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Perennial occurrence of heterotrophic, indicator and pathogenic bacteria in the coastal Bay of Bengal (off Visakhapatnam) - Impact of physical and atmospheric processes

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ABSTRACT

In order to examine the health of the coastal waters off Visakhapatnam in terms of prevalence and abundance of heterotrophic (H), indicator and pathogenic (P) bacterial counts (BC) and influence of physical processes on them, time-series observations were conducted during January (winter), March (spring), July (summer) and October (post-monsoon). We noticed the impact of physical forces on substantial variations in abundance and distribution of the HBC, total coliforms, *Enterococcus faecalis* and *Pseudomonas aeruginosa* in the study region. Based on our results *Escherichia coli* and other PBC were not much influenced by the physical conditions. It has been noticed that the perennial existence of the high abundance of IBC and PBC above the standard limits during the entire study period leading to an alarming situation in the coastal waters off Visakhapatnam.

1. Introduction

Conventionally, indicator bacteria have been used to advocate the prevalence of pathogens (Berg, 1978). Indicator bacteria are two groups which reveal the efficiency of a process like to know the chlorine disinfection (total coliforms (TC)) and another group shows the occurrence of faecal contamination, such as the bacterial groups *Escherichia coli* (EC) or *Enterococcus faecalis* (EF) which surmise that pathogens may be present (Ashbolt et al., 2001). Coliforms endure in a marine environment for multiple weeks (Patti et al., 1987; Piccolomini et al., 1987) and are the prevailing bacteria in the land driven discharges and their existence in the marine environment is considered an indicator of water pollution. There are several adverse conditions and agents which reduce the viability of these bacteria in the marine environment (Robin et al., 2012; Rozen and Belkin, 2001). Contamination of coastal waters with human pathogens is documented (DebRoy et al., 2012; Nagvenkar and Ramaiah, 2009; Patra et al., 2009; Prasad et al., 2015; Robin et al., 2012; Rodrigues et al., 2011). There are several dreadful diseases like cholera, diarrhoea, dysentery and typhoid fever were caused due to different water born pathogenic microbes. Waterborne outbreaks of pathogenic bacteria from contaminated water are serious threats to public health.

The Bay of Bengal, northeastern part of Indian Ocean, is one of the largest bay in the world covers an area of 2,172,000 km^2 and receives huge anthropogenic inputs from large rivers, such as the Ganges, Brahmaputra, Irrawaddy, Mahanadi, Godavari, Krishna etc. (Varkey et al., 1996). As a result of the freshwater discharge, the upper water column stratifies resulting in weak vertical mixing (Prasanna Kumar et al., 2002). The Bay of Bengal coast is shared by several under-developed and developing countries which discharge several pollutants. The seasonal reversing in East Indian coastal currents (EICC) distributes these pollutants along the east coast of India (Varkey et al., 1996). Recently Prasad et al. (2015) reported spatial distribution of heterotrophic, indicator and pathogenic bacteria along the east coast of India due to discharge of freshwater from various rivers, which receive variable magnitude of pollutants. They noticed that higher viable bacterial counts in the coastal waters, off Visakhapatnam, than regions which are influenced by river discharge, due to the discharge of and attributed a significant amount of domestic and industrial sewage. These microbes coming from domestic and industrial activities finally can cause illness to human using recreational activities in the coastal waters or by taking fouled marine foodstuff. Organic matter is a substratum to the bacteria for their growth and several physical processes in the coastal waters supports their production. For instance, coastal upwelling during March to September, vertical mixing due to cyclones during October to December and Ekman pumping during January to March bring nutrient-rich subsurface waters to the surface that promotes phytoplankton production (Maneesha et al., 2011; Sarma et al., 2013). The enhanced organic matter production through in-situ processes may support heterotrophic bacterial abundance in the coastal

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waters. In order to examine health of the coastal waters, in terms of heterotrophic, indicator and pathogenic bacteria, the time-series observation were conducted at 6 stations in the coastal Bay of Bengal, off Visakhapatnam, during four different months (January, March, July and October) corresponding to four different seasons (winter, spring, summer and post-monsoon) to examine distribution of heterotrophic, indicator and pathogenic bacteria. The questions addressed in this study are: 1) What is the abundance and distribution of heterotrophic, indicator and pathogenic bacteria in the coastal Bay of Bengal? 2) what is the role of physical and atmospheric processes on the spatial and temporal variations of these bacteria in the water column? and 3) assessment of quality of coastal waters of Bay of Bengal, off Visakhapatnam, with reference to bacterial population.

2. Materials and methods

2.1. Study site

The north-eastern Indian Ocean (Bay of Bengal) is a distinctive tropical ecosystem which receives enormous amount of freshwater discharge (1.6×10^{12} m^3 year^{-1}) through various rivers, such as Ganges, Brahmaputra, Irrawaddy-Salween, Godavari, Krishna, Mahanadi etc. resulting in reduced salinity in the upper ocean (Varkey et al., 1996; Prasanna Kumar et al., 2002). The coastal circulation reverses its direction from equatorward during summer and poleward during post-monsoon and winter (Varkey et al., 1996). Cyclones/depression is formed every year during summer and post-monsoon periods resulting in high productivity (Maneesha et al., 2011). Based on the occurrence of unique physical processes, the study region is divided into three different periods, viz., winter (December–February) spring (March–May) and summer (June–September) and fall monsoon (October–November) periods. The continental shelf in the study region is quite steep common to the bay (except in Gangetic basin) compared to the Arabian Sea, and the 100 m contour occurs at ~17 nautical miles from the coast (Fig. 1).

