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A bloom of invasive marine Haptophyta, *Phaeocystis globosa* from the Manapad estuary, Gulf of Mannar, South east coast of India

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ABSTRACT

A slimy bloom of the marine Haptophyta, *Phaeocystis globosa* was newly recorded in the Gulf of Mannar, near Manapad coast during the summer season (May-June 2012). The cells were generally in colonial form, embedded with in a gelatinous matrix. The intensity of the bloom was as high 2,96,040 colonies/l. The photosynthetic pigment chlorophyll 'a' ratio varied from 138±145 µg/l. The physical and chemical parameters including salinity, temperature, pH, nutrients and dissolved oxygen were evaluated along with *Phaeocystis* data. In this study, nitrite, nitrate, inorganic phosphate, ammonia was also determined as following ranges 0.454±0.544, 1.16±3.42, 6.70±13.70, and 0.13±0.36 and 5.8±23.30 µg/l respectively. The previous report revealed that the occurrence of *Phaeocystis globosa recorded* in the mid-region of Arabian Sea. Therefore, the present study was proved that this is the first report on the occurrence of *Phaeocystis bloom* from the Gulf of Mannar waters and concluded that this species might be introduced by ballast discharge and adapted to new environments due to anthropoid influence. This newly recorded species is highly deserved for further study.

Introduction

Phaeocystis is nontoxic algal species often causing substantial blooms in the pelagic and benthic region of the ocean (Eilertsen and Raa, 1995; Stabell et al., 1999; Hamm, 2000). *Phaeocystis* is a genus of the family Prymnesiophyta (or Haptophyta) has eurythermal and euryhaline nature, usually distributed from polar to temperate seas (Lancelot et al., 1987; Gibson et al., 1990; Wassmann et al., 1990; Chen et al., 1999; Verity et al., 2007). In some occasional it was recorded in the warmer seas (Al-Hasan et al., 1990).

The causative agent of these toxic blooms has a polymorphic life cycle involving both colonial and flagellated cells. *Phaeocystis globosa* species transform from a tiny single-celled morphotype into a colonial stage in which hundreds or thousands of cells are embedded with in a gelatinous matrix and protected behind an elastic but solute-permeable community membrane in colonial stage. The flagellated cells are motile with 3–8 mm, each cell possessing two almost equal flagella and a short haptonema. These almost mono specific blooms (Lancelot et al., 1987) have a great impact on the local marine food web because; they produce the bulk of the primary production in spring time (Arrigo et al., 1999; DiTullio et al., 2000; Schoemann et al., 2005. At sufficiently high concentrations, colony blooms have been associated with a variety of ecosystem changes and negative effects on fisheries and fish farming (Lancelot et al., 1987; Schoemann et al., 2005) such that blooms of *Phaeocystis* colonies are considered as harmful algal blooms (HABs, e.g., Anderson et al., 1998, Veldhuis and Wassmann, 2005).

Phaeocystis is also a major producer of sulphur compounds (dimethyl sulphide), the gas that lead to ''the smell of the sea'' (Stefels, 2000). As evident in the vast amount of literature available, the main Phaeocystis focus has been on the factors stimulating growth and bloom formation; in particular, nutrients and the role of the gelatinous colonies in the structure and functioning of the ecosystem (Wassmann, 1994; Hamm, 2000). In addition, the average colony size is large enough to escape from predators that normally graze on nanophytoplankton, therefore acting as a second important growth stimulant (Weisse et al., 1994). However some debate arises on the taxonomical identity of various *Phaeocystis* species (Medlin et al., 1995, Vaulot et al., 1994), the most important are *P. pouchetii*, dominant in the northern boreal and polar waters, *P. antarctica*, found in the Southern Ocean and *P. globosa*, a warm water counterpart, found in temperate and at times in tropical waters.

The blooming of this prymnesiophyte is found to be associated with the nutrient enrichment often as a result of anthropogenic inputs into the coastal waters. (Turner et al., 1998; Olsen et al., 2000). There have been 33 cases of algal bloom occurrences reported along the east coast of India dominated by 12 diatom blooms. Among the total blooms, 12 causative bloom species reported. *Asterionella japonica* in Visakhapatnam coastal water (Subba Rao 1969), *Noctiluca scintillans* bloom in the Gulf of Mannar (Gopakumar et al., 2009) and *Trichodesmium erythraeum* (Satpathy et al., 2007; Anantharaman et al., 2010) were the common bloom forming species on the east coast of India. However, interestingly, there is no record so far on the occurrence of *Phaeocystis* bloom in the Gulf of Mannar. The only one record of this species from central Arabian Sea region of Indian waters (Madhupratap et al., 2000). Therefore the present study highlighted the occurrence of *Phaeocystis globosa* in the Gulf of Mannar, south east coat of India, especially in the estuarine mouth water.

Material and Methods

Study area

Manapad is a coastal village in far south Tamil Nadu, India, 11 kilometers from Tuticorin and 12 km south of Tiruchendur. The place is widely familiar because of religious tourism place.

