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Status of Phytoplankton Diversity and Abundance in Damanganga Estuary, Gujarat

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ABSTRACT

Damanganga estuary is very productive and important estuary in South Gujarat for fishing activity. The status of phytoplankton diversity and abundance were checked in this estuary from January to December 2019. For this purpose, phytoplankton samples were collected by following standard procedure and analyzed. The alpha and beta diversity indices were calculated. From this case study it was pointed out that Bacillariophyceae was the dominant phytoplankton in abundance as well as very diverse taxa, although the phytoplankton diversity was poor (H'=1.40 to 1.60) as well as moderate evenness (average 0.5). Phytoplankton abundance was fluctuated spatially and temporally, the maximum abundance was found from midstream (575 No/L) followed by downstream (422 No/L) and upstream (311 No/L) and temporally maximum abundance was found during summer (637 No/L) followed by winter (450 No/L) and monsoon (219 No/L).

Keywords Phytoplankton, Diversity, Abundance, Estuary.

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INTRODUCTION

Phytoplankton is considered to be important primary producers with approximate 90 % of the total oxygen production and 50 % of the total photosynthesis. They also play an important role in water ecosystems as pollution indicators (Singh *et al.* 2013). They are the wanderers in the aquatic realms. They are phylogenetically highly successful groups as regards to phylogenetic age, number of living species and success of adaptive radiation (Santhanam *et al*. 2019). Many authors have undertaken study of plankton in water bodies like rivers, lakes, ponds, reservoirs, fish farms, estuaries giving importance to periodicity in relation to physicochemical regime of water, species abundance and equitability. There had been attempts to study the plankton of Indian waters prior to 1960. During the IIOE survey, although there was a special interest in studying marine plankton, it has culminated only in delineating the areas of high and low productivity (Thippeswamy and Malathi 2009). Many investigators investigated the phytoplanktonic flora in different ecosystems have concluded that it is easier to study the periodicity and distribution of individual groups of plankton rather all the groups together. With this background, in the present study, an attempt has been made to discuss the occurrence and distribution of phytoplankton. It is important to study population dynamics, community structure, species composition, species diversity of phytoplankton while undertaking ecological investigations in aquatic ecosystems, particularly in estuarine water resources. The study on taxonomy, ecology, biology and biochemistry of phytoplankton would give an index of potential in aquatic environment. It is very crucial for both aquatic ecology and human being's future welfare by giving feed as well as livelihood directly or indirectly forthe millions of people living in inland and coastal areas (Santhanam *et al.* 2019).

MATERIALS AND METHODS

The samples were drawn from January to December, 2019 comprising bimonthly intermission at three stations of Damanganga estuary (Downstream, Midstream and Upstream). Phytoplankton samples were collected at 2-8 m depth using plankton net (20 µ mesh size) filtering 50 L water concentrated to 100 mL and preserved in 4% formalin for intended work (Narmada *et al.* 2015). The Microscopy (LABOMED STC-HL) was used to carry out phytoplankton samples analysis at the magnification of 10 x, 40 x and 100 x. Taxonomic study of phytoplankton was carried out by using standard sources (https://www.algaebase.org/, https://www.inaturalist.org/taxa/). The enumerations of phytoplankton were carried out with the aid of standard protocols (Verlecar and Desai 2004).

Species biodiversity measurement: Margalef richness (S), Shannon Wiener Index (H') (1949), Simpson Dominance Index and Pielou's evenness index (1966) (E) have been used for measuring Alpha diversity while Beta diversity was measured using Jaccard Index and Sorensen Index (Niyoyitungiye *et al.* 2019).

RESULTS AND DISCUSSION

The coastal ecosystem has interact zone of aqua and terra systems that connected to the ocean and become an important system, due to the geological, chemical, physical and biological processes in surrounding them (Bauer *et al.* 2013). The results of this study show that changes in the structure of the phytoplankton communities are modulated overtime and space in this estuary. The groups of phytoplankton recorded in the present study of estuarine belt from Damanganga River are Bacillariophyta (31), Chlorophyta (10), Dinophyta (9), Cyanophyta (8), Euglenophyta (3), Chrysophyta (1) and Raphidophyta (1). In this trail total 63 species of phytoplankton were listed out. Among them fifty four species from downstream, 47 species from midstream and 29 species from upstream site were recorded. The numbers of species from downstream were 29 of Bacillariophyceae (A=53.70%), 9 of Dinophyceae (B=16.67%), 5 from Chlorophyceae (C=9.26%), 6 from Cyanophyceae (D=11.11%), 1 from Raphidophyceae (E=1.85%), 3 from Euglenophyceae (F=5.56%) and 1 of Chrysophyceae (G=1.85%). From the midstream, number of recorded species of Bacillariophyceae, Dinophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, Chrysophyceae were 22 (A=46.81%), 6 (B=12.77%), 9 (C=19.15%), 6 (D=12.77%), 3 (F=6.38%) and 1 (G=2.13%) respectively. The upstream site had species composition of phytoplankton with the number of species 10 (A=34.48%), 5 (B=17.24%), 7 (C=24.14%), 4 (D=13.79%), 2 (F=6.90%) and 1(G=3.45%) from respective categories such as Bacillariophyceae, Dinophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Chrysophyceae (Figs. 1-3). Raphidophyceae was not reported from the midstream and upstream. Bacillariophyceae was

Fig. 1. Map of the study area showing sampling sites.

