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Research Article

Distribution and Morphology of *Coscinodiscus* species from the Surface Water of Dhamra Coast, Bay of Bengal (Odisha)

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Abstract

A study on the diversity of diatom *Coscinodiscus* species was carried out in the coastal water of Dhamra during pre-monsoon, monsoon, and post-monsoon period (2021-2022). Surface water was collected from 6 different stations with the help of Niskin water sampler with capacity of 1.5L. Sea Surface Temperature (SST), pH, and transparency were measured on the site and other parameters like, abundance, salinity, Dissolved Oxygen (DO), silicate, nitrite, nitrate and *Coscinodiscus* species identification were done after returning to the laboratory. A total of 6 species *such as C. centralis, C. granii, C. marginatus, C. wailesii, C. radiatus and C. oculus-iridis were* observed. Dhamra coastal water was dominated by *Coscinodiscus* species and the species diversity was high during post-monsoon period as compared to the monsoon and pre-monsoon. Positive correlations between different water parameters were observed.

Keywords: *Coscinodiscus* diversity; Coastal waters; Dhamra

Introduction

Phytoplankton play a major role in the marine ecosystems as they initiate the food chain, maintain global carbon cycle, energy flow, nutrient cycling and also regulate the abundance and diversity of other marine communities [1-3]. Coastal and estuarine ecosystems are economically important and are the most productive ecosystems [4,5]. Distribution and diversity of phytoplankton species are affected by hydrology and atmospheric factors, hence continuous observation can provide valuable information about the water quality, thus making them good bio-indicators of water pollution [6,7]. Phytoplanktons maintain the global carbon cycle or the Red field ratio (C:N:P= 106:6:1) and are excellent source of fossil fuel. Diatoms are commercially important as diatomaceous earth which is a congregation of dead silica rich frustules. They are used in the boilers, electric oven as insulators, as polishing agent for metals, manufacture of concrete, in the separation of paraffin wax from petroleum, filtration of fruit juice and syrup [8]. Diatoms play an important role in marine productivity and carbon fixation [9]. The frustules of diatoms are impregnated with huge amount of silica and various photosynthetic pigments which appear as yellow-brown pigments. They play major role in biogeochemical cycling like Si, N, P, C and mostly depend on silica for their growth and metabolism. Diatoms can act as bio-indicator species due to their sensitivity towards any change in the surrounding water [10]. Diatoms have a hydrocarbon compound known as diatomin which is used as an indicator of rich petroleum grounds and the small free-floating producers act as primary precursor of petroleum rich zones [8].

Odisha has a coastline of over 480 kms, stretching from Subarnarekha River in the north to Rushikulya in the south, and has been one of the major hubs of intense fishing and related activities. Dhamra has Adani port located between the main land and Kanika Island of Bay of Bengal which give anchor to vessels coming from different places. Hence, Dhamra coastal water is considered ecologically sensitive area due to industrialization and commercial activities. Very few plankton studies have been carried out in the coastal waters of Dhamra [11-13]. Physicochemical variables like pH, water temperature, Dissolved oxygen, salinity, and nutrients are important factors controlling phytoplankton growth and diversity in marine environments [14,15]. *Coscinodiscus* is a centric diatom which plays a crucial role in marine primary productivity.As oceans get subjected to continuous change due to fluctuations in weather conditions, it also influences phytoplankton dynamics. Hence, the present study was undertaken to look into the diversity of *Coscinodiscus* species and also understand the role of nutrients and its correlation with phytoplankton diversity.

Materials and Methods

Sampling and measurements were carried out at six stations using GPS based geographical coordinates between 20º46´8.70´´N, 86º51´2.19´´E and 20º51´5.12´´N, 87º02´4.54´´E in coastal waters of Dhamra during March 2021 and February 2022 (Figure 1). Water samples were collected with the help of vertical Niskin water sampler. Water from the surface was collected for the analysis of various hydrological parameters. Sea surface temperature was recorded using a 0.01º C precision thermometer. pH was measured using micro-processor pH meter. Transparency was measured with the help of a Secchi disc. Water samples were fixed following the modified Winkler's method for the analysis of dissolved oxygen. Remaining water samples were transferred to tarson nutrient containers to be analyzed in the laboratory. Dissolved oxygen, salinity and nutrients like