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Manapad is located in the middle of Gulf of Mannar Biosphere Reserve (GOMBR). Many coastal villages occur near Manapad, where the major profession is fishing.

Sample collection

Water and plankton samples were collected during summer season. Water temperature was measured using a standard Celsius Thermometer. Salinity was estimated with the help of a hand – held Refractometer (ATAGO, Japan). The pH was measured using a ELICO Grip pH meter. Dissolved Oxygen was estimated by the modified Winkler's method. Surface water samples were collected in clean polyethylene bottles for the analysis of nutrients, which were kept immediately in an Ice box, and then transported to the laboratory. The collected water samples were filtered by using a Millipore filtering system and then analyzed for dissolved inorganic nitrate, nitrite, and ammonia, reactive silicate, inorganic phosphate, adopting the standard procedures described by Strickland and Parsons (1972) and are expressed in µg/l. Phaeocystis bloom samples were collected by using plankton net (mesh size, 40µm) at the surface layers (Figure 1). The plankton sample were collected and fixed in 5% formaldehyde solution in field. For the identification of species, 1–2 drops of sample were put on a slide, covered with a cover glass and examined under light microscope. The confirmation of algal bloom forming *Phaeocystis globosa* was identified by using the monographs on Carmelo R Tomas, 1997). The bloomed samples of plankton cell counts were performed on Sedgewick- Rafter Counting Slide (Guillard, 1978). Chlorophyll-(90% acetone method) measurements were carried out spectrophotometrically in the laboratory (Strickland and Parsons, 1972) and was expressed in µg /l.

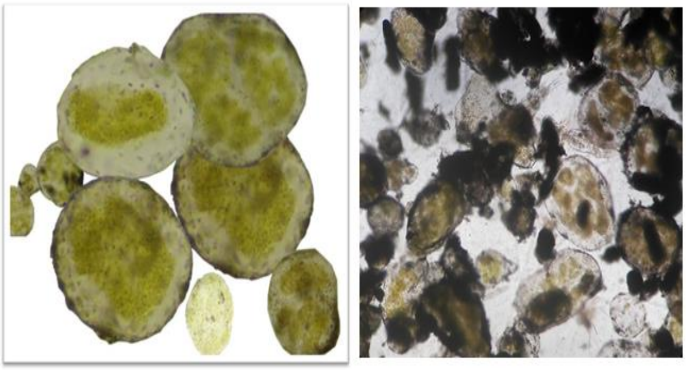

Figure.1a, Spherical *Phaeocystis globosa* colonies attached to larger colony

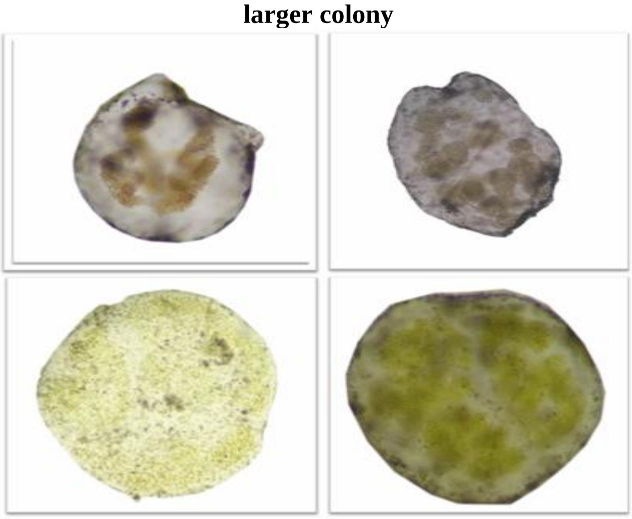

Figure.1b, Light microscopic micrographs of colony stages of *Phaeocystis globosa*

Results and Discussion

The thick green color bloom water of *Phaeocystis globosa* was fist time observed in mouth of Manapad estuary. The cells were mostly in the form of colonies and were embedded in a gelatinous matrix, secreted by the cells themselves. While larger colonies lost their shape due to protection, the smaller colonies showed distinct spherical shape and some of them were found attached to the larger colony matrix (Figure. 1a and b). These blooms have been marked by thick mucus materials that clogged plankton nets during sampling. The mucous, secreted by *Phaeocystis*, is a sticky polysaccharide material and therefore could be found sinking to subsurface layers (~600 m) in the form of large transparent exopolymer particles (Kumar et al., 1998). Production of blooms with a large quantity of mucous materials might adversely affect the biological structure of the region. The minimum numbers of colonies were 4 and maximum number of colonies with in bloomed gelatinous matrix was 17. Also *Phaeocystis globosa* density was 2, 96, 040 colonies/l. However, much lesser value number of cells (10,000 cells per colony) previously reported from the coastal waters of the North Sea (Rousseau et al., 1990). In Arabian Sea report stated that intensity of the *Phaeocystis globosa* bloom had high in 3750×10^6 cells m^{-2} (Madhupratap et al., 2000).

