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RESEARCH ARTICLE

Distribution of Diatoms in Riverine, Estuarine and Coastal Waters off Mangalore, Karnataka

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Abstract

The present study focused on the distribution of diatoms carried out for a period of 16 months from October 2012 to January 2014 in the riverine, estuarine and coastal waters off Mangalore. Large variations in salinity were observed in almost all the stations encompassing the riverine, estuarine and coastal waters suggesting a strong tidal influence during pre-monsoon and influence of riverine influx in monsoon and post-monsoon seasons that resulted in changes in the distribution pattern of diatoms. The vertical haul of plankton samples collected monthly by using Heron-Trantor net showed 43 genera of diatoms to occur in the region, of which 28 belonged to centrales and 15 to pennales. Pennales appeared to be dominant towards riverine waters and centrales towards coastal waters.

Keywords: Diatoms, distribution, Mangalore, coastal waters, salinity, riverine, estuarine, pennales, centrales.

Introduction

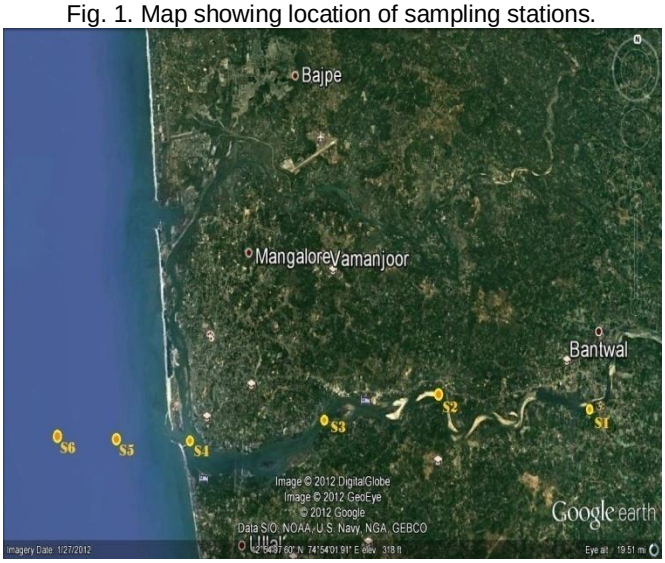
Diatoms are microscopic unicellular algae characterized by large quantity of silica impregnated in the cell wall called frustule and are being extensively used as bioindicators in water quality assessments as they have short generation time and many species have a specific sensitivity to ecological characteristics (Stevenson and Pan, 1999; Goma *et al*., 2005). Diatoms tend to have significantly higher maximum uptake rates of nutrients than any other group (Litchman *et al*., 2006) and are considered as a euryhaline and eurythermal phytoplankton group, which grow quickly under estuarine conditions. They prefer to inhabit and dominate the phytoplankton community in shallow, turbulent and upwelling region i.e. coastal region. Diatoms are generally known to be adapted to low light levels and are therefore capable of surviving in the turbid estuaries, while green algae are known to depend on relatively high light intensities (Lionard *et al*., 2005). Diatoms are the preferred food of many grazers and organisms in the upper trophic levels and thus form the basis for many of the productive fisheries.

Moving down from a river through an estuary and to coastal waters, demonstrates major changes in physico (depth, turbulence etc.) chemical (pH, salinity, nutrients etc.) characteristics. These changes in the hydrological conditions in turn influences the community structure of biota in general and phytoplankton in specific, as these conditions profoundly influences production of phytoplankton, moreover the distribution of phytoplankton is also influenced by the passive transport through water movements. Besides, different multi-stressors (light availability, hydrodynamics, nutrient levels and their stoichiometry, grazing pressure), salinity is often considered as one of the major factor determining the composition and distribution of phytoplankton from river-ocean continuum. During downstream transport from riverine to estuarine waters, stenohaline riverine species will lyse early once when their salinity tolerance exceeds, whereas euryhaline species can regulate their intra-cellular osmotic pressure and continue to grow further downstream seawards. The same is true with marine species that advect upstream in to estuarine waters during tidal mixing. A unique feature of the rivers along the west coast of India is the phenomenal tides to which they are subjected. As a consequence, these rivers experience large influxes of sea water which have a significant impact on circulation, salinity (Vijith *et al*., 2009) as well as water column turbidity caused by the disturbance of bottom sediments (Devassy and Goes, 1988). On account of this, free mixing of coastal sea water with freshwater, these rivers represent a stressing habitat for phytoplankton growth defined by large fluctuations in salinity, nutrients, light and temperature (Devassy and Goes, 1988). Against these backdrops, the present study focused on the distribution of diatoms carried out for a period of 16 months from October 2012 to January 2014 in the riverine, estuarine and coastal waters off Mangalore.

