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Diversity and Distribution of Marine Phytoplankton along the Coastal Areas of Gujarat, India

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***Abstract*—** Phytoplanktons are the primary producer of marine ecosystems and contribute to the primary productivity of aquatic environment. The present study was carried out at 16 different locations of Gujarat coast to ascertain the diversity & distribution of marine phytoplankton. During the study, a total 122 species of phytoplankton belonging to five different classes namely Bacillariophyceae, Cyanophyceae, Miozoaphyceae, Chlorophyceae and Charophyceae were reported from coastline of Gujarat. Of this, the highest species diversity was found at Gulf of Kachchh followed by Gulf of Khambhat > Saurashtra coast > South Gujarat coast. The maximum number of species diversity was contributed by the class Bacillariophyceae (87%) with 106 species; while the least number of species was recorded for the class Charophyceae (1 species).

Keywords— Phytoplankton, Primary productivity, GoK, Gulf of Khambhat, Saurashtra, South Gujarat, algal bloom, coastline

I. INTRODUCTION

Phytoplanktons are the autotrophic (self-feeding) components of the plankton community and a key part of oceans, seas and freshwater ecosystems. The name phytoplankton comes from the Greek words: *phyton*, meaning "plant" and *planktos*, meaning "wanderer" or "drifter". They cannot be seen with naked eye. Phytoplanktons are the foundation of the aquatic food web as they are the primary producers [1]. In the oceans phytoplankton contributes to roughly half of the planetary net primary production [2]. Therefore, phytoplankton are of great significance. The habitat of phytoplankton includes fresh water, brackish water, estuarine water, saltpan and moist soil etc. Phytoplanktonic species are also indicators of environmental changes, and long-term time-series are effective tools to evaluate and understand these changes [3]. Phytoplankton requires inorganic nutrients such as nitrates, phosphates, and sulfur which they convert into proteins, fats, and carbohydrates. A common feature of all phytoplankton is that they contain chlorophyll-a; but there are other accessory pigments such as chlorophyll-b and chlorophyll-c, as well as photosynthetic carotenoids [4, 5]. Through sinking of the fixed organic matter, primary production acts as a biological pump that removes carbon from the surface ocean, thereby playing a global role in climate change [6]. The excessive load of organic pollutant and agriculture runoff results in an algal growth in fresh water or marine water systems, which give rise to many other problems such as harmful algal bloom, eutrophication etc. Harmful algae bloom result in growth of toxin producing algae which hamper the growth of other life form. [7]. Eutrophication (enrichment of water-body with minerals and nutrients which induce excessive growth of algae) is often induced by the discharge of nitrate or phosphate-containing detergents, fertilizers, or sewage into an aquatic system which obstruct the solar radiation. It has detrimental effect on ecosystem. Hence, the study of phytoplankton is very important in ascertaining the health of an ecosystem.

II. MATERIAL METHODOLOGY

Study area:
Gujarat, on the west coast of India has the longest coastline (~1600 km) among all the maritime states of India. Gujarat coast provides a wide variety of coastal features due to its varied physiographic, geomorphology and coastal processes. Saurashtra coast is less indented and moderately straight. From Gopnath point to Diu towards the west, numerous cliffs, mudflats, beaches, estuaries and embayment are seen. The coastline of Gujarat is mainly divided into four segments including two Gulfs;

I. Gulf of Kachchh (GoK): It lies between 22°15' to 23°40'N latitude and 68°20' to 70°40'E longitude. The gulf is an east-west oriented indentation between Saurashtra and Kachchh peninsulas. The GoK is bordered by Kachchh district in north and Jamnagar district, Devbhumi Dwaraka in south with Morbit district covering a little portion of the gulf in its eastern side. Coral reef ecosystem, Marine National Park and Sanctuary, Great and Little ran of Kachchh, Mangrove ecosystem, Sea grass beds and algal communities are the major characteristics of Gulf of Kachchh [8].

II. Saurashtra coast: Encircled by the open sea, the Saurashtra coast is situated between two Gulfs (Latitude 22°15' to 20°50'N and Longitude 68°58' to 71°30' E). It is further divisible into two segments namely the south-western coast of Dwarka- Diu facing the Arabian Sea and the south eastern coast of Diu-Bhavanagar. The Dwarka-Diu segment comprised of smooth and straight sandy beaches whereas the other segment i.e. Diu-Bhavnagar shows a transition from open sea to gulf environment between Diu and Talaja [9].

