsoon) during a period 2014. Sampling locations were received various land drainages and other effluents from different sources such as urban and rural sewage effluents, industrial and agricultural wastes, fishing waste, shipyard waste, ballast water and etc throughout the year, especially during monsoon. Study sites are follows (Figure 1): Manamelkudi coast (S1), Mimisal coast (S2), Thondi coast (S3) and Devipattinam coast (S4). In each locations, two liters of sea water and 250 g of sediment samples were collected by sterile 2500 ml container and sterile spatula, respectively. All samples were kept in ice and transported to the laboratory for further analysis.

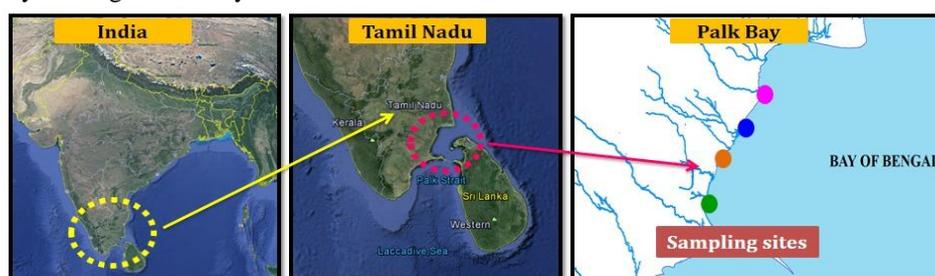


Figure 1: Sampling sites on Palk bay

2.3 Bacteriological analysis

The selective media were used for easy analysis of pollution indicators from any liquid and solid samples. In this study, all the selective media (Table 1) were prepared with the addition of aged sea water and were properly autoclaved for eight different bacterial analysis. Bacterial populations from two different samples (water and sediment) were studied by the spread plating method on selective medium plates with 0.1 mL of suitable serial dilutions [10]. All the media plates were incubated at $37 \pm 1^\circ\text{C}$ for 24 to 48 h except M-FC agar plate which was incubated in $44 \pm 1^\circ\text{C}$ for 24 to 48 h and final counts of colonies

were noted [8]. All trials were performed triplicate and mean values were counted. Specific selective media were used for the enumeration of the bacterial types. Based on the manufacturer's (Hi-media Pvt. Ltd, Mumbai, India) guide of media and knowledge of previous analyses, the isolation and enumeration of bacteria were made using selective growth media[11]. Recommended selective media were used for all organisms and they are to as similar to known microorganisms [12]. All the culture media were obtained from Hi-Media Pvt. Ltd., Bombay, India. Pollution index (PI) was calculated using the ration of Fecal Coliforms (FC) / Fecal *Streptococci* FS [13].

Table 1: Details of specific culture media used for enumeration of pollution indicators

S.No	Bacterial indicators	Culture medium	Positive colonies	Reference
1.	Total Viable Count (TVC)	Nutrient agar	All colonies counted	[10]
2.	Total Coliforms (TC)	MacConkey agar	All colonies counted	[8]
3.	Total <i>Streptococci</i> (TS)	M Enterococcus agar	All colonies counted	[6]
4.	<i>Vibrios</i> Like Organisms (VLO)	TCBS agar	All colonies counted	[12]
5.	Fecal Coliforms (FC)	M-FC agar	Blue colonies counted	[11]
6.	Fecal <i>Streptococci</i> (FS)	KF Streptococcus agar	Red colonies counted	[8]
7.	<i>Vibrio cholerae</i> (VC)	TCBS agar	Yellow colonies counted	[12]
8.	<i>Pseudomonas aeruginosa</i> (PA)	Cetrimide agar	Green colonies counted	[17]

3. Result and discussion

Public visit, massive discharges, holy dipping, tourism, shipping and aquaculture activities are increasing rapidly in coastal regions without too much consideration of their potential impacts on the marine and coastal environment [14]. All the bacterial parameters were higher during the rainy season compared to summer season in all the sampling locations of the Palk bay regions. In water, the mean TVC ranged from $2.0 - 10.8 \times 10^4 \text{ ml}^{-1}$ in summer and $2.47 - 5.4 \times 10^4 \text{ ml}^{-1}$ in monsoon seasons. But in sediment, the TVC was found to range from $3.7 - 22.5 \times 10^4 \text{ ml}^{-1}$ in summer and $3.4 - 13.8 \times 10^4 \text{ ml}^{-1}$ in

monsoon seasons (Figure 2 and 3). In the water samples, among the pollution indicator bacterial groups, TC and TS counts were highest $0.67 - 10.3 \times 10^3 \text{ ml}^{-1}$ and $0.8 - 10.8 \times 10^2 \text{ ml}^{-1}$ during monsoon, and the least $0.54 - 8.5 \times 10^3 \text{ ml}^{-1}$ and $0.7 - 9.0 \times 10^2 \text{ ml}^{-1}$ were noticed during summer. Similar pattern was also observed in sediment samples. Coliform bacteria and *Escherichia coli* itself prevail in ocean waters as well as in effluent samples. Pollution indicator bacteria such as TC, FC and TS are the ones routinely examined for an understanding of the preponderance of human pathogenic bacteria [15].

