

# Spatial and Temporal Variability of Some Coastal Water Parameters at Selected Locations on the East Coast of India



R. Gayathri, V. Ranga Rao, P. Madeswaran, V. Padmavathi, R. ManjuPriya, M. Arunvel and S. R. Kishore Baabu

**Abstract** Seawater quality status of shore and offshore areas of four selected locations (Visakhapatnam, Kakinada, Ennore, and Pondicherry) along the east coast of India were studied based on the analysis of various water quality parameters (Temperature, pH, Dissolved Oxygen, Biological Oxygen Demand, Suspended Sediment Concentration, Nitrate, Phosphate, and Fecal Coliforms collected during 1993–2014 under the COMAPS program of ICMAM-PD, Ministry of Earth Sciences, Govt. of India. The National Sanitation Foundation Water Quality Index was used to estimate the indices for different seasons. The water quality parameters have strong seasonal and spatial variability along the coast. Higher concentration of BOD and SSC toward shore waters and lower concentration toward offshore is noticed. In Visakhapatnam and Kakinada, the nitrate and phosphate concentration was comparatively higher than Ennore and Pondicherry. The Fecal Coliform counts in the shore waters were significantly high for all the four locations. Computation of Water Quality Index based on different water quality parameters reveals that the water quality along these sites varied from ‘medium’ to ‘good’ depending on the location and the season. The analysis of the data clearly emphasize the need for continuous monitoring of these water quality parameters to maintain and preserve the water quality as well as the related coastal ecosystem productivity of the Indian coast. Further, comprehensive studies are required for the Indian coastal water to determine the relative weightages of various water quality parameters and to develop an optimum WQI index methodology.

**Keywords** Temperature · Dissolved oxygen · Nitrates · Water quality index

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## 1 Introduction

Degradation of coastal water quality due to sewage runoff from land is a raising concern in the emerging scenario of urbanization and industrialization. The increase in temperature due to global warming, the excess nutrients from the sewage and fertilizers, and the chemicals from industries could adversely affect the water quality which, in turn, affects the health and wealth of marine biological production. Therefore, to achieve a sustainable management solution for improving the productivity of coastal and marine ecosystems, the assessment of coastal water quality is essential. As an initiation in this direction, ICMAM-PD, Ministry of Earth Sciences, Chennai is monitoring the coastal water quality parameters at regular monthly intervals along the Indian coast since 1993 under its COMAPS (Coastal Ocean Monitoring and Prediction System) and SWQM (Sea Water Quality Monitoring) programs. Extensive field data on various water quality parameters as per the standard COMAPS protocol [1] is being collected at selected locations along the Indian coast. In the present study, some of these data for selected coastal stations (Visakhapatnam, Kakinada, Ennore, and Pondicherry) was utilized to study the spatial and temporal variability of water quality along the east coast of India. A comparative study of these coastal water parameters for the four sites was carried out and presented in this paper.

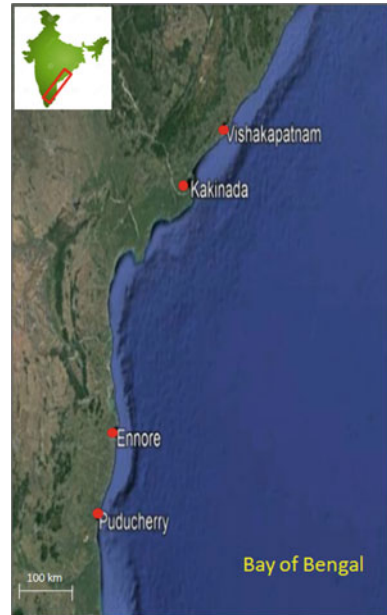
## 2 Study Locations

The four study locations (Fig. 1) chosen for the present study have different anthropogenic and natural influences due to urbanization and industrialization. Sewage is a major influence on coastal waters along all of these four locations. The Kakinada city located on the deltaic coast with major river influence and mangrove forest, which is rich in small water bodies and most of the adjacent agricultural lands are dependent on these water sources. Ennore is located on the northeast of Chennai and consists of alluvial tracts, beach dunes, tidal flats, and creeks. Ennore comprises lagoons, with salt marshes and backwaters, which are submerged under water during high tide and forms an arm of the sea opening into the Bay of Bengal. Puducherry historically known as Pondicherry is a tourist spot with intense urbanization facing various environmental problems especially erosion and sewage.