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silicate, nitrite, and nitrate were analyzed following the procedures as described in Strickland and Parsons 1972 [16]. Dissolved oxygen was analyzed by modified Winkler's method; salinity by argentometric method; silica by silico-molybdic method; nitrate and nitrite by Azo-dye method. 50L of water sample was filtered on board using plankton net (30µ) and then fixed in 2% Lugol's iodine solution for identification and enumeration. 4% buffered formaldehyde solution was added to the water samples for long term preservation. Phytoplankton counting was done with the help of Sedgewick - Rafter counting chamber. Photographs were taken with the help of light microscope Magnus MLX PLUS at 40X magnification for taxonomic identification of various species. Plankton samples were dried and spread over a double-sided adhesive carbon tape on an aluminum stub and the samples were examined under SEM (Gemini SEM 300, Zeiss) at Ravenshaw University, Odisha, India. Identification was done using monographs, NIO identification manual and from marine species.com.

Box plots were plotted using GraphPad Prism 6 for graphical representation of various physico-chemical water parameters. One-way ANOVA was performed to establish the difference in *Coscinodiscus* number based on season. Pearson correlation matrix was calculated to determine the impact of various water quality parameters on *Coscinodiscus* abundance. The relationship between *Coscinodiscus* abundance and environmental factor silicate was analyzed through regression plot in excel. Cluster analysis was carried out to verify the similarity and dissimilarity among various water quality parameters. Biodiversity professional software was used for cluster analysis. Shannon Wiener diversity index (H') was calculated using the following formula Shannon Wiener diversity index (H') = $-\Sigma p_i \ln p_i$.

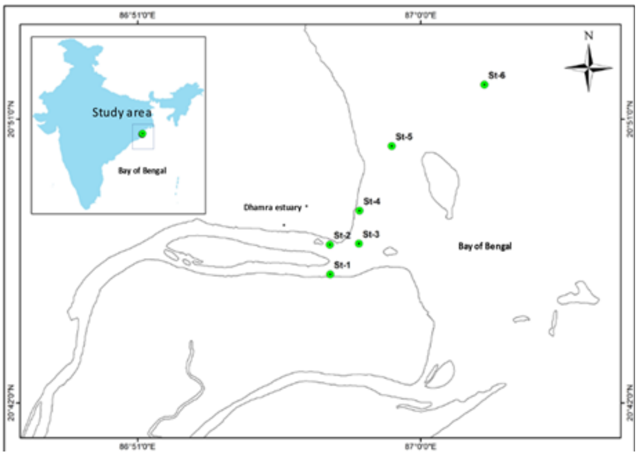

Figure 1: Map showing study area and station locations.

Results

Hydrological parameters

Variations were observed in SST in coastal waters of Dhamra with highest values during monsoon (32 ± 0.63°C) followed by pre-monsoon (27.33 ± 0.82°C) and post-monsoon (26.33 ±1.03°C). Alkalinity of water was maximum during the post-monsoon (pH 8.22 ± 0.08) period followed by pre-monsoon (pH 8.21 ± 0.04) and monsoon period (pH 7.98 ± 0.20). Water transparency was most in post-monsoon (0.82 ± 0.13 m) than compared to pre-monsoon (0.53 ± 0.47 m) and monsoon (0.53 ± 0.31 m). The sea surface salinity varied from 17.12 to 29.46 psu in pre-monsoon period, 0.79 to 21.76 psu in monsoon and 14.86 to 26.54 psu in post-monsoon period. Highest salinity was observed during pre-monsoon period (22.85 ± 4.40 psu) followed by post-monsoon (20.17 ± 4.71 psu) and monsoon (10.40 ± 9.18 psu) periods. Dissolved oxygen concentration was highest during monsoon period (7.23 ± 0.34 mgL^{-1}) in comparison to pre-monsoon (6.73 ± 0.33 mgL^{-1}) and post-monsoon (5.40 ± 0.28 mgL^{-1}) periods. Variations in dissolved oxygen ranged from 6.4 – 7.2 mgL^{-1} in pre-monsoon; 6.8 – 7.6 mgL^{-1} in monsoon and 5.1 – 5.8 mgL^{-1} in post-monsoon periods. The average silicate concentration varied from 0.04 to 0.48 mgL^{-1} (Figure 2). The silicate concentrations ranged from 0.026 to 0.055 mgL^{-1} in pre-monsoon period, 0.101 to 0.816 mgL^{-1} in monsoon period and 0.032 to 0.074 mgL^{-1} in post-monsoon period.

