Seasonal Variation of Phytoplankton Community in Navigable Channel of Gopalpur Port, East Coast of India: A Taxonomic Study

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Abstract The aim of this paper is to determine the current biological state of phytoplankton in the pelagic zone of Gopalpur Port navigable channel. The plankton samples were collected from a fixed sampling location in two different tides i.e. high tide and low tide during three different seasons i.e. pre-monsoon, monsoon, and post-monsoon of the year 2010. Ninety four species of phytoplankton were observed, of which diatom constituted 71 species, dinoflagellate 11 species, green algae 8 species and blue green algae (cyanobacteria) 4 species. Comparing the population of all the groups, the contribution of each group of phytoplankton was in the order of diatoms > dinoflagellates > blue green alga > green alga in all the seasons. The population density of phytoplankton ranged from 2360 Nos./L to 53240 Nos./L (avg. 29683 Nos./L). In premonsoon and post monsoon, Asterionellopsis glacialis, an important bloom forming member of diatom group dominated the phytoplankton population. Among these ninety four species, *Asterionellopsis glacialis, Thalassiothrix longissima, Chaetoceros curvisetus, Coscinodiscus gigas, Ditylum brightwellii* were recorded in all the seasons and the other species have shown seasonal variation. The toxic phytoplankton such as *Pseudonitzschia pungens, Dinophysis caudata* were also recorded during our observation. Our study is a first attempt made in this environmentally sensitive region, being sensitive due to coastal erosion, port activities and adjacent mass nesting beach for Olive Ridley sea turtles.

Keywords Gopalpur Port, Phytoplankton, Seasonal Change, Taxonomy

1. Introduction

Phytoplankton are the main primary producers of marine and freshwater ecosystems. They play specific roles in biogeochemical cycling in marine ecosystems. Their roles in calcification, silicification, dimethyl sulphide (DMS) production and nitrogen fixing have been well established. These tiny organisms initiate the marine food chain by the process of photosynthesis and serve as primary food in marine pelagic zone[1]. Phytoplankton, as the basis of the trophic chain, forms the biological community which regulates the food chain for which scientific attention is focused when a management plan is needed or an evaluation of the ecosystem health is required[2-4]. Knowledge on taxonomy of phytoplankton is essential to study the community dynamics in spatio-temporal scale and to characterize it into functional groups[5]. The species composition and population density of phytoplankton are sensitive to environmental changes. Their documentation in relation to dynamic environment is a valuable

characteristic of water quality. Coastal and near-shore waters are more productive regions in the marine environment due to nutrient add by means of regeneration, upwelling and land run-off. Phytoplankton blooms in these waters follow a seasonal pattern that shapes the coastal marine ecosystem. Environmental forcing, nutrient availability, predator communities and land-driven inputs are the major factors that control coastal and near-shore phytoplankton community and blooms[6]. Several anthropogenic factors in these environments can result in alteration of coastal water quality (eutrophication), introduction of non-native species (ballast action), alteration of predator community (overfishing), etc. As a result, non-periodic and exceptional blooms of both non-toxic or toxic phytoplankton species lasting for few weeks to months are frequently reported, influencing the seasonal patterns of dominant phytoplankton community structure, thereby affecting coastal and estuarine biogeochemical processes[7].

In harbour/port areas, the water quality is changing rapidly due to multiple human activities. The phytoplankton due to its importance in food web requires frequent study under such changing of environment. Regular cargo handling, fishing trawler movements and shipping intensification, anthropogenic pollutant influx are the key sources of water

quality alteration that led the scientific community for regular monitoring.
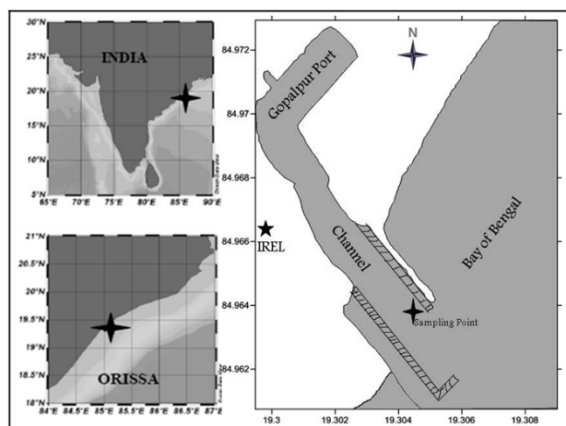

Figure 1. Sampling point in study area marks by asterix

We focus this study as a first attempt in this region to explore the phytoplankton composition in simultaneous seasonal and tidal basis. The outcome of this study will certainly useful for the coastal planners for environmental monitoring and impact assessment work.

