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Occurrence of a multi-species diatom bloom dominated by *Proboscia alata* (Brightwell) Sandstorm along the southwest coast of India

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Key words: Diatom, Harmful Algal Blooms, *Proboscia alata*, southwest coast of India, *Pseudo-nitzschia* spp., Zooplankton

Abstract

The present communication reports on the occurrence of a multi-species diatom bloom in the upwelled waters along the southwest coast of India. During the late summer monsoon season (September 2009) a multi-species diatom bloom with a pale green discoloration of the sea surface was observed in the coastal waters of southwest coast of India. The bloom spread over an area of approximately 15 km^2 along the coastal waters off Kannur (Lat. 11°59.471 N, Long. 75°03.446 E). Total diatom cell density of the bloom area was 16 × 10^4 cells l^{-1}. *Proboscia* (=*Rhizosolenia*) *alata* (Brightwell) Sandstrom constituted 90% of the total phytoplankton population. Other phytoplankton groups that contributed to the bloom population included *Chaetoceros* spp., *Pseudo-nitzschia* spp., *Rhizosolenia* spp., *Coscinodiscus* sp., *Leptocylindrus danicus, Thalassiosira* sp., and *Bacteriosira* sp. Among these *Pseudo-nitzschia multiseries*, a toxic species with the ability to produce potent neurotoxin domoic acid, was observed with a cell density of 4 × 10^3 cells l^{-1}. Surface chlorophyll *a* concentration of the bloom region was 14.1 μg l^{-1}. Nutrient concentrations of the bloom area were 0.01 μmol l^{-1} for NO_2-N, 0.1 μmol l^{-1} for NO_3-N, 0.83 μmol l^{-1} for PO_4-P and 11.44 μmol l^{-1} for SiO_4.

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INTRODUCTION

Phytoplankton play an important role as primary producers in marine ecosystems and they form the basis of the marine food chain. When environmental conditions are favourable these microalgae can proliferate into enormous concentrations (up to one million cells l^{-1}) and obviously discolour the surface of the sea. These natural phenomena are termed "Harmful Algal Blooms" (HABs) or "Red tides". International Council for the Exploration of the Seas (ICES, 1984) has defined the phytoplankton blooms as those which are noticeable, particularly to the general public, directly or indirectly through their effects such as visible discolouration of water, foam production, fish or invertebrate mortality, or toxicity to humans. According to Sournia (1995), of the 5000 known microalgae species only 300, are so far identified to produce HABs constituting about 6 - 7% of the whole. Of these, only 1.8 to 1.9% has been so far identified to be toxic. About 73-75% of these known toxic species are dinoflagellates, followed by diatoms. *Pseudo-nitzschia* is the only diatom genus known to produce the potent neurotoxin domoic acid (DA) (Bates et al. 1998). Domoic acid enters the food chain through filter feeding organisms such as shellfish or finfish and undergoes bioaccumulation, reaching the higher trophic levels and causing Amnesic Shellfish Poisoning (ASP) in humans.

The west coast of India is one of the most biologically productive areas of the world oceans. The biological productivity of the area is influenced by the seasonally reversing monsoon systems, southwest monsoon (June- September) and northeast monsoon (November- February). Phytoplankton blooms triggered by upwelling influenced eutrophication is common in world oceans (Kudela et al. 2005), and also along the west coast of India (Banse et al. 1996). Since 1998, as a part of the regular monitoring of the algal blooms in the Indian Exclusive Economic Zone, Ministry of Earth sciences, Government of India have been conducting regular oceanic cruises for the study of HAB dynamics in the Indian EEZ. There are many available reports on the dinoflagellate and cyanobacterial blooms in the Indian EEZ (Prakash and Sarma 1964; Devassy et al. 1978; Katti et al. 1988; Naqvi et al. 1998; Jyothibabu et al. 2003; Anoop et al. 2007; Helga et al. 2008; Padmakumar et al. 2010, 2011), but diatom blooms are rare and are represented by *Coscinodiscus* sp., *Fragilaria* sp., *Asterionella japonica* and *Hemidiscus* sp. (Subha Rao 1969, Subramanian and Purushothaman 1985, Panigrahy and Gouda 1990, Mishra and Panigrahy 1995). The present study reports the occurrence of a multi-species diatom bloom dominated by *Proboscia alata* and highlights the prevalence of toxin producing diatoms in the coastal waters along the southwest coast of India.

Fig. 1. Map showing the study area. (●) represents the area where the multispecies diatom bloom was observed.