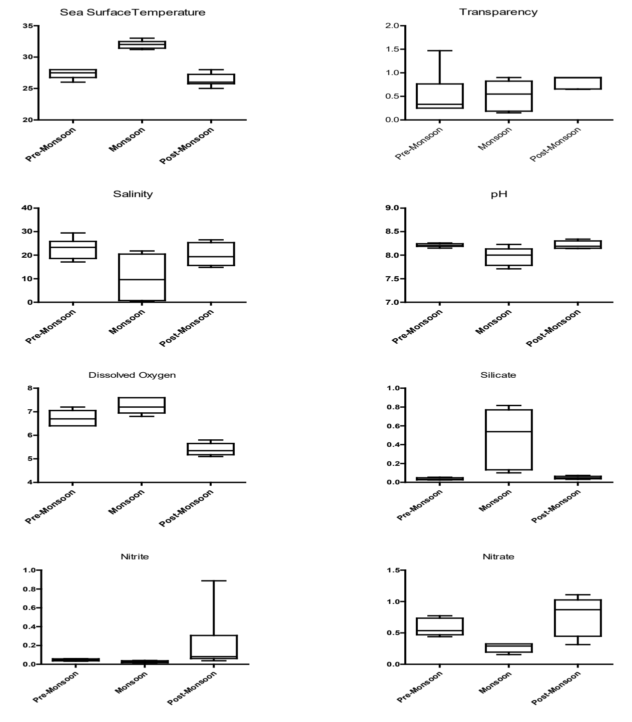

Figure 2: Hydrography results of Dhamra coastal waters during different seasons.

Coscinodiscus diversity and correlated biological parameters

A significant seasonal variation was observed in the distribution and diversity of *Coscinodiscus sp.* in coastal waters of Dhamra during the study period. A total of 6 species belonging to *Coscinodiscus* genera were reported from different sampling stations. Highest number of *Coscinodiscus* was observed at station 2 during the post-monsoon period whereas lowest number of *Coscinodiscus* was recorded at station 4 during the monsoon period (Figure 3). The relationship between silicate concentration and *Coscinodiscus* abundance has been depicted through linear regression graphs (Figure 4). The graphs clearly show the positive correlation between silicate and *Coscinodiscus* in monsoon season and subsequent uptake of silicate by diatoms for their growth which leads to a negative correlation during the post-monsoon period. The observations show that *Coscinodiscus* abundance were more in winter (730/ml) as compared to monsoon season (497/ml). Our study has reported a strong positive correlation ($p \leq 0.05$) between *Coscinodiscus* abundance with sea surface temperature (r = 0.955), silicate (r = 0.861) and nitrite (r = 0.937) in the pre-monsoon period. Our study shows strong negative correlation between *Coscinodiscus* abundance and pH (r = -0.813) but no significant correlation was found to exist between *Coscinodiscus* density and transparency, salinity, dissolved oxygen and nitrate in the pre-monsoon period (Table 1). A strong positive correlation ($p \leq 0.05$) between *Coscinodiscus* abundance with transparency (r = 0.854), salinity (r = 0.720) and silicate (r = 0.884) during the monsoon period. Our study shows strong negative correlation between *Coscinodiscus* abundance and nitrite (r = -0.813) but no significant correlation was found to exist between *Coscinodiscus* density and temperature, pH, dissolved oxygen and nitrate in the monsoon period (Table 2). Our study shows strong negative correlation between *Coscinodiscus* abundance with transparency (r = -0.647) but no significant correlation was found to exist between *Coscinodiscus* density and temperature, salinity, pH, dissolved oxygen, nitrite and nitrate in the post - monsoon period (Table 3). Strong negative correlation was found between *Coscinodiscus* abundance and silicate in the post-monsoon season (r = -0.659). Similarity between various physico-chemical parameters of the coastal waters of Dhamra spread over seasons are depicted in figure 5. A strong correlation was observed in the cluster matrix graph between Sea Surface Temperature (SST) and salinity. Similarly, strong correlation was observed between pH and dissolved oxygen. With the help of Scanning Electron microscope, the pore pattern of various samples were observed and about 6 species of *Coscinodiscus* were identified (Figures 6 & 7). The six prominent species of *Coscinodiscus* spotted in coastal waters were *C. marginatus, C. centralis, C. oculusiridis, C. wailesii, C. radiatus and C. granii* (Figure 6). The entire structure of the frustule was also visualized using Scanning Electron Microscope (SEM), wherein a more detailed and intricate pattern of both valve and the girdle view was obtained (Figures 7a & 7b). Frustule pattern change in the outer and inner surface of the complex structure was observed in different species. The Shannon's species diversity index (H') was calculated to be 0.756 in pre-monsoon, 0.683 in monsoon and 0.646 in post-monsoon.