2. Materials and Methods

The present research work was carried out on a fixed sampling point ($19^0 18'$ 4.08"N, 84^0 58' 0.64"E) in the navigable channel of Gopalpur Port, a seasonal port of Odisha, East Coast of India. This area (Figure.1) is sensitive due to port activities, and adjacent mass nesting beach for olive Ridley sea turtles. Rainfall of this region is primarily concentrated in Monsoon (South-West), which is the major climatic factor of this region. Though Gopalpur Port is a seasonal port, regular fishing trawler and boat movements are common. The navigational channel selected for this study was due to apprehending future pollution as a result of Petroleum Hydro-Carbon (PHC), oil spills and anthropogenic load of organic and inorganic nutrients.

Sampling was carried out during three seasons i.e. pre-monsoon (PRM), monsoon (MON) and post-monsoon (POM) of year 2010 from a fixed location during high tide and low tide to determine the temporal and tidal variation in phytoplankton composition. Phytoplankton samples were collected from surface and stored in polythene bottles after preservation with Lugol's iodine solution. After concentrating the sample by sedimentation method, 1 ml of sample was taken and examined with a Sedgwick rafter counting chamber under a compound microscope (Nikon Eclipse-E600) with different magnifications. For taxonomical analysis, standard literatures[8-10] were referred.

3. Results and Discussion

A total of 94 phytoplankton species under four different groups were observed during the study, of which diatoms constituted 71 species, dinoflagellates 11 species, green alga

8 species and blue green alga (cyanobacteria) 4 species. Population wise Diatoms evolved as the major phytoplankton group followed by dinoflagellate, green algae and cyanobacteria. The dominance of diatoms followed by dinoflagellates is well reported in coastal waters[11].

In pre-monsoon (PRM) during low tide (LT) among diatoms *Asterionellopsis glacialis* (83.5% of total phytoplankton population) was the dominant species followed by *Coscinodiscus eccentricus* (4.2%), *Coscinodiscus sp.* (1.6%), *Eucampia sp.* (1.6%) etc. Only 3 species of dinoflagellates, namely *Ceratium furca* (0.2%), *Prorocentrum micans* (0.1%) and *Pyrophacus steinii* (0.1%) were found. We observed one species of green algae: *Pediastrum duplex* (3.0%) (Table-3).

Table 1. Density (Nos./L) of different phytoplankton groups in Pre-monsoon, Monsoon and Post-monsoon

Groups	Premonsoon		Monsoon		Post monsoon	
	LT	HT	LT	HT	LT	HT
Diatom	39000	48400	2099	11040	20380	53200
Dinoflagellate	160	1000	-	600	320	40
Green algae	1200	-	218	-	-	-
Blue green algae	-	400	44	-	-	-
Total	**40360**	**49800**	**2360**	**11640**	**20700**	**53240**

- :Absent, LT: Low Tide, HT: High Tide

Table 2. Number of species (Nos.) of different phytoplankton groups in Pre-monsoon, Monsoon and Post-monsoon

Groups	Pre-monsoon		Monsoon		Post-monsoon	
	LT	HT	LT	HT	LT	HT
Diatom	18	26	9	24	21	14
Dinoflagellate	3	3	-	3	4	1
Green algae	1	-	7	-	-	-
Blue green algae	-	1	3	-	-	-
Total	**22**	**30**	**19**	**27**	**25**	**15**

LT: Low Tide, HT: High Tide

In pre-monsoon (PRM) during high tide (HT), among diatoms *Skeletonema costatum* (13.3%) was the dominant species followed by *Chaetoceros constrictus* (12.4%), *Chaetoceros lorenzianus* (7.6%), *Chaetoceros sp.* (7.2%), *Eucampia zoodiacus* (5.2%). Three dinoflagellate species- *Prorocentrum micans* (0.8%), *Protoperidinium sp.* (0.8%) and *Dinophysis caudate* (0.4%) were observed. One species of cyanobacteria *Oscillatoria* sp. (0.8%) was observed (Table-3).