Materials and methods

Collection of samples: A total of six stations were selected along river to ocean continuum i.e. two each in riverine (Nethravati), estuarine (Nethravati) and coastal (Arabian Sea, off Mangalore) waters. The riverine stations S1 and S2 were fixed at Panemangalore and Farangipet respectively (Fig. 1).

Fig. 1. Map showing location of sampling stations.



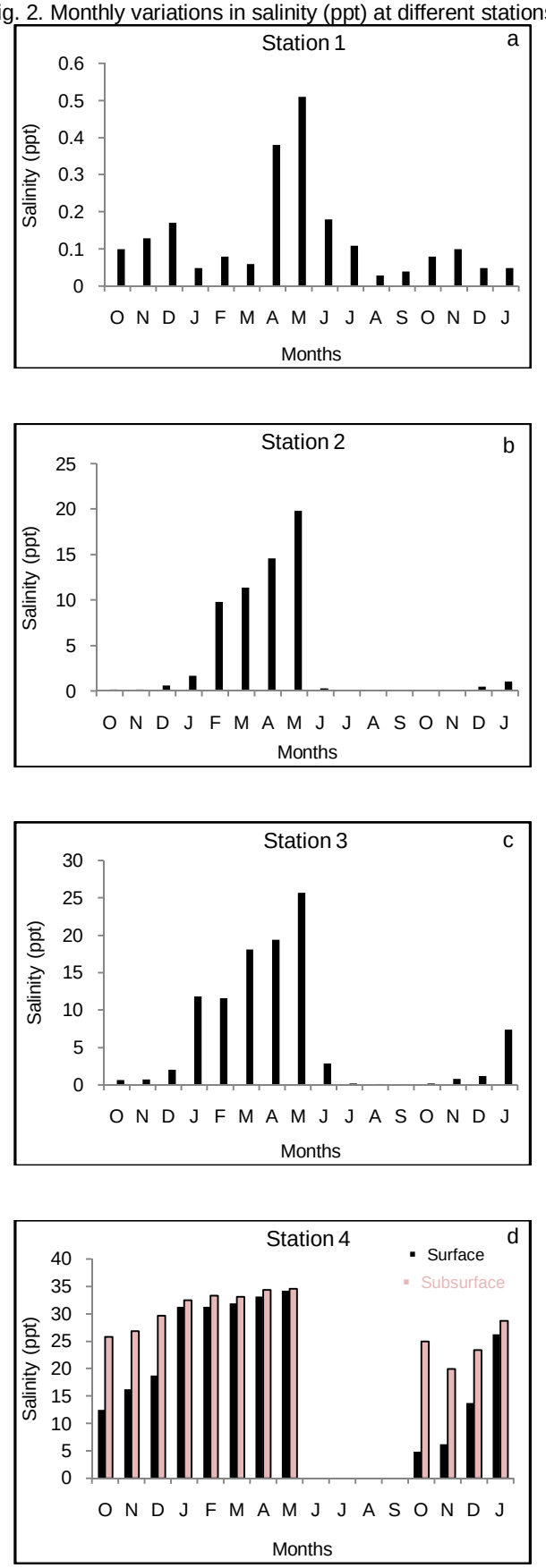
While estuarine stations S3 and S4 were fixed at Adyar and at Lat. 12º.50^{1}.747^{11} North and Long. 74º.49^{1}.685^{11} East av. depth 4.5 m. Coastal stations S5 and S6 were fixed at Lat. 12º.50^{1}.699^{11} North and Long. 74º.48^{1}.940^{11} East av. depth 7.0 m and Lat. 12º.50^{1}.605^{11} North, Long. 74º.47^{1}.948^{11} East av. depth 10.0 m respectively (Fig. 1). Sampling was carried out on monthly basis from all the sampling stations during the period from October 2012 to January 2014, except during southwest monsoon season (June-September) for stations S_4, S_5 and S_6 owing to rough weather conditions of the sea. Water samples were collected at surface in all stations, while subsurface water samples were drawn only at S4, S5 and S6 stations and no subsurface samples were drawn at S1, S2 and S3 stations considering their shallowness.

