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Synechococcus as an indicator of trophic status in the Cochin backwaters, west coast of India

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ABSTRACT

Eutrophication is a major problem in coastal water bodies. Information about the trophic status of water bodies will enable proper management of coastal ecosystems. In this regard, biological organisms which are sensitive to environmental changes can serve as indicators of ecosystem trophic status. In this study, seasonal and spatial variations of picophytoplankton (PP; <3 μm size) community structure was assessed in the Cochin backwaters (CB) with respect to the prevailing environmental conditions during three seasons, post-monsoon (PM-I; October 2011 and PM-II; November 2012), pre-monsoon (PrM; May 2012) and monsoon (MON; August 2012). CB, along the west coast of India, receives continuous load of nutrients throughout the year through anthropogenic wastes. Trophic status index (TRIX) scores showed that CB is highly eutrophic with a high phytoplankton biomass. *Synechococcus* was the dominant PP observed in the study area. Seasonal and spatial salinity variations influenced the PP distribution, especially *Synechococcus* where PE-rich *Synechococcus* (*SYN*-PE) were dominant in higher saline (>30) and PC-rich *Synechococcus* (*SYN*-PC) in lower saline (<30) waters. *SYN*-PC showed a significant positive relation with chlorophyll *a* suggesting that this group contributes substantially to the total phytoplankton biomass. TRIX scores and *SYN*-PC: *SYN*-PE abundance ratio were negatively correlated with salinity suggesting an influence of the tidal amplitude. *SYN*-PC correlated positively and *SYN*-PE negatively with TRIX scores suggesting that these groups occupy contrasting ecological niches. These findings imply that PP distribution pattern can serve as an indicator of the trophic status of coastal water bodies.

1. Introduction

Backwaters are interlinked bodies of waterways, rivers, inlets, lakes and natural canals. These are the largest and the most complex ecosystems in the world. These locations are highly productive and play a distinct role in the livelihood and sustenance of the local people. Physical and chemical variables are the crucial factors supporting the higher productivity. The Cochin backwaters (CB), one of the such estuarine systems along the west coast of India, is considered to be highly productive, where phytoplankton plays an important role in the food web and serves as nursery grounds for fishes and other ecologically and economically important organisms (Qasim, 2003).

Eutrophication is one of the serious problems which CB is facing presently, resulting from the increasing anthropogenic activity. This is mainly due to the location of the Cochin port in the CB, which has accelerated the industrial growth in Cochin, making it one of the fastest growing cities in India. As a consequence, eutrophication becomes a threat for trophic dynamics and functioning of the ecosystem (Madhu et al., 2007; Kaladharan et al., 2011). CB receives a lot of organic and inorganic substances from several industries like oil refineries, fertilizer plants and chemical industries. From these industries, acids, alkalis, suspended solids, fluorides, free ammonium, insecticides, dyes, trace and heavy metals and radioactive nuclei are the major contaminants (Menon et al., 2000; Martin et al., 2012; Anu et al., 2014), which create a polluted environment in CB. For its efficient functioning, such ecosystems should be in a healthy state which can be easily detected through regular monitoring of the base of the food web i.e., phytoplankton.

At the base of the food web, the smallest group of phytoplankton, i.e., picophytoplankton (PP; <3 μm; Sieburth et al., 1978), which forms a major component of phytoplankton in the aquatic ecosystems, both marine and freshwater, including nutrient rich to

Abbreviations: CB, Cochin backwaters; PP, picophytoplankton; *SYN*, *Synechococcus*; PE, phycoerythrin; PC, phycocyanin; *PRO*-like, *Prochlorococcus*-like; PEUK, picoeukaryotes; PM, post-monsoon; PrM, pre-monsoon; MON, monsoon; NBW, near bottom waters; TRIX, trophic status index; SW, south-west; S, station; Chl *a*, chlorophyll *a*; IMD, Indian Meteorological Department; RALS, right angle light scatter; FALS, forward angle light scatter; DO, dissolved oxygen; BOD, biological oxygen demand; DIN, dissolved inorganic nitrogen; DIP, dissolved inorganic phosphate.