In monsoon (MON) during low tide (LT) among diatoms *Thalassiothrix longissima* (34.5%) was the dominant species followed by *Coscinodiscus gigas* (21.6%), *Surirella sp.* (12.0%), *Synedra sp.* (12.5%). No dinoflagellate species was observed. Highest number of green algae species was observed during this sampling period (Table-2 & 3). The dominant green algae species were *Staurastrum* sp. (2.8%),

Eudorina elegans (2.3%), *Botryococcus* sp. (1.4%). Among cyanobacteria *Phromidium* sp. (0.9%) was the dominant species followed by *Anabaena* sp. (0.5%) and *Spirulina* sp. (0.5%) (Table-3). In monsoon (LT), higher number of green alga and cyanobacteria were observed. The occurrence of freshwater cyanobacteria species - *Anabaena* sp. and *Spirulina* sp. indicates influx of freshwater from inner port area to the channel during low tide due to monsoonal rain.

In monsoon (MON) during high tide (HT) the diatom *Thalassiothrix longissima* (17.9%) was dominant followed by *Chaetoceros* sp. (16.5%), *Coscinodiscus gigas* (12.4%), *Ditylum brightwellii* (11.0%) (Table-3). Dominance of *Thalassiothrix longissima* was previously reported by Paul et al., 2007[12] in central Bay of Bengal. The 3 species of dinoflagellates observed were *Prorocentrum maxima* (2.7%), *Prorocentrum micans* (1.4%) and *Peridinium* sp. (1.0%). No species of green algae and cyanobacteria were observed.

In post-monsoon (POM) during low tide (LT) among diatoms *Asterionellopsis glacialis* (80.0%) was the dominant species followed by *Coscinodiscus eccentricus* (5.6%), *Coscinodiscus* sp. (1.9%), *Biddulphia mobiliensis* (1.7%). Among dinoflagellates, *Ceratium tripos* (0.6%) was the dominant species followed by *Ceratium trichoceros* (0.4%), *Prorocentrum gracile* (0.4%). No species of green algae and cyanobacteria were observed (Table-3).

In post-monsoon (POM) during high tide (HT) the same diatom *Asterionellopsis glacialis* (95.9%) was dominant followed by *Coscinodiscus eccentricus* (1.4%), *Biddulphia* sp. (0.8%), *Thalassiothrix frauenfeldii* (0.5%). One dinoflagellate species *Dinophysis caudate* (0.1%) was observed (Table-3). No species of green algae and cyanobacteria were observed.

In pre-monsoon[HT (83.5%)] and post-monsoon[HT (95.9%) & LT (80.0%)], *Asterionellopsis glacialis* an important bloom forming member of diatom group, dominated the phytoplankton population with more than 80% composition. Previously predominance of bloom forming *Asterionellopsis glacialis* (Figure.2) was reported in estuarine waters of Rushikulya River[13] and coastal waters of Gopalpur[14] close to the study area.

Pollution indicating species from cyanobacterial group *viz*. *Oscillatoria* sp. (Figure.2), *Anabaena* sp. were recorded during high tide (HT) of pre-monsoon and low tide (LT) of monsoon season respectively[15].

As far as seasonal abundance of phytoplankton isconcerned, the trend pre-monsoon (45080 Nos./L) > post-monsoon (36970 Nos./L) > monsoon (7000 Nos./L) was observed (Table-1). Highest abundance of phytoplankton during pre-monsoon season might be due to the dominance of diatoms and the lowest during monsoon might be due to the stratification of water column to a large extent because of heavy rainfall, high turbidity caused by river run-off/land run-off, reduced salinity, decreased temperature and pH, overcast sky and cool conditions[16]. Species composition varied considerably in the three seasons. This might be attributed to change in environmental variables specially nutrients and temperature in different seasons[17][18].

As far as temporal species number is concerned more number of species (tidal mean) were identified during pre-monsoon (26) followed by monsoon (23) and post-monsoon (20) (Table-2). Tidal examination of phytoplankton samples for qualitative purpose revealed that more number of species were abundant during high tide than low tide with an exception in post monsoon.