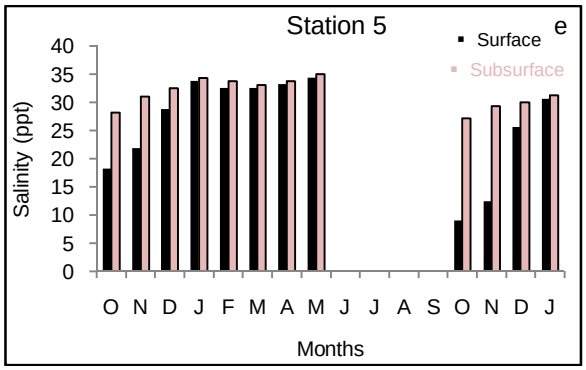
Vertical haul of phytoplankton samples were collected using Heron-Trantor plankton net (60 µm mesh size) and preserved in 4% formalin on board the vessel for further analysis. In the laboratory, the plankton samples were filtered through a 198 µm nylon bolting silk cloth to separate the zooplankton. The filtrate along with the phytoplankton was made up to a known volume (100 mL) and was preserved in Lugol's solution. The subsamples of plankton were used for identification of diatoms to genera level by referring to the standard literature (Smith, 1950; Davis, 1955; Tomas, 1996; Bellinger and Sigee, 2010). For salinity analyses, surface water samples were collected using a clean plastic bucket while subsurface samples using Nansen's reversing water sampler and were transported to the laboratory for further analysis. The salinity was analyzed using standard procedure (Strickland and Parsons, 1972) and expressed in ppt.

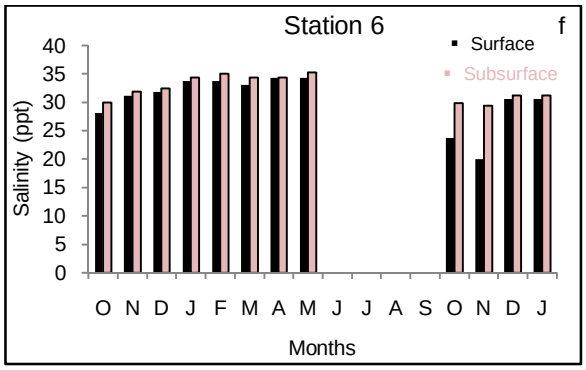
Results and discussion

A salinity gradient was observed moving from riverine stations towards coastal stations. Spatio-temporal variations in salinity profile are plotted in Fig. 2a-f. Wide and significant spatio-temporal variations in salinity were observed along river-ocean continuum.

Fig. 2. Monthly variations in salinity (ppt) at different stations.







The salinity in riverine waters varied from 0.03 ppt to 19.85 ppt with a range of 0.03 to 0.51 ppt at S1 and 0.03 to 19.85 ppt at S2. Though S2 is a riverine station, the salinity range was found to be high at S2 owing to tidal influence especially during pre-monsoon compared to S1. In estuarine waters, the salinity varied from 0.04 ppt to 34.59 ppt with a range of 0.04 to 25.62 ppt at S3 and 4.87 to 34.59 ppt at S4. The large variations in salinity at S3 are due to high tidal influence during pre-monsoon season. Similar variations in salinity were also observed at S4, as it is subjected to coastal water influence throughout as well as freshwater influx during monsoon and post-monsoon seasons. Salinity of coastal waters varied from 9.12 ppt to 35.30 ppt with a range of 9.12 to 34.99 ppt at S5 and 19.99 to 35.30 ppt at S6. At coastal stations, because of their close proximity to the estuarine mouth, freshwater influence was high at S5 and to certain extent at S6 during monsoon season.

A total of 43 genera belonging to centrales (28) and pennales (15) diatoms were recorded during the present investigation. The diversity of centrale and pennate diatoms at each selected station is presented in Table 1. The number of genera of centrales and pennales representing diatom community at different stations is depicted graphically in Fig. 3.