III. Gulf of Khambhat: The Gulf of Khambhat is south to north penetration of the Arabian Sea on the western shelf of India between the Saurashtra peninsula and mainland Gujarat. It is located approximately between 20°30' – 22°20' North latitude and 71°45'-72°53' E longitude. The gulf is intercepted by several inlets of major rivers such as Narmada, Tapi, Mahi, Sabarmati, Shetrunji, and other minor rivers. Extensive mudflats, estuaries and creeks with high regime, large quantities of sediment transport characterize the Gulf of Khambhat [8].

IV. South Gujarat Coast: South Gujarat coastline is situated around 20°30' and 20°07' N – 72°50' E. This region of Gujarat coast has smaller stretch of coastline passing through only Surat, Navsari and Valsad districts and is characterized by high tidal amplitude of 8 to 10 meters [9].

The present study was carried out at 16 locations of Gujarat coast. Table 1 illustrate the GPS locations of sampling sites (n=16) and Fig. 1 depicts the map of sites selected for collection of samples.

Sampling: The plankton samples were also collected on bi-monthly basis from selected sites by horizontal towing of plankton net (20 µ) and preserved in 4% formalin for further analysis. The light microscope (made: Gippon) was used for identifying major taxonomic groups of plankton. The phytoplankton were identified by using the available books and literature [10, 11].

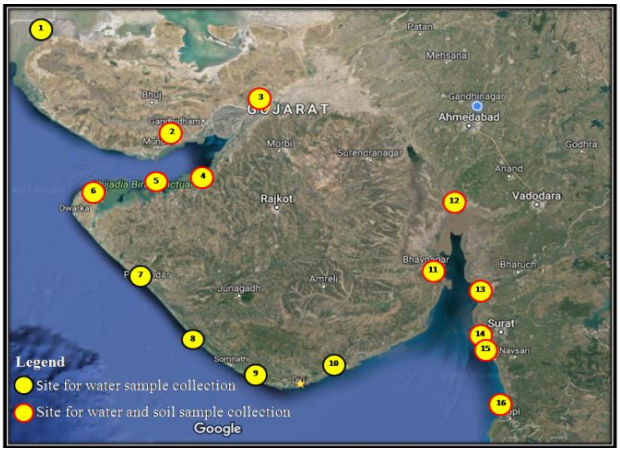


Figure. 1. *Map showing selected sampling sites for plankton sample collection along the Gujarat Coast (Google earth image)*

Table : 1 *Sample collection sites for water and soil of intertidal areas along the Gujarat Coast*

Site No.	Coastal areas	Site	
		Name	GPS location
1.	Gulf of Kachchh	Koteshwar	23° 41′ 532″N; 68° 31′ 564″ E
2.		Bhadreshwar	22° 52′ 597″N; 69° 53′ 942″ E
3.		Surajbari	23° 11′ 411″ N; 70° 43′ 006″ E
4.		Khijadiya	22° 31′ 205″ N; 70° 07′ 599″ E
5.		Narara	22° 29′ 001″ N; 69° 42′ 580″ E
6.		Poshitra	22° 24′ 086″ N; 69° 12′ 215″ E
7.	Saurashtra coast	Harsiddh	21° 50′ 054″ N; 69° 21′ 423″ E
8.		Mangrol	21° 05′ 493″ N; 70° 06′ 436″ E
9.		Mul Dwarka	20° 45′ 245″ N; 70° 39′ 342″ E
10.		Jafrabad	20° 51′ 263″ N; 71° 23′ 015″ E
11.	Gulf of Khambhat	Ghogha	21° 40′ 195″ N; 72° 17′ 132″ E
12.		Vadgam	22° 16′ 716″N; 72° 27′ 199″ E
13.		Katpore	21° 31′ 564″ N; 72° 44′ 312″ E
14.		Dumas	21° 04′ 766″ N; 72° 42′ 419″ E
15.	South Gujarat	Borsi	20° 55′ 758″ N; 72° 46′ 188″ E
16.		Udwada	20° 28′ 006″ N; 72° 51′ 299″ E

III. RESULTS

The phytoplankton community was represented by a total of 122 species belonging to 64 genera, 53 families, 38 orders, 8 classes, 5 phyla and 3 kingdoms from the Gujarat coastline (Fig 2).