Table 3.   Phytoplankton species list, abundance (Nos./L) and percentage composition (in bracket) in Pre-monsoon, Monsoon and Post-monsoon

	Pre-monsoon		Monsoon		Post-monsoon	
	LT	HT	LT	HT	LT	HT
DIATOM						
Actinotychus undulatus	-	-	-	-	40 (0.2)	-
Amphiprora gigantea	-	-	-	-	40 (0.2)	80 (0.2)
Amphiprora gigantea	40 (0.1)	-	-	-	-	-
Amphiprora sp.	80 (0.2)	-	-	-	-	-
Amphora lineolata	-	-	-	-	40 (0.2)	-
Asterionellopsis sp.	440 (1.1)	-	-	-	-	-
Asterionellopsis glacialis	33720 (83.5)	-	-	160 (1.4)	16560 (80.0)	51040 (95.9)
Bacteriastrum comosom	-	-	-	120 (1.0)	-	-
Bacteriastrum hyalinum	-	-	-	160 (1.4)	-	-
Bacteriastrum varians	-	1000 (2.0)	-	-	-	-
Biddulphia heteroceros	-	-	-	-	160 (0.8)	-
Biddulphia mobiliensis	400 (1.0)	1600 (3.2)	-	-	360 (1.7)	-
Biddulphia sinensis	40 (0.1)	-	-	-	-	-
Biddulphia sp.	-	-	-	-	-	440 (0.8)
Chaetoceros constrictus	-	6200 (12.4)	-	-	-	-

Chaetoceros curvisetus	-	1200 (2.4)	-	320 (2.7)	40 (0.2)	40 (0.1)
Chaetoceros lorenzianus	-	3800 (7.6)	-	320 (2.7)	-	-
Chaetoceros peruvianus	-	200 (0.4)	-	-	-	-
Chaetoceros socialis	-	3200 (6.4)	-	-	-	-
Chaetoceros sp.	80 (0.2)	3600 (7.2)	-	1920 (16.5)	-	-
Chetoceros diversus	40 (0.1)	-	-	-	-	-
Cocconeis placentula	-	-	44 (1.8)	-	-	-
Corethron hystrix	-	-	-	160 (1.4)	-	-
Coscinodiscus eccentricus	-	-	-	-	1160 (5.6)	720 (1.4)
Coscinodiscus eccentricus	1680 (4.2)	1800 (3.6)	-	-	-	-
Coscinodiscus gigas	240 (0.6)	-	509 (21.6)	1440 (12.4)	-	120 (0.2)
Coscinodiscus sp.	640 (1.6)	-	-	-	400 (1.9)	-
Cyclotella striata	-	2000 (4.0)	-	120 (1.0)	-	-
Cymbella sp.	-	-	98 (4.2)	-	-	-
Diploneis smithii	-	-	-	120 (1.0)	-	-
Diploneis weissflogii	-	200 (0.4)	-	-	-	-
Ditylum brightwellii	160 (0.4)	1400 (2.8)	-	1280 (11.0)	40 (0.2)	-
Ditylum sol	-	400 (0.8)	-	-	-	40 (0.1)
Eucampia sp.	640 (1.6)	-	-	-	-	-
Eucampia zoodiacus	-	2600 (5.2)	-	-	80 (0.4)	-
Guinardia flaccida	-	-	-	-	-	80 (0.2)
Gyrosigma balticum	-	-	-	160 (1.4)	-	-
Leptocylindricus minimus	80 (0.2)	1800 (3.6)	-	320 (2.7)	-	-
Leptocylindrus danicus	-	-	-	160 (1.4)	-	-
Licmophora sp.	-	200 (0.4)	-	-	-	-
Mediopyxis helysia	-	1000 (2.0)	-	-	-	-
Melosira sp.	-	-	-	-	120 (0.6)	-
Melosira sulcata	-	200 (0.4)	-	-	-	-
Navicula heneiydii	-	-	-	120 (1.0)	-	-
Navicula sp.	-	-	33 (1.4)	160 (1.4)	120 (0.6)	-
Nitzschia longissima	-	2400 (4.8)	-	320 (2.7)	-	80 (0.2)
Nitzscia sp.	-	-	22 (0.9)	-	-	-
Pleurosigma directum	-	-	-	-	-	160 (0.3)
Pleurosigma elongatum	160 (0.4)	-	-	-	120 (0.6)	80 (0.2)
Pleurosigma normanii	-	-	-	-	40 (0.2)	-
Pleurosigma sp.	-	800 (1.6)	11 (0.5)	-	-	-
Pseudonitzschia pungens	-	-	-	160 (1.4)	-	-
Pseudonitzschia sp.	-	400 (0.8)	-	-	-	-
Rhizosolenia crasispina	40 (0.1)	-	-	-	-	-
Rhizosolenia imbricata	-	-	-	160 (1.4)	-	-
Rhizosolenia setigera	-	-	-	-	240 (1.2)	-
Rhizosolenia stolterforthii	-	1000 (2.0)	-	-	-	-
Rhizosolenia stylifromis	-	1600 (3.2)	-	-	-	-
Skeletonema costatum	-	6600 (13.3)	-	480 (4.1)	-	-
Surirella eximia	-	-	-	480 (4.1)	-	-