## 3 Data and Methodology

The data for the present study was extracted from the COMAPS database, collected during the period 1993–2014, covering the shore and offshore areas of the selected locations of the Indian coast. In order to study the seasonal variability, all the collected data over different years have been segregated month wise and finally made into four

**Fig. 1** Study area and station locations

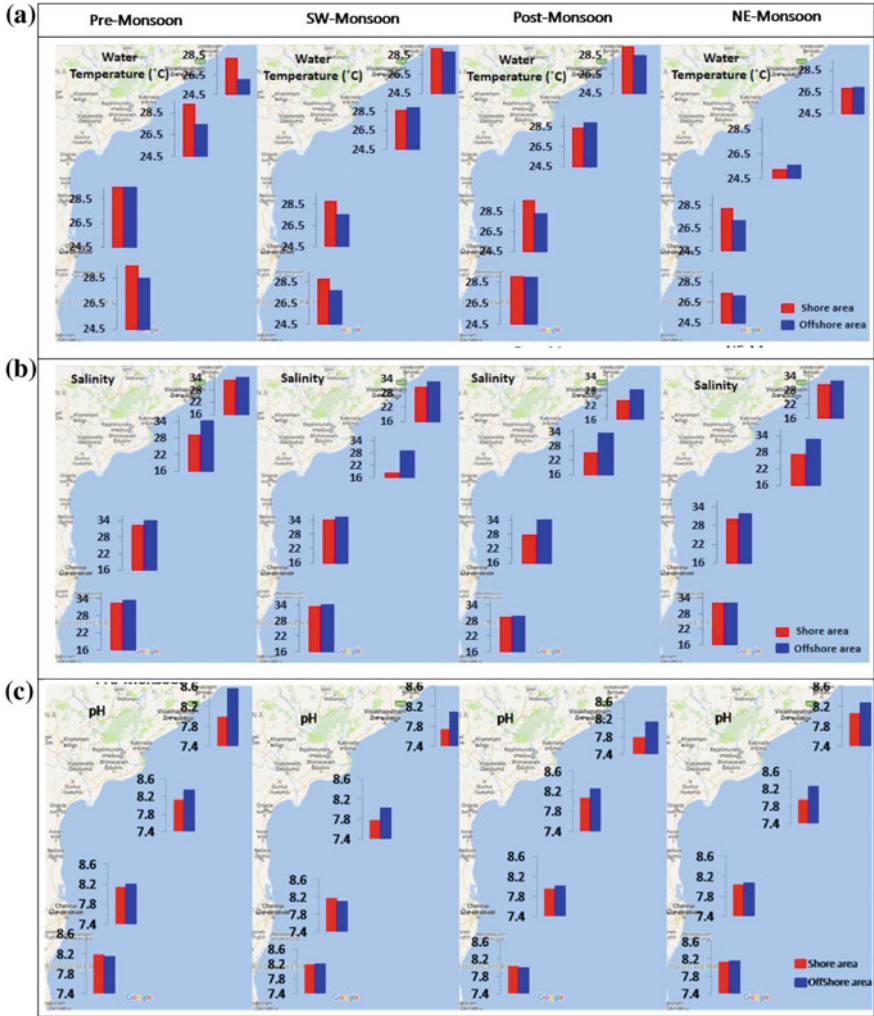


subdivisions of a year, i.e., (i) Pre monsoon (March, April, and May), (ii) Southwest monsoon (June, July, August, and September), (iii) Post monsoon (October and November), and (iv) Northeast monsoon (December, January, and February). The data of each parameter was seasonally averaged based on the available data period to obtain a representative value for each season. Based on this data, a detailed analysis of the seasonal variability of water quality parameters including temperature, pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Suspended Sediment Concentration (SSC), Nitrate, Phosphate, and Fecal Coliforms (FC) was carried out. Further, the Water Quality Index (WQI) based on these parameters was computed by adopting the methodology of National Sanitation Foundation (NSF) [2, 3].