2.2. Sample collection and analysis

The sampling was performed in the coastal and off-shore regions of the Bay of Bengal at six preset stations (Fig. 1) at standard depths during four different months, January, March, July and October 2014. Vertical profiles of pressure, temperature and salinity were measured using a portable conductivity, temperature and depth (CTD) profiler (SBE 19 plus; Sea Bird Electronics, USA). Water samples were collected from standard depths using a 10 L Niskin bottle. Bubble-free water samples were first taken for dissolved oxygen (DO) measurements following the Winkler titration method of Carritt and Carpenter (1966). The analytical precision, expressed as standard deviation, was 0.07% for oxygen. The concentrations of nutrients were measured following standard spectrophotometric procedures using an autoanalyser (Technicon; Traacs, Australia) (Grasshoff et al., 1983). The detection limits for nitrate, ammonium and phosphate were ± 0.05, ± 0.05 and ± 0.02 μM respectively. A 2-L water sample was filtered through a GF/F filter (0.5 μm pore size; Whatman). Chl-*a* on the filter was first extracted with *N*, *N*-dimethylformamide (DMF), at 4 °C in the dark for 12 h and then spectrofluorometrically analysed (Varian Eclipse fluorescence photometer) following Suzuki and Ishimaru (1990). The analytical precision for Chl-*a* analysis was ± 4%.

About 100 ml of sample was taken into a pre-sterilized bottle for bacterial analysis. All samples were collected with precautions required for microbiological analysis and analysed after transporting to the laboratory. The bacteriological examinations were done following Ramaiah et al. (2004) and Prasad et al. (2015) for the enumeration of heterotrophic, indicator and few pathogenic bacteria. The different selective media's were used for the specific bacterial groups. Heterotrophic bacterial counts were determined on R2A agar, enumeration of coliforms on McConkey agar, *Aeromonas* on *Aeromonas* Isolation agar, *Enterococcus faecalis* on Rapid HiEnterococci (RHE) agar, *Escherichia coli* O157:H7 on HiCrome EC O157:H7 agar, *Pseudomonas* spp. on Cetrimide agar, *Salmonella* spp. and *Shigella* spp. on Xylose-Lysine-Deoxycholate (XLD) agar, and *Vibrio* spp. on thiosulphate citrate bile salts sucrose (TCBS) agar. The specific colonies (unique to the organism of interest) on the respective agar media (HIMEIDA) were quantified and the results were expressed in colony forming units (cfu ml^{-1}) according to Nagvenkar and Ramaiah (2009).

3. Results and discussion

3.1. Physicochemical properties

The water column temperatures were relatively lower during winter followed by summer, spring and post-monsoon (Fig. 2a–d). The water column was thermally stratified during spring, summer and post-monsoon period and it was weakly stratified during winter (Fig. 2a–d). The

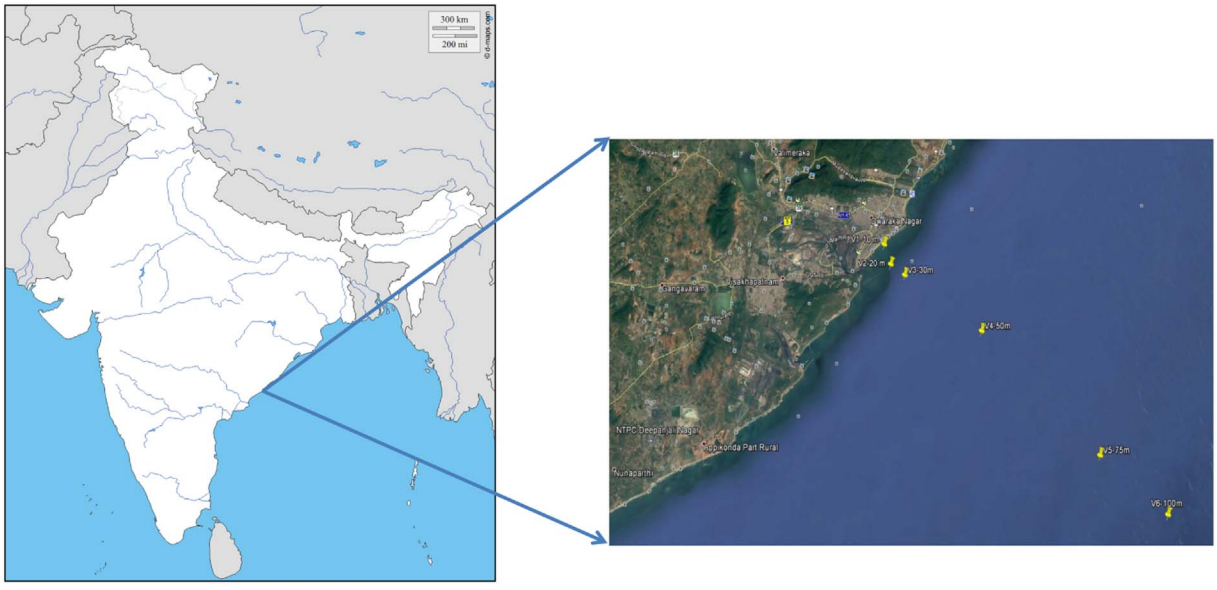

Fig. 1. Sampling locations of the time-series stations, off Visakhapatnam, in the east coast of India.