Surirella fluminensis	-	-	-	-	80 (0.4)	-
Surirella sp.	-	-	284 (12.0)	-	-	-
Synedra sp.	-	-	284 (12.0)	-	-	-
Tabellaria sp.	-	-	-	-	120 (0.6)	-
Thalassionema nitzschioides	-	2400 (4.8)	-	-	-	-
Thalassiosira hyalina	-	-	-	160 (1.4)	-	-
Thalassiosira subtilis	-	-	-	160 (1.4)	-	-
Thalassiothrix frauenfeldii	80 (0.2)	-	-	-	280 (1.4)	240 (0.5)
Thalassiothrix longissima	440 (1.1)	800 (1.6)	815 (34.5)	2080 (17.9)	300 (1.4)	40 (0.1)
Triceratium robertsianum	-	-	-	-	-	40 (0.1)
Triceratium sp.	-	-	-	-	40 (0.2)	-
DINOFLAGELLATE						
Ceratium furca	80 (0.2)	-	-	-	-	-
Ceratium trichoceros	-	-	-	-	80 (0.4)	-
Ceratium tripos	-	-	-	-	120 (0.6)	-
Dinophysis caudata	-	200 (0.4)	-	-	-	40 (0.1)
Peridinium sp.	-	-	-	120 (1.0)	-	-
Prorocentrum gracile	-	-	-	-	80 (0.4)	-
Prorocentrum maxima	-	-	-	320 (2.7)	-	-
Prorocentrum micans	40 (0.1)	400 (0.8)	-	160 (1.4)	-	-
Protoperidinium depressum	-	-	-	-	40 (0.2)	-
Protoperidinium sp.	-	400 (0.8)	-	-	-	-
Pyrophacus steinii	40 (0.1)	-	-	-	-	-
GREEN ALGAE						
Botryococcus sp.	-	-	33 (1.4)	-	-	-
Cosmarium sp.	-	-	11 (0.5)	-	-	-
Eudorina elegans	-	-	55 (2.3)	-	-	-
Pediastrum duplex	1200 (3.0)	-	-	-	-	-
Pediastrum sp.	-	-	22 (0.9)	-	-	-
Spondylosium sp.	-	-	22 (0.9)	-	-	-
Staurastrum sp.	-	-	65 (2.8)	-	-	-
Tetraedron sp.	-	-	11 (0.5)	-	-	-
BLUE GREEN ALGAE						
Anabaena sp.	-	-	11 (0.5)	-	-	-
Oscillatoria sp.	-	400 (0.8)	-	-	-	-
Phromidium sp.	-	-	22 (0.9)	-	-	-
Spirulina sp.	-	-	11 (0.5)	-	-	-
Total	40360	49800	2360	11640	20700	53240

Eucampia sp (200X)   *Asterionellopsis glacialis* (400X)   *Coscinodiscus sp.*(100X)

Ceratium furca (400X)   *Ceratium tripos* (40X)   *Prorocentrum micans* (200X)   *Pediastrum duplex* (800X)