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poor ecosystems, was selected as the study organism (Stockner and Antia, 1986; Shiomoto et al., 1997). PP are significant contributors to primary productivity and total phytoplankton biomass in various ecosystems (Paerl, 1977; Platt et al., 1983). PP forms an important component of the marine microbial food web by creating a linkage with the higher trophic levels (Chiang et al., 2013). PP comprises of three groups; two of cyanobacteria i.e., *Synechococcus* (*SYN*) and *Prochlorococcus* (*PRO*) and a group of picoeukaryotes (PEUK). *SYN* is the major group of PP in well-lit coastal and estuarine waters (Jochem, 1988) with comparatively lower numbers in oligotrophic waters where *PRO* are abundant (Partensky et al., 1999). PEUK are most competitive in nutrient rich waters (Jiao et al., 2005). Although *PRO* is considered to be an oceanic group, recently researchers have reported *PRO*-like cells in low saline waters (Shang et al., 2007; Mitbavkar et al., 2012) and it is still speculative whether this group of cells is actually growing in these waters or is being carried from the offshore waters (Partensky et al., 1999). *SYN* is further differentiated based on phycobilisome composition into phycoerythrin (PE) rich and phycocyanin (PC) rich in estuarine and coastal ecosystems (Murrell and Lores, 2004). Previous studies have suggested that salinity plays an important role in the spatial distribution of *SYN* where PE rich *SYN* dominates high saline waters whereas, PC rich *SYN* are abundant in lower saline waters (Murrell and Lores, 2004; Rajaneesh and Mitbavkar, 2013). Based on PE fluorescence intensity, different clades of PE rich *SYN* have been observed in the Mississippi river plume (Liu et al., 2004), Pearl River estuary (Lin et al., 2010) and the Zuari estuary (Mitbavkar et al., 2012).

CB is influenced by the south-west (SW) monsoon (MON). Generally, estuaries influenced by monsoonal rainfall are highly productive due to excess nutrient input from the landmass. Studies conducted in tropical (Qiu et al., 2010; Rajaneesh and Mitbavkar, 2013) and subtropical (Lin et al., 2010; Qiu et al., 2010; Zhang et al., 2013) regions, which come under the influence of monsoonal rainfall, have suggested that riverine runoff influences the PP growth. Physico-chemical and biological characteristics of the CB (Menon et al., 2000; Madhu et al., 2009) have suggested that this region is highly eutrophic and productive, where nanoplankton are the major component of phytoplankton (Madhu et al., 2007) and is also a perfect breeding ground for economically important fishes and other organisms (Qasim, 2003). In the monsoonal Zuari estuary along the west coast of India, rainfall intensity was found to regulate freshwater runoff, which controls the estuarine environment thereby resulting in temporal and spatial niche segregation of *SYN* groups (Rajaneesh and Mitbavkar, 2013). The present study was carried out on a seasonal basis to characterize the main environmental factors, which control the spatial distribution pattern of PP groups and consequently whether these organisms can serve as ecological indicators. Since *SYN*-PE is known to prefer clear waters and *SYN*-PC turbid waters (Stomp et al., 2007), we hypothesize that these organisms can serve as good indicators of the trophic status of the water column.

2. Materials and methods

2.1. Study area

Sampling was carried out in an area within the CB, along the west coast (9°34′48″N, 76°08′24″E) of India (Fig. 1). It is situated along