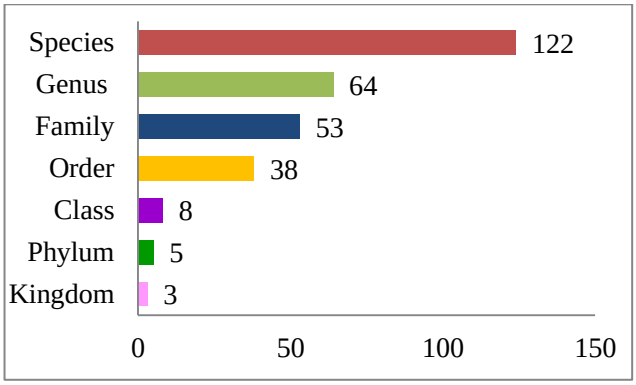


Figure. 2 *Composition of Phytoplankton of the coastal area of Gujarat*

The location wise number of phytoplankton species is given in Fig. 3. Among all the sites, the highest number of species were recorded from Poshitra followed by Borsi > Vadgam > Narara> Muldwarka ≥ Katpore > Mangrol > Surajbari > Harsidh > Gogha > Khijadiya ≥ Udwada > Koteshwar > Dumas > Bhadreswar ≥ Jafrabad. The least

number of species were found at both Bhadreswar and Jafrabad. The site-wise occurrence of phytoplankton species is given in table 2.

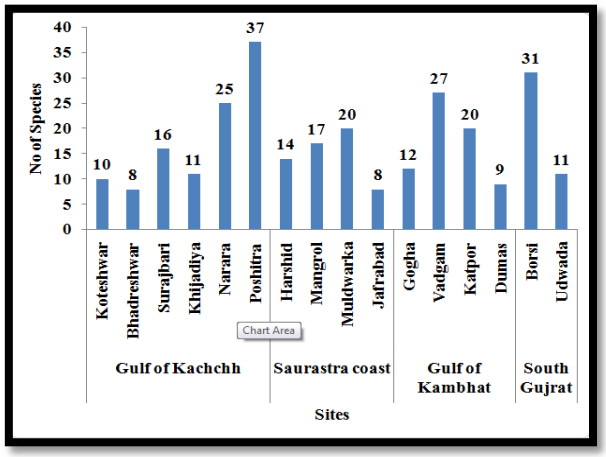


Figure. 3 *Number of phytoplankton species recorded at selected sites (n=16) of Gujarat Coast*

during present study. Bacillariophyta (106 species) was found to be most dominant phylum followed by Cyanobacteria (8 species), Miozoa (4 species), Chlorophyta (3 species) and Charophyta (1 species). Charophyta was the least dominant phylum represented with single species. The site wise % occurrence of phytoplankton phylum is depicted in Fig. 5.

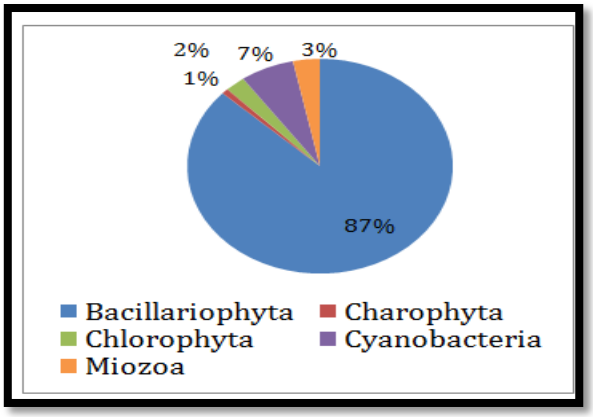
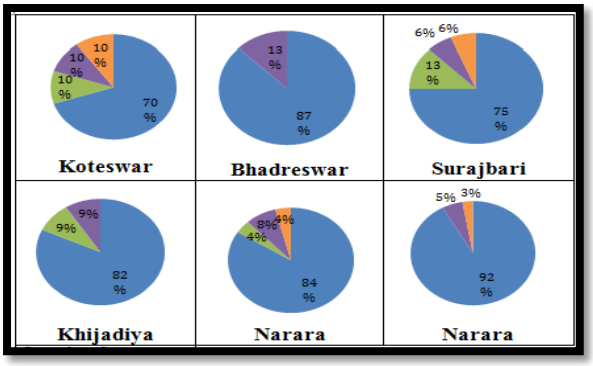
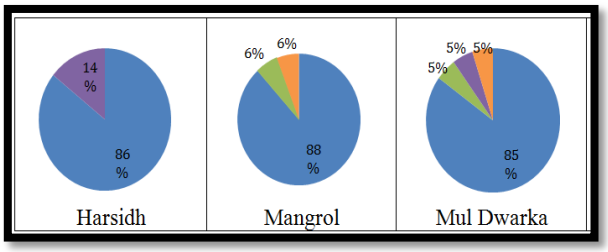
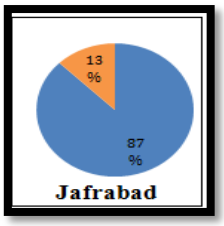


