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SEASONAL ABUNDANCE AND MORPHOLOGICAL OBSERVATIONS OF A RAPHID PENNATE DIATOM *ASTERIONELLA GLACIALIS* CASTRACANE FROM THE COASTAL WATERS OF KARACHI, PAKISTAN

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Abstract

Diatom community has thousands of species belonging to the pennate and centric groups in which *Asterionella glacialis* is a raphid pennate diatom species known to form blooms in various regions including Pakistani waters. Its seasonal abundance and detailed morphological data were missing from coastal waters of Pakistan. To fill the gap of knowledge for these data this species was studied during the period of May 2002 to July 2003 at Manora Channel. Considerably lower cell abundance was encountered during study period. Maximum cell density 127cell^{-1} was observed in the month of July, 2002. The species abundance has a significant positive correlation (Pearson) 0.980 with the salinity but a negative correlation with chlorophyll a -1.00.

Introduction

Diatoms contribute significantly to the primary productivity in the world oceans and play a key role in the global carbon flux (Roy *et al*., 2006). The diatom community consists of a large number of abundant and many rare species (Saifullah & Moazzam, 1978; Ramiah *et al.*, 2007). Since change in water quality changes the community composition, therefore it defines the suitability of a habitat and indicates ecosystem's health (Snyder *et al*., 2002).

Species morphology, composition and seasonal abundance of diatoms in the coastal waters of Karachi, Pakisatn region is generally lacking, although a few reports are available on their morphometric assessment (Saifullah & Steven, 1973; Saifullah & Moazzam, 1978; Shameel & Tanaka, 1992; Tabassum & Saifullah, 2010). The present communication deals with taxonomy and seasonal abundance of *Asterionella glacialis* Castracane from Pakistan. Diatoms (bacillariophytes) are divided on the basis of shape into 2 groups, pennate and centric (Tomas, 1997). *Asterionella glacialis* is a raphid pennate diatom of family fragillariaceae is cosmopolitan but mostly found in neritic and planktonic habitats of warm waters (Round *et al.*, 1990) for example, from Bay of Bengal (Subbah Rao, 1967). A bloom of *Asterionella* sp. has previously been reported from Clifton beach of Karachi coast (Khan, 1986). This species is also reported from eastern coast of Sindh and Manora Channel (Ghazala *et al.*, 2006; Naz *et al*., 2010), but its detailed taxonomic features have not been described before from Pakistani waters. *Asterionella glacialis* is a non-toxic bloom forming species, produces dark greenish-brown patches in water and has been included among red tide species (Cox *et al*., 2003, Kyushu Report, 2009). *Asterionella glacialis* abundance is recommended to be monitored on regular basis in Pakistani waters as it may be implicated in damage to fisheries industry.

Materials and Methods

Sampling area: The samples were collected bimonthly during May 2002 to July 2003 from Karachi coastal water (Manora Channel) at 2 stations A (mid channel, 24˚49.77'N 66˚57.85'E) and B (channel mouth, 24˚47.93'N 66˚58.87'E). Manora Channel is influenced by the coastal pollution and discharges from the Layari River.

Sampling techniques: Triplicate samples were retrieved from 1 m depth using 1.7 L Niskin bottle and preserved in 1% Lugol's solution and stored in dark-colored bottles at 4ºC. Samples settled in a settling chamber (50 mL; Hydro-Bios, Germany). The settled samples were observed using inverted microscope and number of cells counted according to the procedure described earlier by Utermohl, (1958). Cells were counted from the entire chamber and abundance was calculated as cells^{-1}. Samples were recorded as, for instance, May1, May2, June1 and June, 2 and so on.

Light microscopy (LM) and Scanning electron microscopy (SEM): Water samples were fixed in 1% Lugol's solution for the light microscopic studies using inverted microscope (Olympus BX-51, Japan). Sample for scanning electron microscopy (SEM) were collected in July, 2007 and prepared by the method described by Sournia, (1978). Sample was prepared for SEM by air drying material on clean cover slips. Material was picked up onto a double sticking tape which was then mounted on a stub, sputtered with gold and viewed on a SEM (JSM6380A). The identification was based on Tomas, (1997).

