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Prevalence of non toxic and harmful algal blooms along Kerala coast

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The oceans are home to thousands of microscopic algae which constitute the base of the marine food web. These phytoplankton are essential for the production of biomass at all levels of the food web and thus play an important role in ocean's ecology. Beneficial phytoplankton blooms defined as –'a significant population increase during which the bloom and the subordinate species within the community have equivalent ecological and physiological valence', are thus intrinsically beneficial to food web processes as they channel carbon or energy into the marine food web. There are, however a few dozen of algal species whose blooms are associated with some adverse impacts. According to International Council For the Exploration of Seas (1984), exceptional blooms have been defined as 'those which are noticeable, particularly to the general public, directly or indirectly through their effects such as visible discolouration of the water, foam production, fish or invertebrate mortality or toxicity to humans'. Species abundance data is considered crucial, as it gives valuable information on quantitative and qualitative changes in the relative frequency of occurrence of exceptional/ harmful algal species.

Study Site

A continuous study is thus essential for understanding the bloom dynamics of a region. A continuous and regular phytoplankton monitoring was done at two sites, one each along the north and south coasts of Kerala. Sites were selected on the basis of previous records of harmful algal bloom occurrences. Vizhinjam in Trivandrum district, situated in the extreme southwest coast of India (Lat 8^0 22' N, Long 76^o 56' E) was selected as sampling station along south Kerala. A natural bay (Vizhinjam bay) is present in the region formed by two rock promontories, Mathalipuram on the west and Kottapuram in the east, which makes the area an enclosed water body facilitating fishing and mariculture operations. Samples were collected from two sites at Vizhinjam, one from within the bay and the other from the adjacent sea. Chombala in Calicut district (Lat 11^0 43' N, Long 75^o 33' E) was selected as the sampling site in the north coast of Kerala. Samples were collected from a depth of 8 meters at a distance of about 3 kilometers from the shore, at Chombala and Vizhinjam sea. In the bay, the depth was 6 meters. Sampling was done at a monthly frequency at both these stations for a period of two years, Chombala from October 2001 to September 2003 and at Vizhinjam from October 2001 to August 2003. Sampling could not be done during September 2003 at Vizhinjam, as the sea was very rough due to northeast monsoon winds.

Harmful algae in the community

Twelve species with known records of toxicity- *Noctiluca scintillans, Gymnodinium mikimotoi*, *Prorocentrum lima, Prorocentrum micans, Dinophysis caudate, Dinophysis acuminata*, *Dinophysis miles, Pseudo-nitzschia* sp, *Pseudo-nitzschia pungens, Chattonella marina, Ceratium fusus* and *Trichodesmium* sp. were identified to occur along the Kerala coast. Of these *Prorocentrum lima* and *Chattonella marina* were unique to Chombala and *Ceratium fusus* and *Dinophysis miles* to Vizhinjam.

Pseudo- nitzschia spp., a major causative agent in Amnesic Shellfish Poisoning (ASP) was also noted at both the sites. Mouse bioassay showed the presence of a water soluble toxin in the month in which the species was present in the community.

Occurrence of algal blooms

Seventeen algal blooms were recorded along the Kerala coast during the study period. At Chombala, there were 9 algal blooms of which 7 were diatom blooms. Two of them were caused by the species *Coscinodiscus asteromphalus* (53,000 and 4,10,000 cells l^{-1}), and one each by *C.janischii* (35,000 cells l^{-1}), *Thalassiothrix frauenfeldii* (88,500 cells l^{1}), *Thalassionema nitzchioides* (3,75,600 cells l^{-1}) and *Pleurosigma normanii* (26,40,000 cells l^{-1}) and 2 due to the harmful alga *Chattonella marina* (17 $x10^4$ and $13.5x10^6$ cells l^{-1}).

In the coastal waters of Vizhinjam, 7 blooms were recorded, of which 6 were diatom blooms. Three of the blooms were caused by *Chaetoceros curvisetus* ($1x10^5$ –$1.82x10^7$ cells l^{-1}) and one each by C*. eibinii* (82 to $85x10^5$ cells l^{-1}), *Fragilaria oceanica* (46,000 and 498000 cells l^{-1}) and *Coscinodiscus sublineatus* (82,850 and 128500 cells l^{-1}) and one harmful bloom caused by the dinoflagellate *Noctiluca scintillans* (102000 and 55000 cells l^{-1}). The harmful dinoflagellate *D. caudata* formed 23 % of the phytoplankton community at Vizhinjam in December 2001, but no casualties were reported.