Figure 4 *Percentage distribution of phytoplankton phyla in Gujarat Coast*

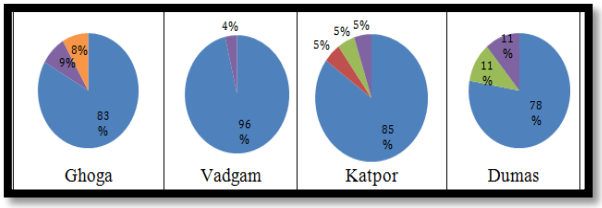


Gulf of Kachchh

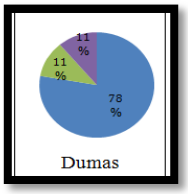




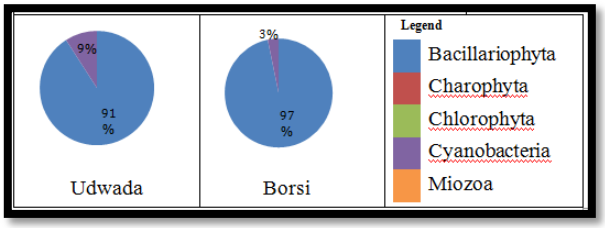
Saurstra Coast



Gulf of Kambat



Gulf of Kambhat



South Gujarat

Figure 5. *Percentage distribution of phytoplankton phylum at each selected site of Gujarat Coast*

Gulf of Kachchh:

1. **Koteshwar:** Koteshwar is a small village and the location of an ancient Shiva temple. It is located near the mouth of Kori Creek, in the west of Kachchh district of Gujarat, India. It is an important site for Mangrove and marine life. The phytoplanklton at Koteshwar are represented by Bacillariophyta (70 %) and 10 % each for Chlorophyta, Cyanobacteria and Miozoan. Only one species of pollution indicator is reported from this site *i.e. Oscillatoria* sp.
2. **Bhadreshwar:** Bhadreshwar is a village in Mundra Taluka having mudflat as major habitat covered by patches of sand, silt and clay. The sub-tidal area of Bhadreshwar is a fishing ground which provide livelihood to local people. Bhadreshwar coastal waters

were represented by Bacillariophyta and Cyanobacteria. One pollution indicator phytoplankton species was reported from this site *i.e. Spirulina* sp.

3. **Surajbari:** Surajbari is a narrow funnel shaped region that connects LRK with the Gulf of Kachchh. It is one of the nesting sites for flamingos. The area has intertidal mudflat, Saltpan and sparse mangrove. Phytoplankton at Surajbari are represented by Bacillariophyta, Chlorophyta, Cyanobacteria, Miozoa. Among these phytoplabnkton, Bacillariophyta was the dominant group of phytoplankton. The pollution indicator species were totally absent from this area.
4. **Khijadiya:** Khijadiya is a bird Sanctuary having amazingly large number of resident and migratory birds in a relatively small area-particularly during winters. The region comprises both types of biodiversity *i.e.* coastal and marine. The sanctuary and its adjoining areas bear a remarkable diversity of habitats and ecosystems which include marine habitat, fresh water habitat, marshy lands, mangroves, *Prosopis* areas, salt pans, open & intertidal mudflats, creeks, scrubs sandy beaches and adjoining farmlands. Bacillariophyta was the dominant phytoplankton group at Khijadiya. These were followed by Chlorophyta and Cyanobacteria. Pollution indicator species were not recorded from this site depicting good water quality of this site.
5. **Narara:** It is one of the vast expansions of coral reef, supporting wide range of biodiversity in the marine protected area. The area support mangroves, mudflats and coral reefs as the major habitats. Bacillariophyta was the dominant phytoplankton group followed by Cyanobacteria, Chlorophyta and Miozoa. *Aulacoseira* sp. was the only Pollution indicator species, documented from this site.
6. **Poshitra:** Poshitra reef is located near the mouth of the Gulf of Kachchh in the Devbhumi Dwarka District .The region mainly comprises of Rocky shores. The major habitats present here are coral reefs and patches of mangroves. The reef is characterized by diverse coral species hence it's often referred as 'Crown of the Gulf of Kachchh' . Bacillariophyta was major group of phytoplankton followed Cyanobacteria and Miozoa. One pollution indicator species (*Oscillatoria* sp.) was recorded from this site.