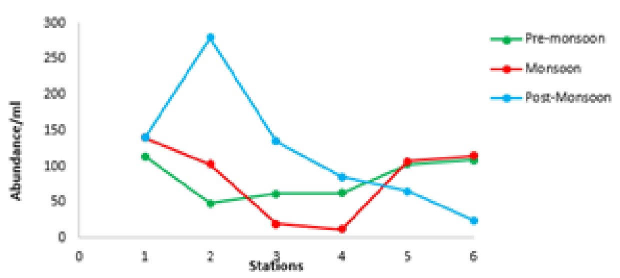

Figure 3: Station wise abundance of *Coscinodiscus* during different seasons.

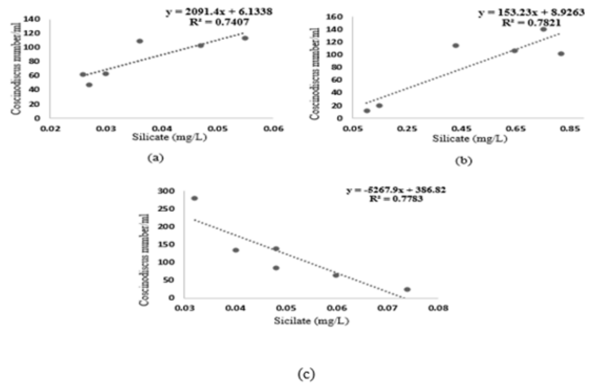

Figure 4: Linear correlation between silicate and *Coscinodiscus* abundance during (a) pre-monsoon (b) monsoon and (c) post-monsoon in coastal waters of Dhamra in 2021–2022.

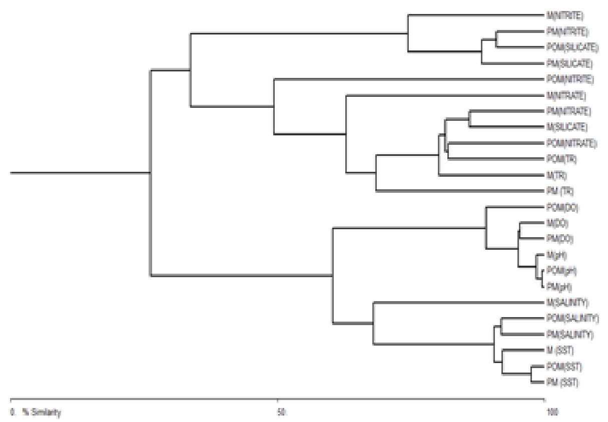

Figure 5: Cluster matrix showing the interrelationship between physicochemical parameters of coastal waters during different seasons [PM: Pre-monsoon, M: Monsoon, POM: Post-monsoon].

Discussion

The physico-chemical parameters like SST, pH, salinity, transparency, DO, silicate, nitrate, and nitrite exhibited different seasonal variations. Water transparency was low during monsoon period as fresh water runoff from river was high. Highest salinity was observed during the pre-monsoon period which can be attributed to increase in solar radiation and evaporation from the water surface. Lower salinity was observed during monsoon period because of ingress of both rain water and fresh water into the sea water. Similar results were observed in the studies carried out by Dash et al. 2017 [17] and Jyothibabu et al. 2008 [18]. Dissolved oxygen was maximum during the monsoon period, probably due to heavy rainfall and high wind velocity. Lower concentration of dissolved oxygen during the pre-monsoon period was due to more abundance of diatom species at the sampling stations. Stations close to the coastal region showed fluctuation in DO values due to influx of fresh water. Our results showed negative correlation of SST with dissolved oxygen across all seasons indicating increase in temperature contributed towards decreased solubility of oxygen in coastal waters of

Variables	SST	Transparency	Salinity	pH	DO	Silicate	Nitrite	Nitrate	*Coscinodiscus*
SST	1								
Transparency	0.376	1							
Salinity	-0.497	0.249	1						
pH	0.710*	-0.131	0.385	1					
DO	-0.500*	-0.263	0.711*	0.581*	1				
Silicate	0.776*	-0.082	-0.426	-0.903*	-0.326	1			
Nitrite	0.832*	0.506*	-0.22	-0.677*	-0.246	0.727*	1		
Nitrate	-0.07	-0.47	0.042	-0.432	0.26	0.530*	0.248	1	
Coscinodiscus	0.955*	0.388	-0.381	-0.813*	-0.418	0.861*	0.937*	0.177	1

Table 1: Pearson correlation matrix between hydrology and biological parameters of the coastal waters of Dhamra during pre-monsoon period. *Significant at $p \leq 0.05$.