Water parameters: Temperature, salinity (refrectometer), dissolved oxygen (DO; Wrinkler's method: Hanna C100), pH (Hanna HI9023, Italy) and chlorophyll a (Chl a; Strickland & Parsons, 1972) were measured during the study period and correlated with the abundance of *Asterionella glacialis var. japonica* Castracane.

Results

Morphological observations of *Asterionella glacialis*: In light microscopic studies the cells were found in star shaped colony or sometimes in chain of two or three (Fig. 1A & B). The cells are linear and needle like with dissimilar valve ends. Cells ends are expanded from one end called foot poles. The remaining portion of the cell is straight and varies in diameter (Fig. 1C). Cells are united with one and other by gelatinous cushions at the end point of the base. Each valve has a narrow pseudoraphe, which can be seen in Fig. 1. In SEM the apical axis measured 60µm. Tansapical axis of head pole and foot pole were measured 2 µm and 10 µm respectively (Table 2).

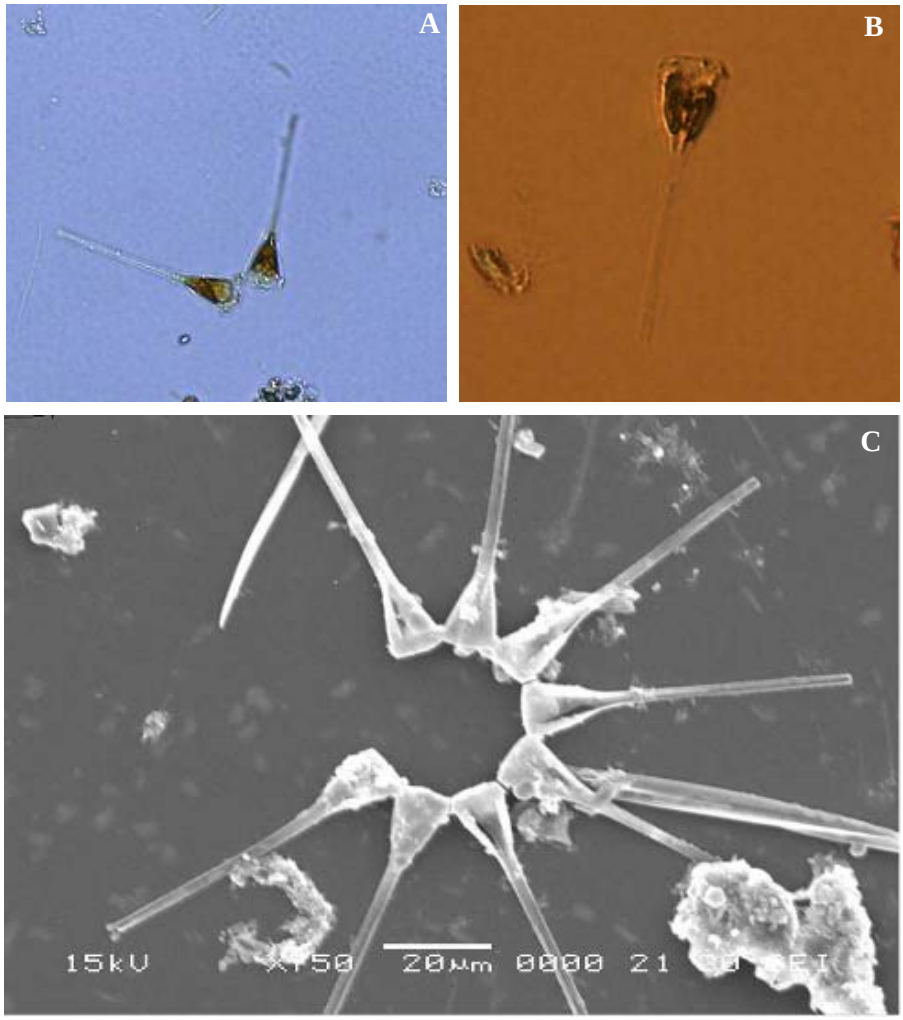

Fig.1. Star shaped colony of *Asterionella glacialis,* (A, B) LM (Light microscopic micrograph, (C) SEM (Scanning electron micrograph).