MATERIALS AND METHODS

In connection with the monitoring and surveillance of HABs along the southwest coast of India onboard *FORV Sagar Sampada*, a multi-species diatom bloom which caused a pale green discoloration of the sea surface was observed off Kannur (Lat. 11°59.471 N, Long. 75°03.446 E, Fig. 1), on 28th September 2009. For the qualitative and quantitative analysis of phytoplankton, about 50 litres of discoloured surface water were collected using a clean plastic bucket and filtered through 20 µm bolting silk. The filtrates were preserved in 1-3% neutralized Formalin- Lugol's iodine solution. Quantitative analysis of the phytoplankton was done using a Sedgwick-Rafter counting chamber under a *Nikon Eclipse* microscope. Standard identification books and keys were used for the species level identification of diatoms (Cupp 1943, Hasle and Syvertsen 1997, Hasle 1995). Temperature and salinity of the sampling stations were recorded using a *Seabird 911 plus CTD*. The sea surface temperature (SST) was measured using a bucket thermometer. Salinity values from the CTD were calibrated against the values obtained using the *Guildline Autosal* onboard. Dissolved oxygen was estimated following the Winkler method (Gaarder and Gran 1927). Chlorophyll *a* was determined by filtering one litre water through GF/F Whatman filter paper. Filter papers with filtrates were placed in extraction vials containing 10 ml of 90% acetone. The extractions were performed at cold temperatures in the dark over a 24 hour period. Chlorophyll *a* was measured spectrophotometrically (*Thermo UV1*) according to the methods described by Parsons et al. (1984). Nutrients (nitrate, phosphate and silicate) were analysed using a segmented flow Auto Analyzer (*SKALAR*) onboard the vessel following standard procedures (Grasshoff et al. 1983). Meteorological parameters were obtained via a continuous Automated Weather Station (*AWS*).

Mesozooplankton samples were collected from mixed layers using the Multiple Plankton Net (*Hydrobios*) and from the surface using Bongo nets. The samples were preserved in 4% formalin prepared in sea water after determining the biomass by displacement volume method.

Results And Discussion

From the microscopic analysis of the bloom sample it was observed that the genus *Proboscia* (= *Rhizosolenia*) was the dominant constituent of the bloom area and was represented by *Proboscia alata* (Brightwell) Sandstorm, *Rhizosolenia calcar-avis* and *R. formosa* (Fig. 2). Total diatom cell density of the bloom area was 16 × 10^4 cells l^{-1} and *Proboscia alata* constituted 90% of the total phytoplankton population with a cell density of 13 × 10^4 cells l^{-1} (Fig. 3). Other diatoms were represented by the genus *Chaetoceros*, *Pseudo-nitzschia, Coscinodiscus, Leptocylindrus, Bacteriosira and Thalassiosira*. Several species of *Rhizosolenia* have been reported as producers of important blooms in different areas of the world (Jordan and Priddle 1991, Jordan et al. 1991, Garate Lizarraga et al. 2003) and some of them form macroscopic aggregations up to 30 cm in size (Shipe et al. 1999). Dinoflagellates were scarce and were represented by *Pyrophacus steinii*. These levels of microalgal abundance and biomass are typical of the summer diatom blooms in this region. In the phytoplankton composition of the bloom area, the toxic diatom genus *Pseudo-nitzschia* was present with cell density of 4 × 10^3 cells l^{-1}. The genus *Chaetoceros* was represented mainly by *C. decipiens, C. coarctatus, C. didymus* and *C. compressus* (Fig. 4).

The physico-chemical parameters of the bloom area were conducive for the formation of a diatom bloom. The sea surface temperature was about

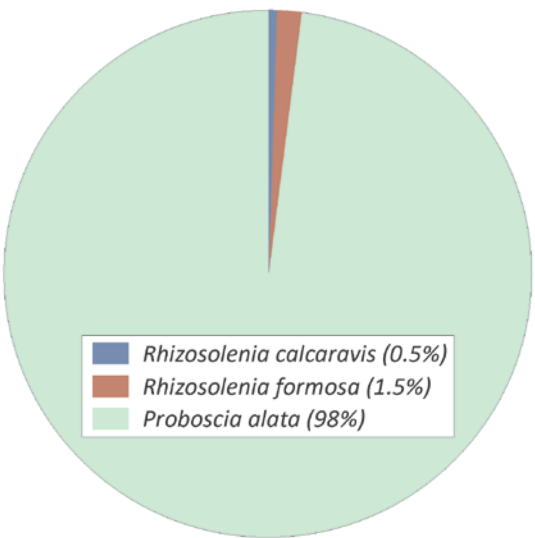

Fig. 2. Percentage composition of the genus *Rhizosolenia* in the bloom area.