The species *Phaeocystis globosa* usually reported in the temperate region of the world. The temperature ranges and maximum salinity tolerance were found at 4 to 22°C and 40‰ respectively (Jahnke and Baumann 1987; Thomsen 1978). However, the earlier reports revealed that the species observed in various other environmental conditions. Al-Hasan et al., (1990) reported the value of seawater temperature of these species ranges from -2°C, its glacial fact, to an extreme 36°C and *P. globosa,* the salinity range of 36 to 37‰ were found in the Arabian Gulf. The *P. globosa* was able to culture at salinity range from 25 to 50‰ (Stefels 1997), also several studies indicated the *P. globosa* is considered as an euryhaline species (Lancelot et al., 1998). In the present study, the observed water temperature, Salinity and pH was recorded as 27 °C, 39 ‰ and 7.5, respectively (Table 1). These optimum conditions of pH values favored the Phaeocystis bloom in Manapad. On the other hand, dissolved oxygen concentration was obtained 2.8 mg/l, which indicated the higher photosynthetic process of phytoplankton in the surface layer of water during day time. Phaeocystis blooms also associated with the content of Chlorophyll 'a'. The values of Chlorophyll 'a' varies from the range as 0.02 to 1.10 mg m^{-3} and high as 50 mg m^{-3} (Lancelot, 1989; Madhupratap et al., 2000). The present study recorded the Chlorophyll 'a' concentration range was determined as 138±145 µg/l, which well demonstrated the hypereutrophic state of the water in the sampling site.

Thus the Bloom formation of *Phaeocystis* in these ecosystems is mainly caused by riverine inputs of nutrients, i.e. they have an anthropogenic nature (Cadee and Hegeman, 2002) and bloom continents with nutrient enriched waters from Arabian gulf and southeast coastal waters of china (Lancelot et al., 2002; Schoemann et al., 2005). Therefore, this parameter should be considered as an important factor in *Phaeocystis* bloom in the reservoir. Proliferation of a non-siliceous species, *P. globosa* required unbalanced delivery of nutrients compared to phytoplankton N: P: Si requirements (e.g. Billen et al., 1991). The current nutrient enrichment of the estuarine and coastal area is characterized by a large excess of dissolved inorganic nitrogen, mainly nitrate, compared to phosphate and silicate

(Brion et al., 2008). Their peculiar biological and Eco physiological properties make Phaeocystis colonies particularly well adapted to take benefit from the excess nitrate in the low phosphate conditions characterizing the coastal waters (Lancelot et al., 1998; 2002). The present study recorded, the inorganic nutrients such as nitrite, nitrate, phosphate, ammonia were determined with ranged from 0.454±0.544, 1.16±3.42, 6.70±13.70, 0.13±0.36 and 5.8±23.30 μg/l, respectively (Table 1). It is highly attributed the formation of the bloom.

Table 1. The physicochemical and biological parameters of sampling site Parameter

Parameters	Unit
Water temperature	27 °C
Dissolved oxygen	2.8 mg/l
Salinity	39 ‰
pH	7.5
Nitrite	0.454±0.544 μg/l
Nitrate	1.16±3.42 μg/l
Ammonia	6.70±13.70 μg/l
Inorganic phosphate	0.13±0.36 μg/l
Silicate	5.8±23.30 μg/l
Chlorophyll 'a'	145 μg/l
Phaeocystis globosa	2, 96, 040 (Colony/ml)

Carbon sequestration by *P. globosa* is reduced when the bloom develops under the nitrogen limitation, as compared to phosphorus limitation (Mari et al., 2005). It is therefore important to consider the effects of nutrient conditions for predictions of bloom development. The large blooms of *P. globosa* assimilate significant amounts of inorganic carbon into cell material and mucus and may therefore act as a feedback mechanism to increasing carbon concentrations in the atmosphere. *Phaeocystis globosa* is also known for the production of dimethyl sulfonio propionate (DMSP). After release from the cell, part of the DMSP is enzymatically cleaved into dimethyl sulfide (DMS) and acrylate (Stefels et al., 1995; Stefels, 2000). Furthermore, in the atmosphere, the oxidation products of DMS can impact global climate by acting as condensation nuclei, changing the cloud by greenhouse gas, it may locally contribute to acid rain and having a cooling effect on Earth's climate (Charlson et al., 1987; Stefels et al., 1995; Stefels, 2000; Clarke et al., 1998). This gives *P. globosa* an important role in the Earth's sulfur cycle (Schoemann et al., 2005). *Phaeocystis* bloom is known to increase in density over the years (Cadee 1989). Rottenly massive blooms in temperate and polar regions and recent tropical waters recorded of *Phaeocystis* sp species were identified from Mahanadi estuary (Naik et al., 2009), if massive spreads of the coastal waters of India, it may affect the fisheries badly.

Conclusion:

Phaeocystis globosa seems to be a new invasive indication to the coast of Gulf of Mannar, south east coast of India. It might be through ballast water from Tuticorin shipping harbor. Bloom occurs in mouth of the estuary due to the enriched state of nutrient. These areas deserve further research lead to the prevalence of blooms in the estuarine and coastal waters systems, which will provide a wide range of valued ecosystem services. A much better understanding of this invasive species issues is urgently need to conserve the native organisms of the ecosystem.

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