Investigating on Bhadra river waters, Sashishekar *et al.* (2008) reported presence of diatom genera such as *Melosira, Cymbella, Gomphonema, Navicula, Fragilaria, Pinnularia, Nitzschia, Surirella, Tabellaria, Gyrosigma* spp. while, Das and Dutta (2011) observed the diatoms *Asterionella, Fragilaria, Navicula, Surirella, Tabellaria* in Pagladia river waters. Suresh *et al*. (2013) in Tungabhadra river waters noticed the diatom genera *Nitzschia, Navicula, Pinnularia, Fragilaria, Melosira.* In River Seeta at Seetanadi, Ramesha and Sophia (2013) observed the presence of diatoms belonging to genera *Diploneis, Gyrosigma, Navicula, Pinnularia, Gomphonema, Asterionella, Fragilaria, Tabellaria, Surirella, Nitzschia* spp. During the present investigation, the diatom genera that were encountered in Nethravati riverine waters included, *Campylodiscus, Coscinodiscus, Cymbella, Diploneis, Melosira, Planktoniella* spp. among centrlales and *Asterionella, Fragilaria, Gomphonema, Gyrosigma, Navicula, Nitzschia, Pinnularia, Pleurosigma, Surirella, Tabellaria, Thalassionema and Thalassiothrix* spp. among pennales.

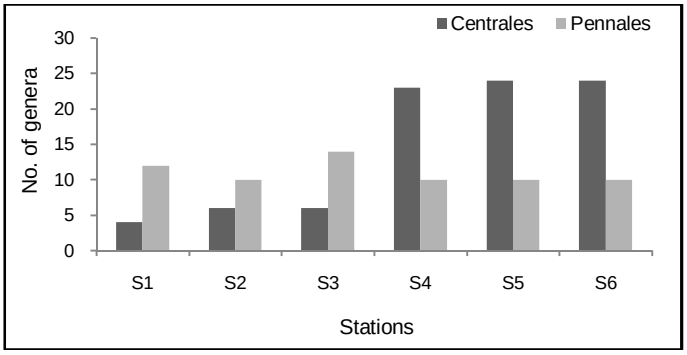
Investigating on Zuari estuaine waters, Redekar and Wagh (2000) reported diatom genera like *Coscinodiscus, Biddulphia, Skeletonema, Rhizosolenia, Chaetoceros, Ditylum, Lauderia, Melosira, Planktoniella, Bacteriastrum, Bacillaria, Navicula, Nitzschia, Pleurosigma, Thalassiothrix, Asterionella* spp. Perumal *et al*. (2009) observed the diatom genera *Asterionella, Bacillaria, Bacteriastrum, Biddulphia, Bellerochea, Chaetoceros, Coscinodiscus, Cyclotella, Ditylum, Eucampia, Fragilaria, Gyrosigma, Leptocylindrus, Lauderia, Navicula, Nitzschia, Planktoniella, Pleurosigma, Rhizosolenia, Skeletonema, Helicotheca, Thalassionema, Thalassiothrix* and *Triceratium* spp. in Kaduviyar estuary. In Mahanadi estuarine waters, Naik *et al*. (2009) documented the presence of diatoms belonging to genera *Asterionella, Biddulphia, Coscinodiscus, Melosira, Rhizosolenia, Skeletonema, Leptocylindrus* and *Thalassiothrix* spp. Palleyi *et al*. (2011) observed the diatoms *Coscinodiscus, Skeletonema, Navicula, Nitzschia, Thalassiothrix, Triceratium, Biddulphia, Melosira, Rhizosolenia, Thalassionema, Chaetoceros, Bacillaria* and *Pleurosigma* spp. in Dharma river estuary. Shruthi *et al*. (2011) reported diatom genera such as *Cyclotella, Gomphonema, Melosira, Navicula, Nitzschia, Pinnularia, Pleurosigma, Pseudo-nitzschia, Rhizosolenia, Skeletonema* spp. in Dakshina Kannada estuarine waters, Karnataka. George *et al*. (2012) noticed the presence of *Plerosigma, Biddulphia, Chaetoceros, Coscinodiscus, Fragilaria, Leptocylindrus, Navicula, Nitzschia* and *Synedra* spp. of diatoms in Tapi estuarine waters. In the present investigation, the diatom genera that were documented in Nethravati estuarine waters includes, *Bacteriastrum, Bellerochea, Biddulphia, Campylodiscus, Cerataulina, Chaetoceros, Climacodium, Coscinodiscus, Cyclotella, Ditylum, Eucampia, Guinardia, Helicotheca, Lampriscus, Lauderia, Leptocylindrus, Lithodemium, Melosira, Planktoniella, Proboscia, Rhizosolenia, Skeletonema* and *Triceratium* spp. among centrales and *Asterionella, Bacillaria, Fragilaria, Gomphonema, Gyrosigma, Navicula, Nitzschia, Pinnularia, Pleurosigma, Pseudo-nitzschia, Surirella, Synedra, Tabellaria, Thalassionema* and *Thalassiothrix* spp. among pennales.