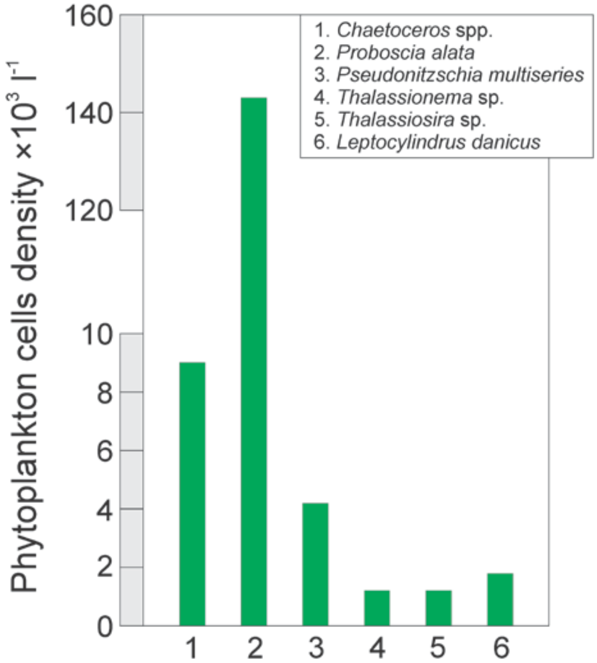

Fig. 3. Cell density of phytoplankton in the bloom area.

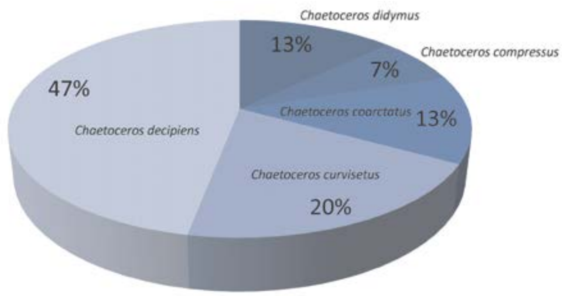

Fig. 4. Percentage composition of the genus *Chaetoceros* in the bloom area.

24.5°C and salinity 34 PSU. Low dissolved oxygen concentration was observed in the surface waters, 3.4 ml l^{-1}, which decreased further in subsurface layers (0.5 ml l^{-1}). Surface nutrient levels in the bloom region showed lower values for nitrate (0.1 μmol l^{-1}), and high concentrations of phosphate (0.4 μmol l^{-1}) and silicate (11.4 μmol l^{-1}). The vertical distribution of temperature, salinity, nutrients, and chlorophyll *a* is presented in figure 5. With increase in depth, the nutrient concentration tends to decrease, except for nitrate which has a peak value in the subsurface waters. The chlorophyll *a* concentration in the bloom region was as high as 14 μg l^{-1} in the surface waters and approximately 9.8 μg l^{-1} in the subsurface waters.

The major secondary producers in the bloom area were polychaete larvae, chaetognaths,

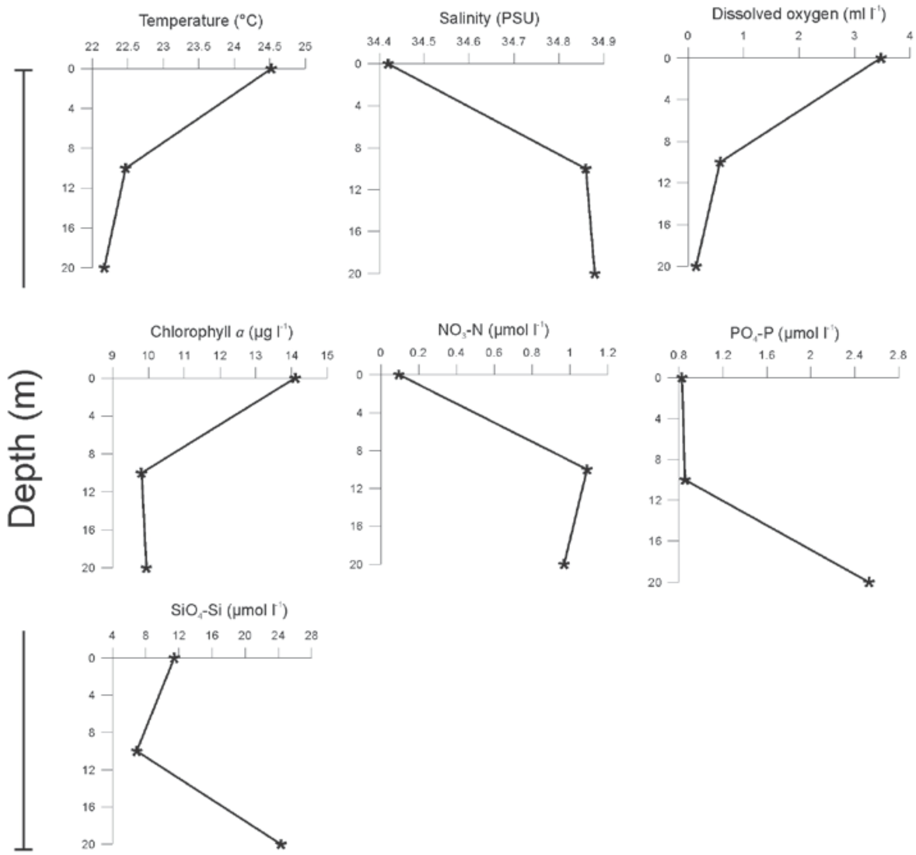

Fig. 5. Vertical distribution of temperature, salinity, dissolved oxygen, chlorophyll *a*, nitrate, phosphate, and silicate in the bloom area.