Seasonal abundance of *Asterionella glacialis*: The species was recorded twice at station B and on three occasions at station A. Average cell abundance ranged from 67-127 cells^{-l}, (mean±SD; 91±32) at station A and 27-107 cells^{-l}, (mean±SD; 67±57) at station B (Table 3). Highest cell numbers (127cells^{-l}) were observed in the month of July, 2002 at station A. Lower cell concentration (27 cells^{-l}) was observed in the month of June, 2002 and higher cell counts were encountered (107cells^{-l}) in the month of February, 2003 at station B (Table 1). Overall the high cell abundance recorded in the month of July, 2002.

Seasonal variations of water parameters: The water parameters including Chlorophyll a, temperature, salinity, pH, dissolved oxygen and transparency were measured during the study period. Chlorophyll a concentration ranged from 2.3-4.8µg/ L with an average of 3.8±1.3 and from 2.0-103.2µg/ L with an average of 52.6±71.5 at station A and B respectively (Table 3). Maximum value for Chlorophyll a was observed in June-1, 2002 at station B and minimum value was recorded in February, 2, 2003 at station B. Salinity ranged from 36-39psu and with an average of 37±2 and 38psu with an average of 38±0 at station A and B respectively (Table 3). Highest salinity was recorded in July, 1, 2002 at station A and lower value was also observed in July, 1, 2003 at same station. Water temperature fluctuated from 28-30◦C and 24-30◦C with an average of 30±2 and 27±4.2 at stations A and B respectively (Tab 3). High value of temperature was recorded in July, 1, 2003 at station A and minimum value was observed in February, 2, 2003 at station B. Dissolved oxygen concentration was ranged from 3.2-5.6 mg/L and 3.2-4.8 mg/L with an average of 4.7±1.3 and 4.0±1.1 at stations A and B respectively (Table 3). High dissolved oxygen was recorded in July, 1, 2002 at station A and lowest values were recorded in June, 1, 2002 at both stations. The pH values ranged from 7.3-7.8 and 7.4-7.7 with an average of 7.5±0.27 and 7.5±0.2 at stations A and B respectively (Table 3). Maximum value was observed in July, 1, 2002 at station A and at station B it was in February, 2, 2003. Seechi depth (transparency) ranged from 32-43cm and 30-134cm with an average of 38±8 and 82±73.5 at stations A and B respectively (Table 3). Maximum value observed was in July, 1, 2003 at station A and in February, 2, 2003 at station B.

Table 1. Seasonal variation in total abundance (cells^{-l}), temperature (°C), salinity (psu), dissolved oxygen (mg/L), chlorophyll a (µg/L), transparency (cm) and pH within the sampling month.

Stations	Month	Abundance (cells-l)	Temperature (°C)	Salinity (psu)	DO (mg/L)	Chlorophyll a (µg/L)	Transparency (cm)	pH
A	June, 2002	80	30	37	2.9	4.3	32	7.3
	July, 2002	127	28	39	5.2	2.3	31	7.8
	July, 2003	67	32	36	5.1	4.8	43	7.4
B	June, 2002	27	30	38	3.2	103.2	30	7.4
	Feb, 2003	127	24	38	4.8	2.06	134	7.4

Table 3. Average and men ± SD of total cell abundance (cells^{-l}), salinity (psu), temperature (°C), dissolved oxygen (DO, mg/L), chlorophyll a (µg/L), transparency (cm) and pH within the sampling month from station A, B.