Table 1. List of centric and pennate diatoms encountered at different stations during the present investigation period (Oct 2012–Jan 2014).

Types of water/Stations	Riverine waters (Salinity range: 0.03-19.85 psu)		Estuarine waters (Salinity range: 0.04-34.59 psu)		Coastal waters (Salinity range: 9.12-35.30 psu)	
Genera	S1	S2	S3	S4	S5	S6
Centrales						
Bacteriastrum spp.	-	-	-	P	P	P
Bellerochea spp.	-	-	-	P	P	P
Biddulphia spp.	-	-	-	P	P	P
Campylodiscus spp.	P	P	P	P	P	P
Cerataulina spp.	-	-	-	P	-	-
Chaetoceros spp.	-	-	P	P	P	P
Climacodium spp.	-	-	-	P	P	P
Coscinodiscus spp.	P	P	P	P	P	P
Cyclotella spp.	-	-	P	P	P	P
Cymbella spp.	-	P	-	-	-	-
Diploneis spp.	-	P	-	-	-	-
Ditylum spp.	-	-	-	P	P	P
Eucampia spp.	-	-	-	P	P	P
Guinardia spp.	-	-	-	P	P	P
Helicotheca spp.	-	-	-	P	P	P
Hemiaulus spp.	-	-	-	-	P	P
Lampriscus spp.	-	-	-	P	P	P
Lauderia spp.	-	-	-	P	P	P
Leptocylindrus spp.	-	-	-	P	P	P
Lithodesmium spp.	-	-	-	P	-	-
Melosira spp.	P	P	P	P	P	P
Planktoniella spp.	P	P	-	P	P	P
Proboscia spp.	-	-	-	P	P	P
Pseudosolenia spp.	-	-	-	-	P	P
Rhizosolenia spp.	-	-	-	P	P	P
Skeletonema spp.	-	-	-	P	P	P
Stephanopyxis spp.	-	-	-	-	P	P
Triceratium spp.	-	-	P	P	P	P
Pennales						
Asterionella spp.	P	-	P	P	P	P
Bacillaria spp.	-	-	P	P	P	P
Fragilaria spp.	P	P	P	P	P	P
Gomphonema spp.	P	P	P	-	-	-
Gyrosigma spp.	P	P	P	P	P	P
Navicula spp.	P	P	P	P	P	P
Nitzschia spp.	P	P	P	P	P	P
Pinnularia spp.	P	P	P	-	-	-
Pleurosigma spp.	P	P	P	P	P	P
Pseudonitzschia spp.	-	-	-	P	P	P
Surirella spp.	P	P	P	-	-	-
Synedra spp.	-	-	P	-	-	-
Tabellaria spp.	P	P	P	-	P	P
Thalassionema spp.	P	-	P	P	P	P
Thalassiothrix spp.	P	P	P	P	-	-