Saurashtra coast

7. **Harsidh:** Harshad village is located along the south-west coast of Saurashtra peninsula, in Porbandar district. The village is a pilgrimage site, known for the ancient temple of Goddess Harsiddhi. The area near this site is sandy with dry white soil. The water is clear and is considered pure due to the region's religious association. The coastal areas of Harsidh comprise of sand dunes, small patch of mangrove and inter-tidal area of rokyshore. The site is important for sea and shore birds. Phytoplanktons in Harsidh were represented by Bacillariophyta and Cynobacteria. The Bacillariophyta have the highest contribution among all he phyla recorded from this site. None of the pollution indicator species were recorded from this site.
8. **Mangrol:** Mangrol is an important harbour as far as the fish industry is considered. Many fish landing centers are located here. The sandy beach of Mangrol provides ground for sea turtle nesting. Bacillariophyta was the dominated phytoplankton group recorded during present study. On the other hand, Chlorophyta and Miozoa were represented by a single species. Only one pollution indicator species was reported from this site *i.e. Odontella sinensis*.
9. **Mul Dwarka:** Mul Dwarka is situated about 7 km from Kodinar town on the Saurashtra coast. Presently, it serves as a fishing harbour and most of the residents of this village are fishermen. The site is important for Sea & Shore birds. The phytoplankton community was represented by a total of four groups among which Bacillariophyta has the highest number of species (17 species) whereas the other three groups namely Chlorophyta, Cyanobacteria and Miozoa were represented by a single species each. Aulacoseira sp. and Oscillatoria sp. were the pollution indicator species recorded from this site.
10. **Jafrabad:** Jafrabad is one of the major fishing harbours in Gujarat. Majority of population rely on fishing. Several salt works are also located along the backwaters of Jafrabad. The site provides suitable habitats for congregation of sea and shore birds. Bacillariophyta and Miozoa contributed 87% and 13%, respectively for phytoplankton community. Two pollution indicator species were found at this site i.e. *Aulacoseira* sp. and *Nitzschia palea*.

Gulf of Khambhat

11. **Ghogha:** Ghogha is a small coastal town situated on the mid-western shore of the Gulf of Khambhat. It comprises unique characteristics in having supra-tidal zone sandy, while middle intertidal zone is rocky-muddy with sparse mangrove and lower intertidal zone is highly muddy. *Avicennia marina* is the principal mangrove species of the coast. Ghogha is also known to provide a harbour for large ships though they would lie dry in mud during low tides. The phytoplankton at this is composed of three groups, Bacillariophyta (10 Species), Cyanobacteria (1 Species) and Miozoa (1 Species). Only one pollution indicator species (*Oscillatoria*) was recorded from this site.
12. **Vadgam:** Vadgam is a site situated near Sabarmati estuary. However, this area faces freshwater scarcity as the river is ephemeral in nature. This site is also considered good for prawn cultivation. *Avicennia marina* is a main mangrove species found in this area. Bacillariophyta and Cyanobacteria contributed 96% and 4%, respectively to the phytoplankton composition at this site. The pollution indicator species recorded from this site is *Surirella ovata*.
13. **Katpor:** This site is located near Narmada estuarine region mainly comprised of mudflats. The site is important for mangroves. Shrimp cultivation sites of

various companies are situated near this site. The site is comprised of four groups of phytoplankton viz., Bacillariophyta, Charophyta, Chlorophyta and Cyanobacteria. None of the pollution indicator species have been recorded from this site during present study.