A massive bloom of *Chattonella marina* with high density of 4.68 x 10^{5} cells l^{-1} was recorded for the first time from Narakkal region along Vypin island, central Kerala. Bloom of *Noctiluca scintillans* (98,000 cells l^{-1}) and associated mortality, especially of bivalves was recorded at Thankassery bay, a semienclosed man made bay along south Kerala in October 2002. At both the stations, it was noticed that the dominant members of the phytoplankton community of the region, the diatoms, bloomed first utilizing the favourable conditions. The diatom *Coscinodiscus asteromphalus* blooms at lower temperatures, <31^{0}C and salinity, <33 ppt. Rather than a definite range, the bloom was found to be stimulated by a sudden lowering of both the parameters associated with rainfall. Cell densities were highest when the temperatures was the lowest, 27^0 C. Nitrate and phosphate were higher, with dissolved inorganic phosphate between 0.4 to 3 μmol l^{-1} and dissolved inorganic nitrate between 2.8 and 23.02 μmol l^{-1}. Associated with the bloom, an increase in TSS levels (10.4- 50.2mg l^{-1}) and a decrease in dissolved oxygen levels (3.26- 4.83 mg l^{-1}) were observed.

Pennate diatoms *Thalassiothrix frauenfeldii, Asterionella japonoica, Thalassionema nitzschoides, Pleurosigma normanii* were found to bloom at lower temperatures (<30^{0}C), but at higher salinities (30 to 36 ppt) and had an absolute requirement for phosphate (>1.25 μmol l^{-1}) as indicated by the triggering of the bloom when there was an addition of phosphate to the system. An increase in nitrogen source was not found essential. *Fragilaria oceanica* bloomed when phosphate was higher than. 2.5 and nitrate between 10.16 to 19 μmol l^{-1} respectively.

Chaetoceros, the most frequent bloomer at Vizhinjam was found to prefer lower temperatures (27-28^{o}C), but higher salinities (34-35 ppt), had a lower requirement for nutrients but bloomed whenever there was a slight increase in nutrients, in either nitrate or phosphate. At Vizhinjam, the species bloomed when the dissolved inorganic nitrogen was between 0.06 to 11.68 μmol l^{-1} and dissolved inorganic phosphate between 0 to 1.41 μmol l^{-1}. Decrease in surface temperature, increase in surface salinity and an increase in nutrients especially that of phosphate following monsoon and upwelling led to the blooming of *Chaetoceros curvisetus*. A lesser temperature led to the replacement of this species and blooming of another, *C.eibinii*. A further increase in nutrient concentration was followed by the bloom of the diatom *Fragilaria oceanica* succeeded by *Coscinodiscus* and then when the nutrient levels were low, *C. curvisetus* bloomed. *Noctiluca scintillans* was recorded at Chombala, Vizhinjam and Thankassery bay. It was present in low densities at Chombala (100 to 142 cells l^{-1}) but reached bloom densities at Vizhinjam and Thankassery bay (1,02,000 and 98,000 cells l^{-1}). Abundance of diatoms, its main food and stable weather with high temperatures led to its bloom. At Vizhinjam and Thankassery, the species bloomed when the concentration of nitrate was high>15 μmol l^{-1}. Along the Calicut coast, the bloom of *Chattonella marina* was observed in the transition period between SW and NE monsoon indicating a well-defined periodicity and annual rhythm in appearance. The annual cycle of occurrence of the alga is controlled by the formation of cyst and its germination. The excystement of cysts showed a strong correlation with temperatures and the vegetative cells remained in bloom condition as long as a higher temperature was maintained, perishing with the lowering of temperature associated with the onset of NE monsoon.

The phytoplankton blooms in the study sites were found to have two definite pattern, a restricted seasonal occurrence as exemplified by marine diatoms that dominate spring blooms and a non seasonal increase in densities of dinoflagellates in response to short term events such as sunny calm weather that establishes thin upper layer within which motile species accumulate. *Noctiluca* blooms always followed diatom maxima and stable weather. *Chattonella marina* illustrated a different seasonal pattern similar to that of dinoflagellates but the bloom occurs by the excystment of cysts which is triggered by an increase in water temperature and is known to be genetically controlled.

Mass mortality of fishes was observed in the region between Puthiyappa and Kappad during the bloom of *Chattonella marina* in September 2002. Major fishes which were killed include *Epinephelus spp, Otolithes* sp, *Cynoglossus* sp and *Johnius* sp. Subsequent to this, mass mortality of green mussels of the region was also observed. Besides fishes and mussels, the mole crab *Emerita spp* and the bivalve *Mactra violacea* also suffered severe mortality. Low dissolved oxygen (0.22 mg/l), low pH (7.05) and the production of a lipid soluble toxin were the major reasons for the large scale mortality during the *Chattonella marina* blooms.