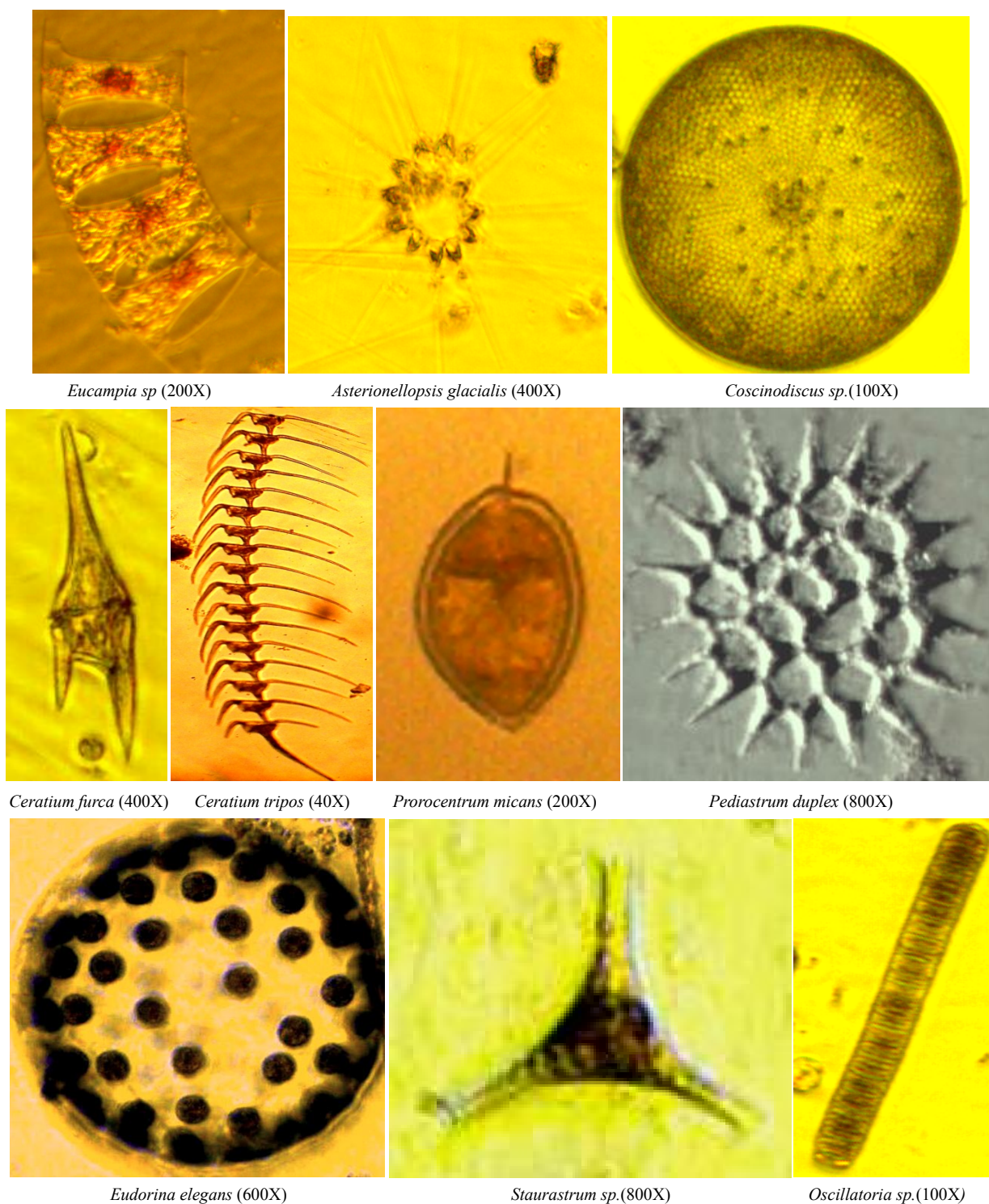*Eudorina elegans* (600X)   *Staurastrum sp.*(800X)   *Oscillatoria sp.*(100X)

Figure 2. Some important dominant phytoplankton species

As phytoplankton species composition determines the health of the food chain, our result depicts a healthy condition of the surrounding environment. Diatom dominance without any bloom can be treated as a major stable result for justifying the healthy condition. Presence of few toxic species is normal in occurrence in a port environment. The outcome of the present study will serve as baseline data to carry out future environmental impact assessment (EIA) studies for both existing port and another adjacent major all weather port under construction.

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