Stations	Abundance (cells-l)	Temperature (°C)	Salinity (psu)	DO (mg/L)	Chlorophyll a (µg/L)	Transparency (cm)	pH
A	67 – 127	36 – 39	28 – 30	3.2 – 5.6	2.3 – 4.8	32 – 43	7.3 – 7.8
	91 ± 32	37 ± 2	30 ± 2	4.7 ± 1.3	3.8 ± 1.3	38 ± 8	7.5 ± 0.27
B	27 – 107	-38	24 – 30	3.2 – 4.8	2.0 – 103.2	30 – 134	7.4 – 7.7
	67 ± 57	38 ± 0	27 ± 4.2	4.0 ± 1.1	52.6±71.5	82 ± 73.5	7.5 ± 0.2

Table 4. Correlations (Pearson) of total abundance with water parameters at station A.

	Abundance	Salinity	Temp.	DO	Trans.	pH
Salinity	0.980*					
Temp	-0.983	-0.211				
DO	0.347	0.241	0.322			
Trans	-1.000	0.080	-0.379	0.056		
pH	0.938*	-0.136	-0.003	0.159	0.504	
Chl a	-1.000	-0.266	0.144	-0.133	-0.084	0.079

Chl a. DO. Temp. Trans refer to chlorophyll a, dissolved oxygen, temperature and transparency respectively.
*=Significant at probability 0.05

Table 2. Measurements of *Asterionella glacialis*.

Character	Measurements
Apical axis	60 µm
Transapical axis	
(Head pole)	2 µm
(Foot pole)	10 µm

Statistical analysis: Correlation (Pearson) was applied to investigate the relationship of cell abundance *Asterionella glacialis* and water parameters. At station A positive values were observed as 0.980, 0.347, 0.938 with salinity, dissolved oxygen and pH respectively with abundance (Table 4). A negative correlation was observed as -0.983, -1.000 and -1.000 with temperature, transparency and chlorophyll a, respectively (Table 4). The correlation values at station B were not calculated because of the less number of observations.

Discussion

Asterionella glacialis is reported as a bloom forming diatom species from many regions including Pakistani coastal areas (Khan, 1986) but considerably lower cell abundance was encountered from Manora Channel during our study period. This could be due to the increasing trend of pollution along the channel during the last two decades. Manora Channel, from where the samples were collected, also faces effluent discharges and sewage inputs from Layari River causing eutrophication in the area (Tabassum & Saifullah, 2011; Naz *et al*., 2012).

A large bloom of *Asterionella* species was reported from Willapa Bay USA in the month of July during 2002 by Cox *et al.*, (2003). Our findings also show the high abundance in the month of July at station A. This species was also reported from Zuari estuary, Goa, west coast of India (Redekar & Wagh, 2000) in the month of February, similar with our findings high cell density was also observed there in the same month at station B. From Malabar Coast, India (Ramiah *et al.*, 2007) this species was recorded and showed highest cell numbers in the month of July during 2005. Our results also showed highest cell abundance in the same month. Verlecar *et al.*, (2006) reported this species from Karnataka (India) in high abundance from a station Kulai facing effluent discharges. This species was also reported as dominant species from Daya Bay South China Sea (Wang *et al.*, 2004).

Asterionella glacialis abundance was usually seen in the months of July and February at the end of upwelling season (South west and Northeast Asian monsoon) as reported from various geographical regions mentioned above including present investigations with comparatively lower temperature, high dissolved oxygen and significant positive correlation= 0.980 with salinity.

The studied areas are constantly experiencing various hydrographical changes due to the monsoon system persistently affecting the Asian regions. Upwelling is a phenomenon constantly taking place in the northern Arabian Sea by the force of monsoon system. It could be the reason that up-welled waters have great influence on abundance of this species and that may be a requirement for the existence of this species.

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