Madhav and Kondalarao (2004) while investigating on the phytoplankton of coastal waters of east coast of India, noticed the diatom genera *Bacillaria, Bacteriastrum, Chaetoceros, Climacodium, Ditylum, Eucampia, Fragilaria, Guinardia, Hemiaulus, Lauderia, Leptocylindrus, Melosira, Navicula, Nitzschia, Planktoniella, Plerosigma, Pseudo-nitzschia, Rhizosolenia, Stephanopyxis, Thalassionema* and *Triceratium.* In Agnitheertham and Kothandaramar Koil coastal waters, Sithik *et al*. (2009) reported the presence of diatoms *Coscinodiscus, Planktoniella, Skeletonema, Ditylum, Triceratium, Chaetoceros, Bacteriastrum, Biddulphia, Bellerochea, Eucampia, Leptocylindrus, Rhizosolenia, Bacillaria, Pleurisigma, Nitzschia, Navicula, Stephanopyxis* and *Thalassionema* spp. Investigating on the phytoplankton of coastal waters of Mangalore, Harnstom *et al*. (2009) revealed the presence of diatoms belonging to genera *Asterionella, Biddulphia, Bacteriastrum, Chaetoceros, Climacodium, Coscinodiscus, Ditylum, Eucampia, Fragilaria, Guinardia, Hemiaulus, Leptocylindrus, Melosira, Rhizosolenia, Skeletonema* and *Thalassionema.* Sahu *et al*. (2012) in Kalpakkam coastal waters observed the diatoms belonging to genera *Coscinodiscus, Leptocylindrus, Melosira, Stephanopyxis, Lauderia, Skeletonema, Cyclotella, Proboscia, Rhizosolenia, Guinardia, Bacteriastrum, Chaetoceros, Biddulphia, Eucampia, Hemiaulus, Ditylum, Helicotheca, Campylodiscus, Triceratium, Fragilaria, Asterionella, Thalassionema, Navicula, Pleurosigma, Gyrosigma, Bacillaria, Pseudo-nitzschia* and *Nitzschia* spp.

Fig. 3. Genera wise distribution of centrale and pennate diatoms at different stations.



In the present study, the diatom genera that were noticed in coastal waters of Mangalore includes, *Bacteriastrum, Bellerochea, Biddulphia, Campylodiscus, Chaetoceros, Climacodium, Coscinodiscus, Cyclotella, Ditylum, Eucampia, Guinardia, Helicotheca, Hemiaulus, Lampriscus, Lauderia, Leptocylindrus, Melosira, Planktoniella, Proboscia, Pseudosolenia, Rhizosolenia, Skeletonema, Stephanopyxis* and *Triceratium* spp. among centrales and *Asterionella, Bacillaria, Fragilaria, Gyrosigma, Navicula, Nitzschia, Pleurosigma, Pseudo-nitzschia, Tabellaria* and *Thalassionema* spp. among pennales.

The centrale diatoms belonging to the genera *Campylodiscus, Coscinodiscus, Melosira* and *Planktoniella* spp. and pennales belonging to the genera *Asterionella, Fragilaria, Gyrosigma, Navicula, Nitzschia, Pleurosigma, Tabellaria* and *Thalassionema* spp. were observed in Nethravati river, Nethravati estuary and coastal waters of Mangalore. The pennate diatoms that were exclusively observed in estuarine and coastal waters includes *Bacillaria* and *Pseudonitzschia* spp., while, *Gomphonema, Pinnularia* and *Surirella* spp. were observed exclusively in riverine and estuarine waters. Among centrales, *Cymbella* and *Diploneis* spp. were observed exclusively in riverine waters, whereas, *Cerataulina* and *Lithodesmium* spp. were found exclusively in estuarine waters. *Hemiaulus, Stephanopyxis* and *Pseudosolenia* spp. were observed exclusively in coastal waters. The centrales that were observed exclusively in estuarine and coastal waters includes *Bacteriastrum, Bellerochea, Biddulphia, Campylodiscus, Chaetoceros, Climacodium, Coscinodiscus, Cyclotella, Ditylum, Eucampia, Guinardia, Helicotheca, Lampriscus, Lauderia, Leptocylindrus, Melosira, Planktoniella, Proboscia, Rhizosolenia, Skeletonema* and *Triceratium* spp.

Conclusion

The present investigation revealed pennales to be the dominant in riverine waters, including estuarine head while, centrales towards the coastal waters with respect to the number of genera representing diatom community. A discernable shift with respect to the dominance, from pennales to centrales that was observed in estuarine waters between S3 (estuarine head region, experiencing riverine influence) and S4 (estuarine mouth region, experiencing coastal water influence) stations suggest in part that, salinity might have played a prominent role in their distribution.

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