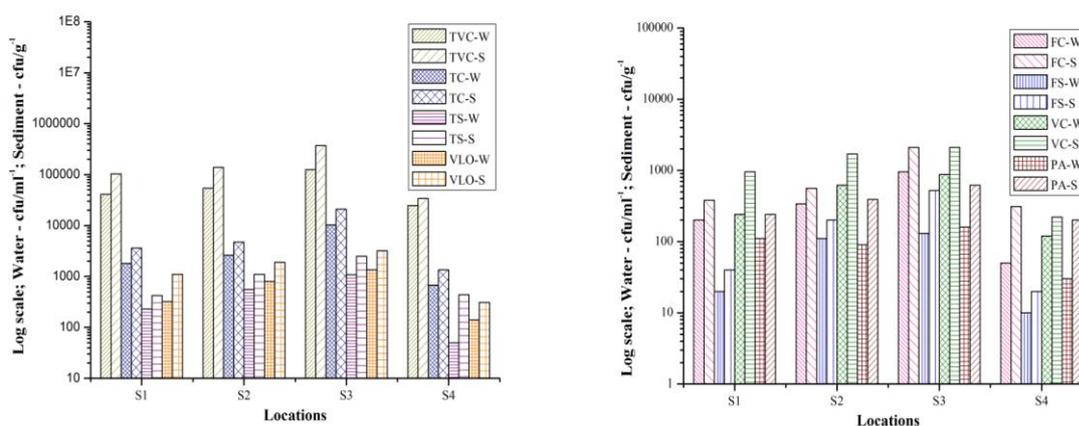


Figure 2: Pollution indicator levels in water (W) and sediment (S) samples during monsoon

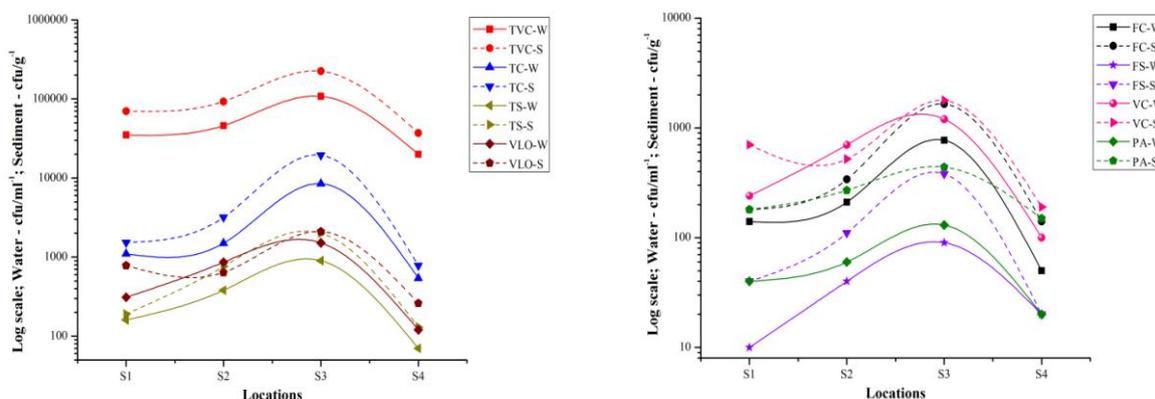


Figure 3: Pollution indicator levels in water (W) and sediment (S) samples during summer

The variation of bacterial counts at the Palk bay indicated that the different sources were influenced the coastal pollution and the higher counts were recorded in Thondi (S3) than other coastal regions. This implies that the Thondi coast receive a higher load of fecal matters from human/ animals due to the fisherman's activities. In Thondi, the counts of *Vibrio* like organisms (VLO) from both samples were observed during summer and monsoon in the range of $0.12 \text{ ml}^{-1} - 2.1 \text{ g}^{-1} [\times 10^3]$ and $0.14 \text{ ml}^{-1} - 3.2 \text{ g}^{-1} [\times 10^3]$, respectively. Most of the bacterial populations were lowest during summer and highest during monsoon, similar reports are made by Vignesh et al (2014) in Tamil Nadu coast and Ramaiah et al (2004) in Mumbai waters. The increase of bacterial parameters in rainy season may be due to the rain water that are drained variety of waste materials into the ocean, as it was the major source of bacterial populations in ocean waters [11].