siphonophores and doliolids. Among these Polychaete larvae formed about 62% of the total population (Fig. 6). Upon detailed evaluation it became clear that the common zooplankton groups such as copepods, decapod larvae and fish larvae are very few in the bloom area. Low dissolved oxygen in the area might have limited the number of secondary producers. Moreover, exclusion of these forms due to inhibiting effects of the diatoms may also have restricted their occurrence. Poulet et al. (1994) have generalized from experimental evidence that diatoms have evolved an allelopathic, antipredation strategy by which they reduce copepod population levels by inhibiting their reproductive success. *P. alata* is known to perform vertical migration across the water column, thereby utilizing nutrients present in the deeper waters, especially nitrate when it is scarce in the surface waters (Villareal et al. 1993, 1999).

Although *P. alata* dominated this multi-species diatom bloom, *Pseudo-nitzschia* spp. was also present in a significant cell density. Several species of *Pseudo-nitzschia*, mainly *Pseudo-nitzschia multiseries* (Hasle) Hasle are known to produce the potent toxin domoic acid and were identified among the bloom population. The phytotoxin produced undergoes bioaccumulation through the food chain and causes Amnesic Shellfish Poisoning (ASP). According to Todd (1993), these species are responsible for human fatality due to Amnesic Shellfish Poisoning (ASP) resulting from the HAB. Shellfishes and some finfishes filter these diatoms from water and these toxins tends to accumulate in their viscera, causing risk to the human consumers. ASP is characterized by gastrointestinal and neurological disorders in human beings. Recent study on the toxic phytoplankton species along the coastal waters along Goa (Alkawri and Ramaiah 2011) also revealed the presence of potentially toxic species of *Pseudo-nitzschia* and *P. pungens*. In the current bloom area though the cell density of *Pseudo-nitzschia* was lower than that of *Proboscia alata*, but when favourable conditions persist they can break out into intense blooms causing

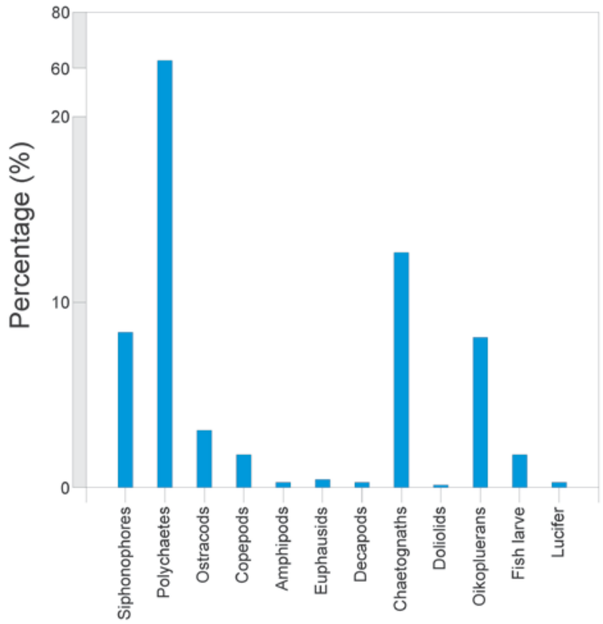

Fig. 6. Percentage composition of various zooplankton groups in the bloom area.

deleterious effects. The southwest coast of India, mainly the Malabar Coast, is a well-known finfish and shellfish harvesting area. Hence, the prevalence of such toxic strains of phytoplankton which can cause finfish and shellfish toxicity requires special attention.

CONCLUSION

Mixed diatom blooms occur in coastal waters because of the increased nutrient inputs due to physical processes like upwelling, terrigenous sources through river runoff. Certain diatoms, mainly some species of *Pseudo-nitzschia*, are known to produce potent neurotoxins and were identified in the coastal waters off Kannur along the southwest coast of India. Since this area is an active fishing zone, such blooms are of great concern. The consequences of harmful algal blooms are potentially significant and varied, affecting the entire trophic mechanism. Globally, occurrences of algal blooms are increasing. Even if some of the increase can be attributed to increased monitoring and a change in scientific focus, anthropogenic influences like coastal pollution and increased use of fertilizers, which reach coastal waters through river runoff, alters the marine ecosystem and favour the outbreak of algal blooms.

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