14. **Dumas:** Dumas Beach is an urban beach along the Arabian Sea located 21 kilometers South-West of Surat City of Gujarat. It is a popular tourist destination in south Gujarat. It is an important site for Mangroves and sea birds. 78% of species at this site is composed of Bacillariophyta whereas the remaining percentages were occupied by the other two groups recorded in this study i.e. Chlorophyta and Cyanobacteria. Two pollution indicator species namely *Aulecoseira* sp.and *Spirulina* sp.were found to be present at this site.

South Gujarat Coast

15. **Borsi:** Borsi is a small village situated in Jalapore taluka of Navsari district. The region is comprised of estuarine ecosystem as it is located near Purna estuary. It is one of the centers; important from the view point of fisheries. The phytoplankton at this site is mainly comprised of Bacillariophyta and Cyanobacteria with 97% and 3% of species contribution, respectively. *Surirella ovata*, a pollution indicator species was found to be present at this site.
16. **Udwada:** Udwada is a coastal town in Valsad district. It is renowned for the Zoroastrian Atash Bahram fire temple. Udwada literally stands for `grazing ground of camels`, which was actually the town's condition, prior to becoming a fishing village. Majority of population residing in this area depends on Fishing. The major groups of phytoplankton identified from this site are Bacillariophyta and Cyanophyta with 10 and 1 species, respectively. One pollution indicator species i.e. *Spirulina* sp. also occurred at this site.

IV. DISCUSSION

Phytoplankton species have environmental and ecological significance. The phylum Bacillariophyta which include *Cocconeis placentula*,, *Corethron criophilum*, *Cyclotella* sp., *Nitschia closterium*, *Pseudo-nitzschia pungens*, *Rhizosolenia setigera*, *Thalassionema nitzschioides* are indicator of moderate to good quality water. Such species have been observed in most of the sites of Gujarat coast (Table 2). Moreover, *Chaetoceros* sp. and *Corethron criophilum* blooming have harmful effect on gills of fish. *Corethron criophilum* may cause physical obstructions in gills of farmed salmon [12]. High concentrations of these species cause irritation in fish gills and may leads to mortality of fishes [13, 14]. Such blooming of these species were not found at any of the selected sites. Other adverse impacts of caused by phytoplankton are production of toxins which causes fish poisoning. *Pseudo-nitzschia pungens* is capable of producing domoic acid, a neurotoxin that causes ASP (amnesic shellfish poisoning) [15]; This species was recorded from only two sites namely Bhadreshwar and Udwada. *Prorocentrum micans* can form extensive blooms, but it is considered harmless [16]. It may excrete chemicals that inhibit diatom growth, but these substances do not affect organisms in higher trophic levels [16]. High cell concentrations deplete oxygen causing fish kills [16]. Some of the species of *Gymnodinium sp.* release *Saxitoxins* & *Gonyautoxins. Alexandrium* is a genus of Miozoa which causes toxic harmful algal blooms (HAB) which results in Paralytic Shellfish Poisoning (PSP) in humans. In present study, these species of phytoplankton were not found to form blooms and therefore, it cannot be considered harmful to other living organisms. *Thalassionema nitzschioides* commonly found in nutrient-rich upwelling regions [17]. Its presence indicates conditions of high productivity [18]. This species was recorded from a total of four sites viz; Katpor, Poshitra, Vadgam and Borsi suggesting its nutrient rich environment. *Cyclotella* sp. is common in oligotrophic environment. The valve morphology is highly variable and appears to respond to subtle micro-environmental changes. *Cyclotella* is able to continue to grow in periods of sustained darkness by making use of glucose or other dissolved organic compounds from the environment [19]. In present study, this species was observed at Katpor, Poshitra, Mangrol and Koteshwar indicating high nutrient concentration at these sites. Water columns that are vertically mixed have more upwelling of nutrient-rich, high salinity water to the surface; and these conditions result in large populations of small-sized *Paralia sulcata*, this species was recorded in waters of Poshitra which suggests that the phenomenon of vertical upwelling of water is more active at this site.