Counts of fecal *Streptococci* (FS) in the sediment samples ranged from $0.2 - 3.8 [\times 10^2] \text{ g}^{-1}$ and $0.2 - 5.2 [\times 10^2] \text{ g}^{-1}$ during summer and monsoon, respectively. In water, the fecal *Streptococci* (FS) counts were low at the sampling site Devipattinam (S4) during the summer and monsoon seasons i.e., 20 ml^{-1} and 30 ml^{-1} . The range of fecal coliform (FC) from both samples in Thondi and Mimisal were $0.77 \text{ ml}^{-1} - 1.65 \text{ g}^{-1} [\times 10^3]$ and $0.21 \text{ ml}^{-1} - 0.34 \text{ g}^{-1} [\times 10^3]$ during summer and $0.96 - 2.1 [\times 10^3] \text{ ml}^{-1}$ and $0.34 - 0.56 [\times 10^3] \text{ ml}^{-1}$ during monsoon, respectively. But, the FC counts were moderate in Manamelkudi (S1) at both seasons and the ranges were $1.4 \text{ ml}^{-1} - 1.8 \text{ g}^{-1} [\times 10^2] \text{ ml}^{-1}$ and $2.0 \text{ ml}^{-1} - 3.8 \text{ g}^{-1} [\times 10^2] \text{ ml}^{-1}$ during summer and monsoon seasons. Fluctuations in the number of pollution indicators in different samples are mainly attributed to the intensity and duration of pollution in addition to the physical stress (temperature, pH, Salinity, Wave, Tide and etc) and the amount of runoff waters [16].

In this study, the bacterial concentrations were higher in the sediment samples than the water

samples. Higher bacterial densities were retrieved from sediments than from the overlaying seawater because it contains rich nutrients/ organic contents which promotes the growth of microorganisms [10]. In monsoon sediment sample, the higher VC count was observed in Thondi (2100 g^{-1}) followed by Mimisal (1700 g^{-1}), Manamelkudi (960 g^{-1}) and Devipattinam (200 g^{-1}). But in summer water sample, the higher VC count was observed in Thondi (1200 ml^{-1}) followed by Mimisal (700 ml^{-1}), Manamelkudi (240 ml^{-1}) and Devipattinam (100 ml^{-1}). In water, the mean *Pseudomonas aeruginosa* (PA) ranged from $0.3 - 1.6 [\times 10^2] \text{ ml}^{-1}$ during monsoon and $0.2 - 1.3 [\times 10^2] \text{ ml}^{-1}$ during summer periods. But in summer sediment sample, the PA counts were 180 g^{-1} , 270 g^{-1} , 440 g^{-1} and 150 g^{-1} in Manamelkudi, Mimisal, Thondi and Devipattinam, respectively.

In this study, higher values (> 1) of the pollution index (PI) (FC/FS) ratio reveals, human fecal pollutions affect the coastal water and sediment quality. The PI ratio showed a remarkable microbial contamination was observed in sediment sample than water sample and the order of PI observed were Thondi $>$ Mimisal $>$ Manamelkudi $>$ Devipattinam. The highest PI ratio (15.5) was observed in Devipattinam sediment sample at monsoon season while lowest (2.5) was noticed in Devipattinam water sample at summer season (Figure 4). This PI ratio indicated that the impacts of human excreta on coastal regions may damage the coastal water and sediment quality in a large extent. Bacteriological analysis of sea water indicated that water was polluted by fecal contamination to an extent that it became unsuitable for recreational activities. Fecal matter degrades water and sediment quality due to the possible introduction of pathogens, nutrients, and organic matters. The fecal pellets may contain an antibiotics and it will create a pressure on microbial strains in the aquatic environments

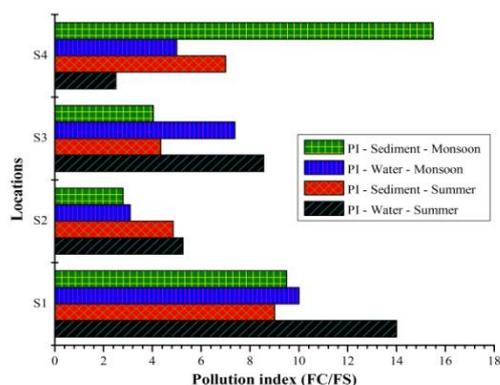


Figure 4: Level of pollution index (PI) in the water (W) and sediment (S) samples

4. Conclusion

The present study concludes the highest counts of bacterial strains were observed in monsoon than summer. Both season and location wise changes were noticed due to the human population and their activities. *Vibrio* sp. were predominant microbial pollutants in the study area and most of the samples were crossing the TC level as per WHO standard. Based on the PI ratio and our findings, areas were contaminated by human/ animal excretions, urban/ slum sewage, shipping activities and industrial effluents to an extent that these areas became unsuitable for recreation purposes. Hence, continuous monitoring was necessary to prevent the microbial pollution in aquatic environments.

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