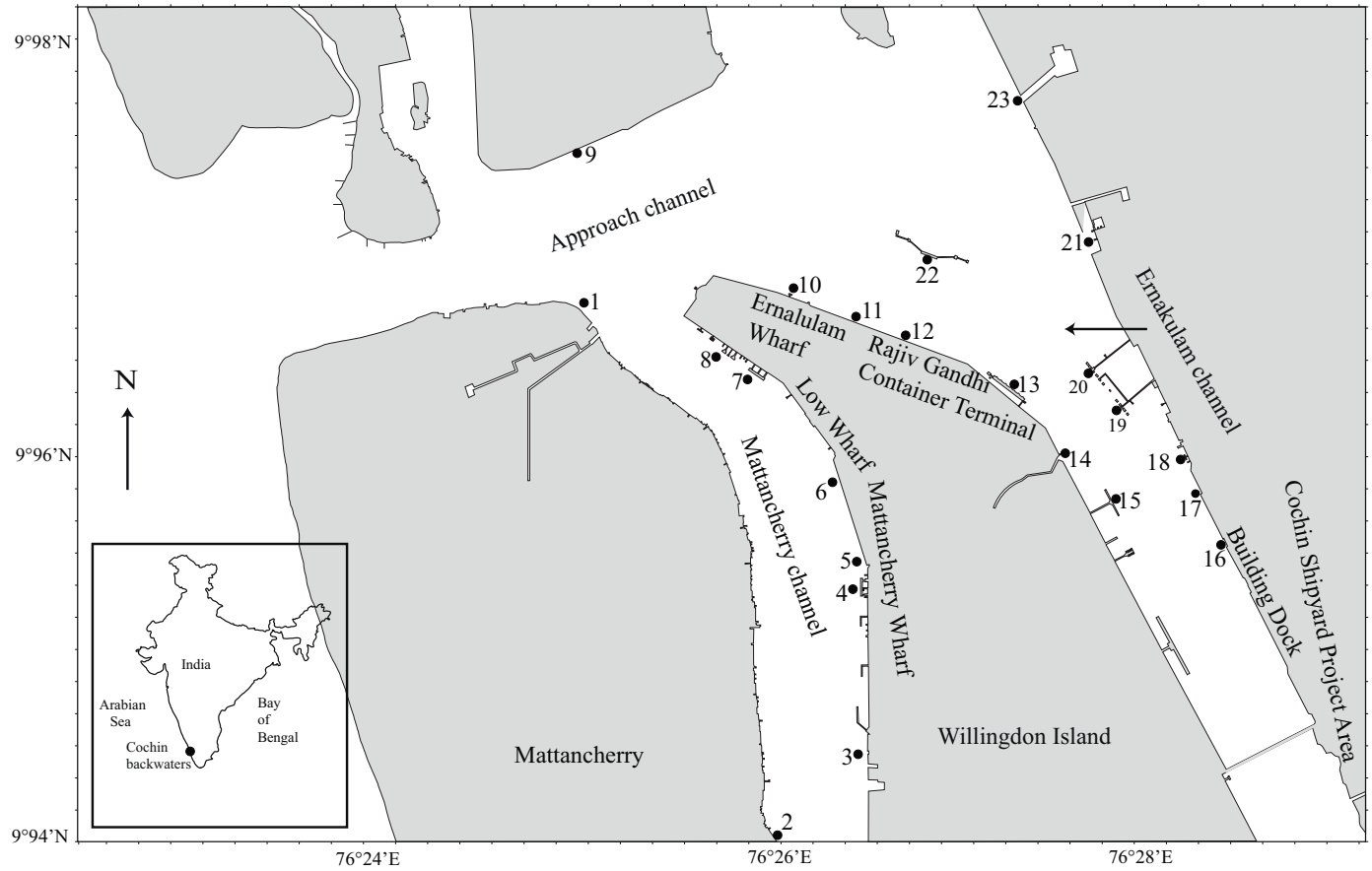

Fig. 1. Sampling stations located in the Cochin backwaters, west coast of India. (1) Custom buoy, (2) fishery harbor, (3) dry dock, (4) south coal berth, (5) Quay-1, (6) Quay-2, (7) north coal berth, (8) boat train pier, (9) container terminal, (10) DC jetty, (11) Quay-6, (12) Quay-8, (13) Quay-10, (14) Ro-Ro jetty, (15) naval jetty, (16) Cochin shipyard, (17) bunker oil jetty, (18) integrated fisheries project jetty, (19) south tanker berth, (20) north tanker berth, (21) Ernakulam ferry jetty, (22) Cochin oil terminal, (23) Ernakulam creek mouth.