In Miozoa phylum, *Prorocentrum micans* is abundant in coastal water around the world [19, 16]. Which was observed during the present study. Further, the study revealed presence of total 122 species of phytoplankton dominated by phylum Bacillariophyta with 106 species. In general marine water supports wide variety of Bacillariophyta members as their cells are made up of a silicate; which is one of the major elements found in sea water. A total of six pollution indicator species were observed during present study. However, Harsidh, Katpor, Khijadiya and Surajbari did not showed presence of any of these species demonstrating good water quality conditions. The variation in species distribution may be due to the environmental conditions prevailing in various segments of coast. The presence of certain harmful phytoplankton species have been recorded during present study and therefore, regular monitoring of water sample in these coastal areas are recommended.

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[21] *Red-Tide. Prorocentrum micans Ehrenberg* **1833, 2011.**

AUTHORS PROFILE

Mr. Roshan Bhagat, has completed his M.S.C in Environmental Science from Bhartividya peeth, Pune. and He is a JRF at GEER Foundation, Gandhinagar. He has been working on Coastal & Marine Environment. He has broad experiences plankton study.

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Mr. R. D. Kamboj, is an Indian Forest Services Officer of Gujarat cadre (1986 batch) of the rank of Additional Principal Chief Conservator of Forests. He holds post graduate degree in Agriculture from Haryana Agriculture University, Hisar & in Forestry from Indira Gandhi National Forest Academy, Dehradun. He has served in various positions in Gujarat Forest Department for last 32 years. He has published more than 70 research papers and has written Working Plans/ Management Plans for various forest divisions including Gir National Park & Sanctuary. Presently he is serving as Director, Gujarat Ecological Education and Research (GEER) Foundation, Gandhinagar.

SN	***Phytoplankton species***	***KT***	***BH***	***SU***	***KH***	***NA***	***PO***	***HR***	***MG***	***MD***	***JF***	***GH***	***VD***	***KP***	***DU***	***BO***	**UD**
1	*Achnanthes minutissima*	-	-	-	-	+	-	-	-	+	+	+	-	-	-	+	-
2	*Achnanthes* sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
3	*Achnanthes dispar*	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
4	*Alexandrium* sp.	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
5	*Amphiprora* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
6	*Amphora* sp.	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
7	*Aulacoseira* sp.	-	-	-	-	+	-	-	-	+	+	-	-	-	+	-	-
8	*Bacillaria paxillifer*	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+
9	*Biddulphia biddulphiana*	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-
10	*Biremis ambigua*	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
11	*Campylodiscus* sp.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
12	*Campyloneis* sp.	-	-	-	+	-	-	-	-	-	-	-	+	-	-	+	-
13	*Chaetoceros curvisetus*	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	+
14	*Chaetoceros* sp.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
15	*Climacosphenia moniligera*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
16	*Climacosphenia* sp.	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-
17	*Cocconeis pediculus*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
18	*Cocconeis placentula*	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	*Cocconeis* sp.	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+
20	*coleastrum* sp.	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-
21	*Corethron criophilum*	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-
22	*Coscinodiscus asteromphalus*	-	-	-	-	-	-	-	-	+	-	-	+	+	-	+	-
23	*Coscinodiscus centralis*	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-
24	*Coscinodiscus radiatus*	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-
25	*Coscinodiscus robustus*	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-

26	*Coscinodiscus* sp.	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-
27	*Cosmarium* sp.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
28	*Cyclotella* sp.	+	-	-	-	-	+	-	+	-	-	-	-	+	-	-	-
29	*Cymatosira* sp.	+	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-
30	*Cymbella* sp.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
31	*Dinophysis* sp.	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-	-
32	*Diploneis oblongella*	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+
33	*Ditylum brightwellii*	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
34	*Dolichospermum* sp.	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-
35	*Entomoneis alata*	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-
36	*Entomoneis ornata*	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
37	*Entomoneis paludos*	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-
38	*Entomoneis* sp.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
39	*Gloeocapsa* sp.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
40	*Gomphonema* sp.	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-
41	*Grammatophora marina*	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-
42	*Grammatophora oceanica*	-	-	-	-	+	-	-	-	-	+	-	-	+	-	-	-
43	*Guinardia flaccida*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
44	*Gymnodinium* sp.	+	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-
45	*Gyrosigma acuminatum*	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
46	*Gyrosigma balticum*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
47	*Gyrosigma fasciola*	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-
48	*Gyrosigma* sp.	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-
49	*Haslea crucigera*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
50	*Haslea vitrea*	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
51	*Haslea* sp.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-