## 4 Results and Discussions

### 4.1 Spatial and Temporal Variations

The seasonal variation in the mean values of various water quality parameter is presented elaborately in this section. Comparison of various sea water quality parameters of shore and offshore regions at the four selected stations on the east coast of India for different seasons are shown in Fig. 2a–i. In general, it is observed that BOD, SSC, Nitrate, Phosphate, and FC have higher concentrations inshore compared to that of the offshore region at all the four locations. This is a clear indication of the influence



**Fig. 2** 2a–c—Distribution of water quality parameters (water temperature, salinity and pH) at shore and offshore areas of selected locations (Visakhapatnam, Kakinada, Ennore, and Puducherry) along the east coast of India; 2d–f—Distribution of water quality parameters (DO, BOD, and SSC) at shore and offshore areas of selected locations (Visakhapatnam, Kakinada, Ennore, and Puducherry) along the east coast of India; 2g–i—Distribution of water quality parameters (Nitrate, Phosphate, and FC) at shore and offshore areas of selected locations (Visakhapatnam, Kakinada, Ennore, and Puducherry) along the east coast of India

of land-derived material and their dispersion in the coastal waters. Along the shore, the comparatively higher temperature was observed. The variability in temperature (Fig. 2a–c) between shore and offshore peaked to about 1.5 °C during pre monsoon due to hot weather conditions. During winter, the lowest temperature was noticed

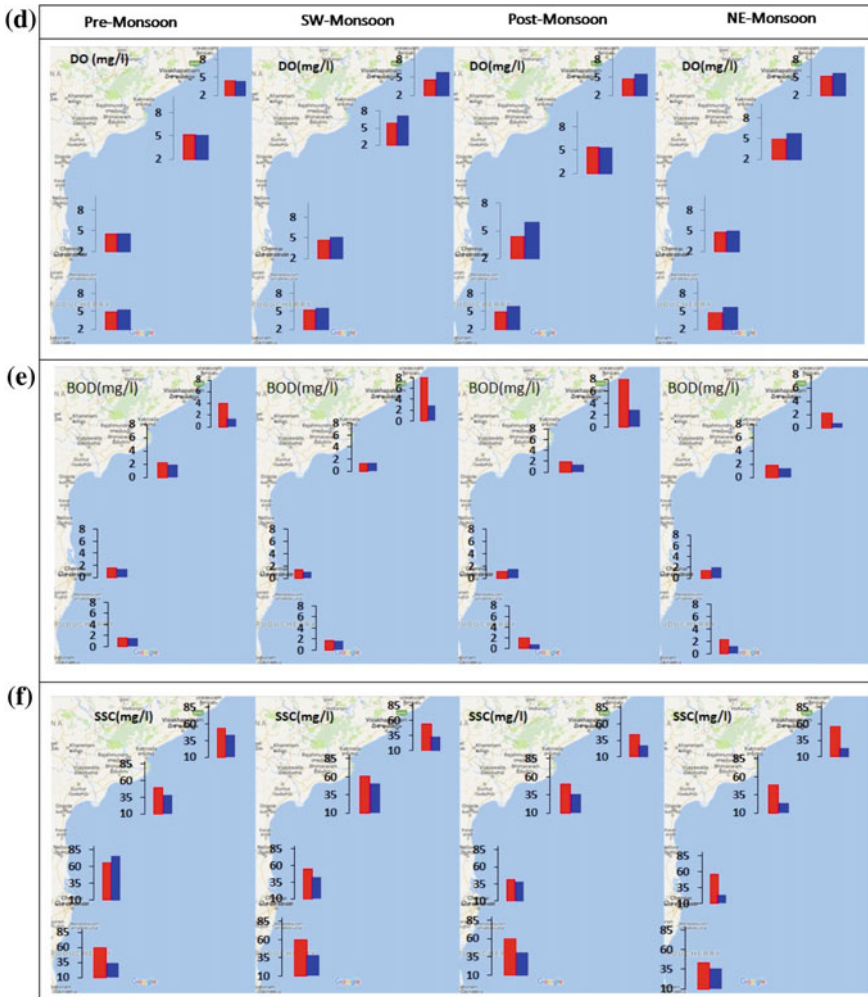


Fig. 2 (continued)

in Kakinada and one of the possible reasons for this can be the advection of the freshwater from the rivers north of the location. As heat influences the chemical process and consequent life cycle of organisms, the water temperature controls the distribution of marine organisms and fishes [4], and therefore seasonal variations of water temperature may play a major role in biological production along the coast.