Variables	SST	Transparency	Salinity	pH	DO	Silicate	Nitrite	Nitrate	*Coscinodiscus*
SST	1								
Transparency	-0.01	1							
Salinity	-0.233	0.930*	1						
pH	-0.644*	0.311	0.394	1					
DO	-0.351	0.252	0.263	0.660*	1				
Silicate	0.601*	0.595*	0.541*	-0.37	-0.409	1			
Nitrite	-0.518*	-0.523*	-0.351	0.619*	0.454	-0.742*	1		
Nitrate	0.623*	-0.755*	-0.802*	-0.765*	-0.462	-0.011	-0.026	1	
Coscinodiscus	0.41	0.854*	0.720*	-0.139	-0.208	0.884*	-0.813*	-0.362	1

Table 2: Pearson correlation matrix between hydrology and biological parameters of the coastal waters of Dhamra during monsoon period. *Significant at $p \leq 0.05$.

Variables	SST	Transparency	Salinity	pH	DO	Silicate	Nitrite	Nitrate	*Coscinodiscus*
SST	1								
Transparency	-0.500*	1							
Salinity	0.317	0.116	1						
pH	-0.104	0.432	0.901*	1					
DO	-0.351	0.695*	-0.382	-0.126	1				
Silicate	0.2	0.541*	0.775*	0.774*	-0.019	1			
Nitrite	0.780*	-0.655*	-0.116	-0.513*	-0.530*	-0.148	1		
Nitrate	-0.26	-0.226	-0.987*	-0.916*	0.35	-0.846*	0.128	1	
Coscinodiscus	-0.02	-0.647*	-0.33	-0.364	-0.107	-0.659*	-0.042	0.464	1

Table 3: Pearson correlation matrix between hydrology and biological parameters of the coastal waters of Dhamra during post-monsoon period. *Significant at $p \leq 0.05$.

Dhamra. Concentration of silicate was maximum during the monsoon period, indicating increased abundance of diatom species. Lower silicate values during post-monsoon period might be due to uptake of silicate by diatoms for their biological activity. Higher concentrations of nitrite and nitrate were observed during post-monsoon period, which might be due to release from bottom sediments. Our results are supported by similar findings in a study carried out by Shirodkar et al. 2009 [19].The species composition, growth, production and diversity of diatoms in marine water is greatly influenced by various physico-chemical parameters of its particular environment. The diatoms were more abundant in post-monsoon season which could be correlated with increased amounts of silicate during monsoon period which were evident in our results. The enhanced amounts of silicates during the monsoon period might have led to increase in abundance of *Coscinodiscus* in the post-monsoon period.

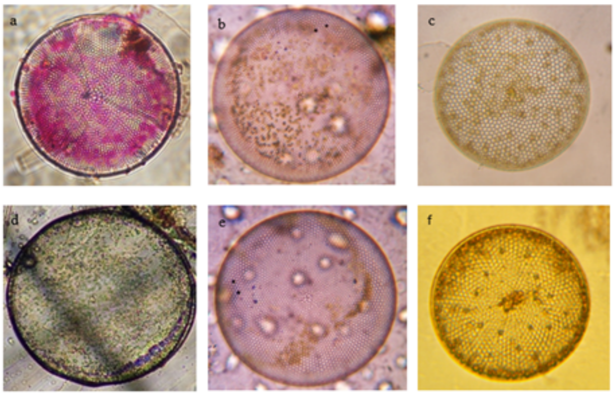

Figure 6: *Coscinodiscus* species in Dhamra coastal waters. a. *C. marginatus b. C. centralis c. C. oculus-iridis d. C. wailesii e. C. radiatus f. C. granii* (photographs taken at 40× magnification).