52	*Leptocylindrus denicus*	-	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-
53	*Licmophora abbreviata*	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
54	*Licmophora sp*	-	-	-	-	+	+	-	-	+	-	-	-	-	-	-	-
55	*Licmophora splendida*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
56	*Lyrella* sp.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-
57	*Mastogloia erythraea*	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
58	*Mastogloia* sp.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
59	*Melosira*	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
60	*Melosira nummuloides*	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-
61	*Microcystis viridis*	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
62	*Minidicus* sp.	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+
63	*Navicula radiosa*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
64	*Navicula* sp.	-	-	+	+	-	+	-	+	+	-	-	-	-	-	-	-
65	*Navicula transitans var.delicatula*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
66	*Nitzschia acicularis*	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
67	*Nitzschia closterium*	-	-	+	+	+	+	-	+	-	-	-	-	-	-	-	-
68	*Nitzschia ditstant*	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-
69	*Nitzschia improvisa*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
70	*Nitzschia longissima*	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-
71	*Nitzschia lorenziana*	-	-	-	+	+	+	+	-	-	-	+	-	-	-	+	-
72	*Nitzschia palea*	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
73	*Nitzschia recta*	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-
74	*Nitzschia sigma*	-	-	-	-	+	+	+	-	+	-	+	+	-	-	+	-
75	*Nitzschia sigmoida*	-	-	-	-	+	+	-	-	-	-	+	+	-	-	+	-
76	*Nitzschia* sp.	-	-	-	-	-	+	+	+	+	-	-	+	-	-	+	-
77	*Nodularia* sp.	-	-	-	-	-	+	-	-	-	-	-	+	-	-	+	-

78	*Nostoc sp*	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
79	*Odontella aurita*	-	-	-	+	-	+	+	-	-	-	+	+	+	-	+	-
80	*Odontella mobiliensis*	+	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-
81	*Odontella sinensis*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
82	*Odontella* sp.	-	-	+	-	-	-	-	-	-	-	-	+	-	-	+	-
83	*Oscillatoria* sp.	+	-	-	-	-	+	-	-	+	-	+	-	-	-	-	-
84	*Parllia sulcara*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
85	*Pediastrum simplex*	-	-	+	+	+	-	-	-	-	-	-	-	-	+	-	-
86	*Phormidium* sp.	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-
87	*Pinnularia* sp.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
88	*Pleurosigma angulatum*	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-
89	*Pleurosigma decorum*	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
90	*pleurosigma directum*	-	-	-	-	-	+	-	-	-	-	-	+	-	-	+	-
91	*Pleurosigma elongatum*	-	-	-	-	+	-	-	-	+	-	-	+	-	-	+	-
92	*Pleurosigma intermedium*	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
93	*Pleurosigma javanicum*	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
94	*Pleurosigma naviculaceum*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
95	*Pleurosigma nomanii*	-	-	-	-	+	-	+	-	-	-	-	+	-	-	+	-
96	*Pleurosigma* sp.	+	-	-	-	-	-	-	+	+	-	+	-	-	+	-	-
97	*Pleurosigma var. rhomboides*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
98	*Podocystis spathulata*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
99	*Prorocentrum micans*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
100	*Pseudo nitzschia pungen*	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
101	*Pseudo Nitzschia* sp.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
102	*Rhaphoneis* sp.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-
103	*Rhizoclonium* sp.	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-

104	*Rhizosolenia setigera*	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-
105	*Spirulina* sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	+
106	*Stauroneis* sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
107	*Surirella brebissonii*	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
108	*Surirella fastuosa*	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-
109	*Surirella ovata*	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-
110	*Surirella* sp.	-	-	-	-	-	+	-	+	+	-	+	-	-	-	-	-
111	*Synedra* sp.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
112	*Synedra tabulata*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
113	*Synedra ulna*	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	-
114	*Thalassionema frauenfeldii*	-	-	-	-	+	-	-	-	-	-	-	+	-	-	+	+
115	*Thalassiosira leptopus*	-	-	-	-	+	+	-	-	-	-	-	-	-	-	+	-
116	*Thalassiosira lineata*	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
117	*Thalassiosira* sp.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
118	*Thalassiosira tenera*	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-
119	*Thalassionema nitzschioides*	+	-	-	-	-	+	-	-	-	-	-	+	-	-	+	-
120	*Trachyneis aspera*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
121	*Triceratium pulvinar*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
122	*Triceratium* sp.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-

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