However, the parameters such as salinity, pH exhibits relatively higher values in offshore waters compared to that inshore waters and hence they are influenced mostly by neritic waters. Visakhapatnam and Kakinada coastal waters show higher variability in pH between shore and offshore waters and thus it clearly indicates the impact of land-derived pollutants have an influence on water quality along these two

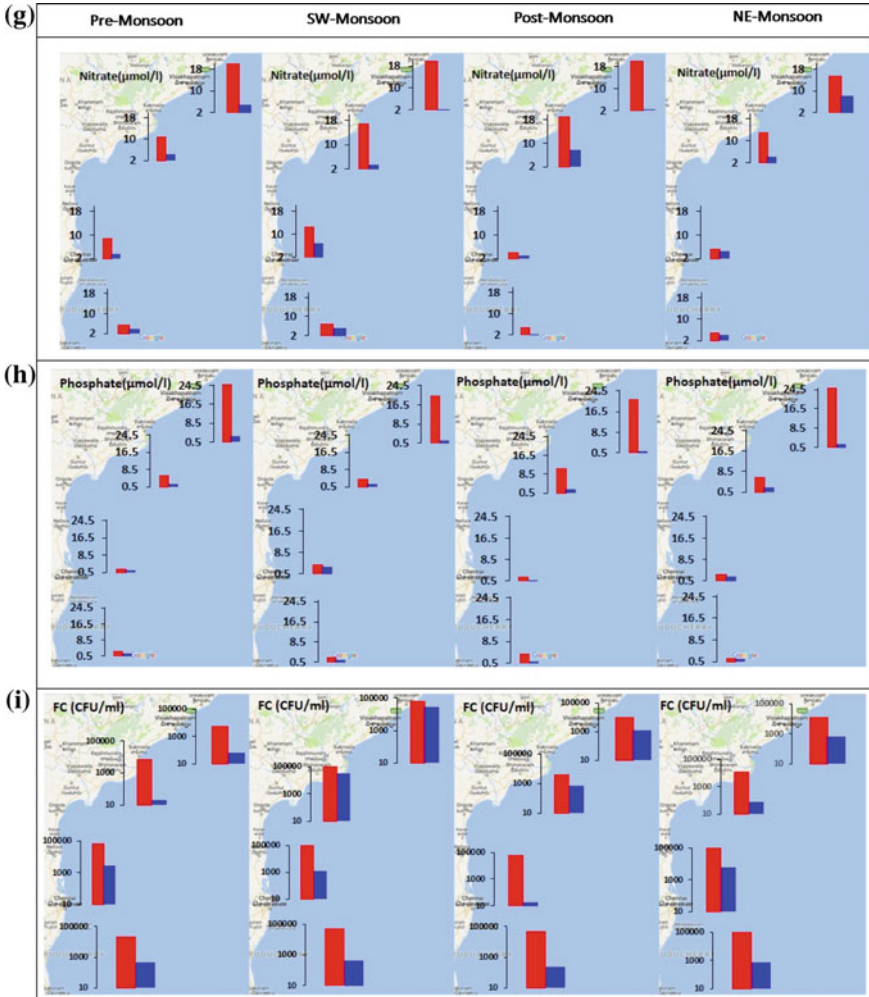


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coastal sites. However, at Ennore and Pondicherry, there is no significant variation in pH between shore and offshore waters. In general, the pH range at the four stations is within the range of 7.6–8.6 with a highest offshore value of 8.6 at Visakhapatnam.

The DO concentration along the coastal water was within a range of 3–7 mg/l with no significant variability in the shore and offshore waters. The highest DO concentration was noted in the offshore waters during SW Monsoon and Post Monsoon. Similar to DO, the higher concentration of BOD was also observed during the SW Monsoon and Post Monsoon. The BOD values peaked to nearly 8 mg/l in the shore waters of Visakhapatnam, whereas the values were less than 3 mg/l for the rest of the locations. The nutrient distribution also indicated a higher concentration in Visakha-