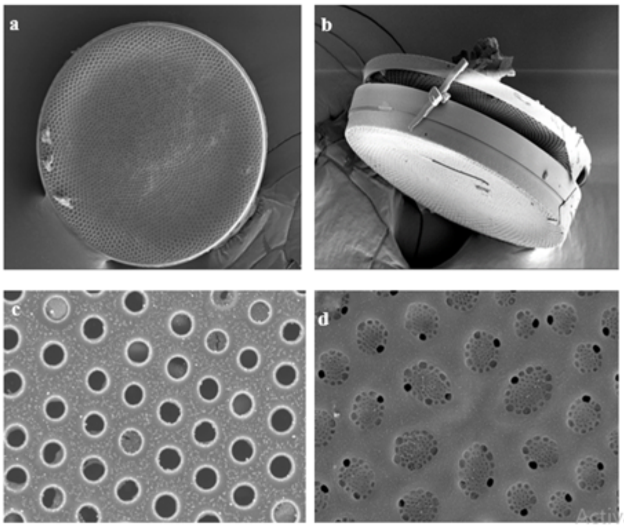

Figure 7: Scanning Electron Microscopy (SEM) images of *Coscinodiscus sp*. (a) SEM image of the of the whole *Coscinodiscus sp*. (b) Whole frustule (c) Porous structure of the *Coscinodiscus sp*. from the inner side and (d) Outer side of the valve.

Silicate was found to be negatively correlated with diversity during post monsoon indicating high uptake by few species. Similar results have been observed by Sas et al. 2022 [20], wherein silica was found to be negatively correlated with epipelic diversity of diatom due to the intensive uptake by some group or species. Shannon diversity index was lower during post-monsoon period and higher during pre-monsoon and monsoon period. The higher the value of H, higher will be the diversity of a species. The lower the value of H, the lower will be the diversity and a value of H=0 indicates presence of only one species. Delayed monsoon effects like upwelling and land runoff favours the growth and proliferation of diatom species. Similar results regarding influence of chemical parameters on phytoplankton diversity were also noticed in coastal waters of Parangipettai, Bay of Bengal [15]. Diatoms including several species of *Coscinodiscus* are reported to be Harmful Algal Bloom species (HABs). *Coscinodiscus wailesii* mostly occurs in warm waters which produces profuse amount of mucilage which aggregate, sink and cover the seabed and in turn affecting the benthic habitat. It also harms the microalgae cultivation, fish and shellfish farming etc [21]. These are also highly tolerant to heavy metals. Its high density leads to depletion of oxygen and nutrients [22,23]. *Coscinodiscus centralis* have been reported causing blooms near the coastal region of south Andaman Sea [24]. In the shallow estuarine regions of Amba river of West Coast of India, *Coscinodiscus oculus-iridis* are found extensively forming algal blooms [25]. Similar species of *Coscinodiscus* were also found in the coastal waters of Dhamra which can cause algal blooms, thus affecting food web patterns. Diatom frustules are highly ornamented, forming an amazing range of forms and the shape of the diatom frustule is species specific [26]. Centric diatoms thrive well in coastal waters due to buoyancy and can also survive in turbulent waters [27]. Study carried out by Kraberg et al. 2010 [28] and Kuhn & Kohler-Rink 2008 [29] reported toleration of wide range of temperature variation and resistance against parasitic infection by *Coscinodiscus granii*. Occurrence of *Coscinodiscus* species is an indication of rise in temperature and it was observed as bloom forming species during the sample collection period. The occurrence index of plankton at the sampling stations showed that Coscinodiscaceae (*Coscinodiscus sp.*) dominated the plankton groups [30] and the dominance of family Coscinodiscaceae across different sampling stations was similar to the findings of Varadharajan and Soundarapandian, 2015 [31]. Diatoms dominance could be the result of their ability to tolerate wide geographical and climatic conditions [32]. Increase in *Coscinodiscus* sp. might have been triggered by the presence of nutrients coming as runoffs with rain water. Similar bloom of *Coscinodiscus centralis* was observed by Kartik et al. 2014 [33] in coastal waters of South Andaman Sea under the influence of nutrients coming as runoffs. Significantly higher diatom might lead to increase in fish production as diatoms form the base of the food web. Diatoms are important components which contribute towards the stability of the intertidal mudflats and they release polysaccharides, which help to trap sediment grains and in turn stabilize the sediment [8]. Data about phytoplankton can help in better management of fishery resources and understanding of the ocean's biogeochemical cycles [34].

Conclusion

The present work has reported about six species of *Coscinodiscus* from the coastal waters of Dhamra. The centric diatoms are ecologically significant as they contribute more than 20% of the total primary productivity and are a major dominating group under micro phytoplankton. Reported centric diatoms *Coscinodiscus* species are generally found in nutrient rich water. It can be concluded that Dhamra coastal water is favorable for diatoms as evident from the various physicochemical parameters and their correlation with the abundance of centric diatoms.

Declaration of Competing Interest

Authors report there are no competing interests to declare.

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