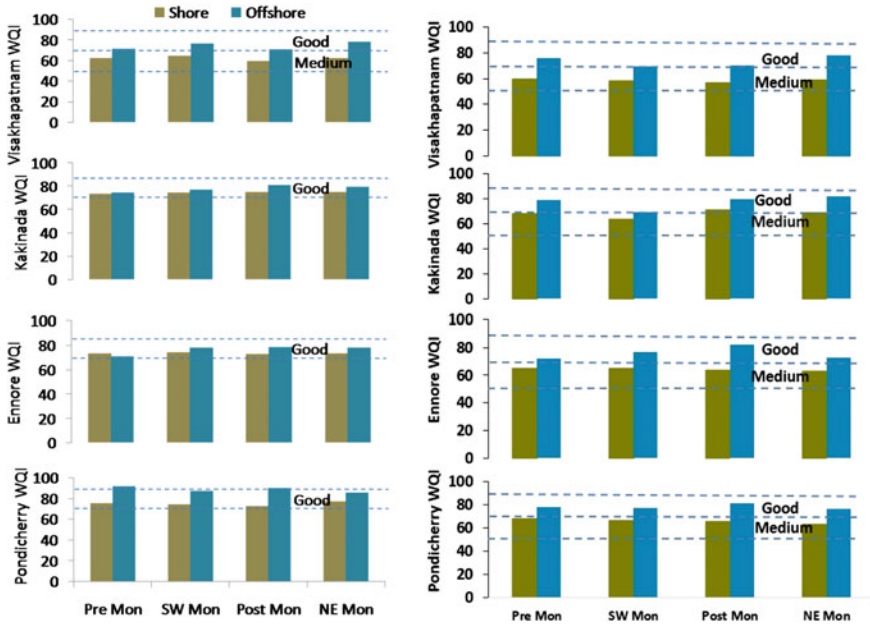
patnam and Kakinada. Compared to the Pondicherry and Ennore, the nitrate and phosphate values are several folds higher at these locations. This is undoubtedly the effect of the land runoff. Further, the effect of land runoff can be noted in the FC concentrations also.

## 4.2 *Water Quality Status*

In order to study the status of water quality along the four locations, the data discussed above was utilized to calculate WQI. The index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. WQI based on a few very important parameters can provide a simple indicator of water quality. It gives the public a general idea about the possible problems with the water in the region. Total Eight water quality parameters (DO, FC, pH, BOD, temperature change, total phosphate, nitrate, and total solids) were utilized to derive the index. The FC concentration of the coastal water was quite higher and hence the computed sub-index values were very low. Therefore separate calculation of WQI with and without FC was carried out. This type of WQI derived for the four locations Visakhapatnam, Kakinada, Ennore, and Pondicherry is shown in Fig. 3. The results indicate that without FC sub-index, except Visakhapatnam all the other three locations (Kakinada, Ennore, and Puducherry) showed good water quality along their respected coasts both inshore and offshore regions. However, Visakhapatnam coast showed medium water quality especially in the shore region which indicates clearly the influence of land-derived material along the coast. It can be expected as Visakhapatnam is one of the fast developing cities with most anthropogenic influence both in terms of urbanization and industrialization when compared to other three locations. The water quality status showed evident variations FC index was considered. The shore water quality shifted to medium from good water quality. This variability showed the importance of each parameter and their relative weightage in affecting the water quality. Therefore, the choice of water quality index method, the parameters and their relative weightage for a location need further investigation.

## 5 **Conclusion**

Significant spatial and seasonal variability was noticed among various water quality parameters at Visakhapatnam, Kakinada, Ennore, and Pondicherry coastal waters. The variation of the parameters in the shore, and offshore locations clearly indicate that for parameters like temperature, suspended sediment concentration, and oxygen, the spatial variability for post monsoon was found negligible, however, there is a strong spatial variability for pH and BOD. The spatial distribution of nitrate throughout the season clearly indicated a higher concentration in the shore water and



**Fig. 3** Water quality index without FC(left panel) and with FC(right panel) for four seasons (Pre monsoon, SW monsoon, Post monsoon, and NE monsoon) along the four selected locations (Visakhapatnam, Kakinada, Ennore, and Pondicherry) along the east coast of India (dashed lines in the figure indicate the limits of appropriate water quality status, i.e., GOOD or MEDIUM)

it gradually decreased towards the offshore. An average value was computed from the shore, and offshore values and then the water quality index (WQI) was determined. The WQI based on the different parameters falls within a range of 60–90 indicating MEDIUM to GOOD coastal water quality. Without considering the FC, only the shore waters of Visakhapatnam showed MEDIUM water quality unlike the GOOD water quality of other locations. Though the present study indicated a good WQI, a regular assessment of the water quality is mandatory to maintain and preserve the coastal water quality and related ecosystem.

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