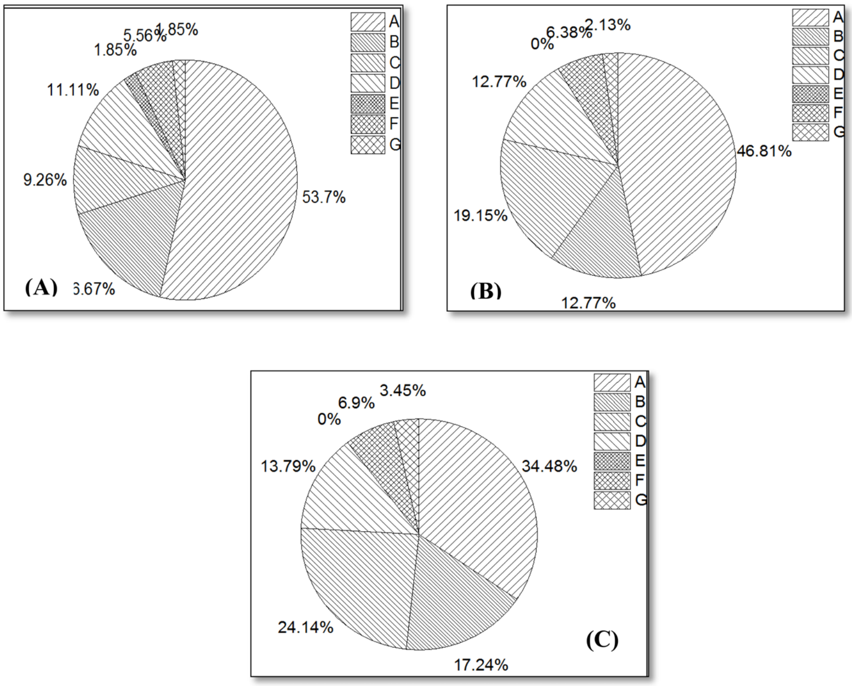


Fig. 2. Phytoplankton species composition (A) Downstream, (B) Midstream, (C) Upstream.

the dominant in this estuary. Bat *et al.* (2011) reported Bacillariophyceae were the most dominant in the Black Sea which is corroborating with our record. The fluctuation of phytoplankton assemblages is strongly affected to water stratification and meteorological system (Narmada *et al.* 2015). The diatom was reported as the most diverse group from Coastal Mediterranean Lagoons (Stefanidou *et al.* 2020). The phytoplankton taxa of riverine and estuarine ecosystems varied temporally and during rainy season they are varied predominantly, due to the amount of river flow and nourishing components runoff from surroundings governed through the heavy rain falls into the lower estuary. Phytoplankton species composition, diversity, biomass and distribution experience constant changes because of seasonal and temporal variations (Córdoba-Mena *et al.* 2020).

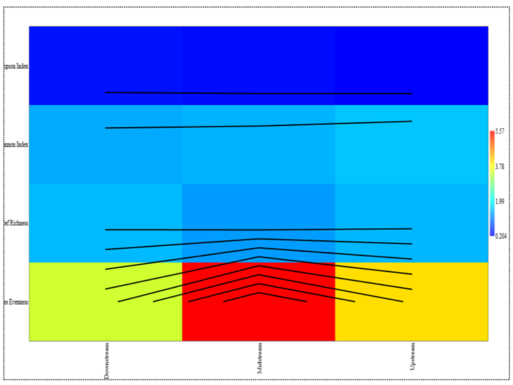
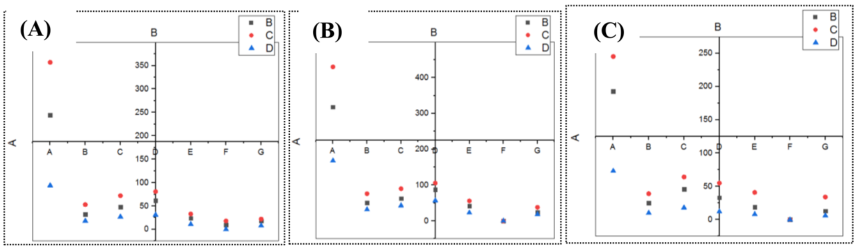


Fig. 3. Alpha diversity indices for phytoplankton diversity.

Alpha diversity indices (Fig. 3) and beta diversity indices (Tables 1, 2) were measured from this estuary based on spatial distribution of phytoplankton as like in Coastal Mediterranean Lagoons (Stefanidou *et al.* 2020). Shannon-Wiener diversity index is ranged from 1.40 to 1.60 indicated less diversity of phytoplankton from this estuary. Hastuti *et al.* (2018) also noted low diversity of plankton in Perancak estuary, Bali.Simpson dominance index and Margalef richness index were found between 0.20 to 0.33 and 1.30 to 1.50 respectively revealed poor richness. Pielou's



*(B=winter; C=summer, D=Monsoon)

Fig. 4. Phytoplankton abundance (A) Downstream, (B) Midstream, (C) Upstream.

evenness index was 0.4417, 0.5677 and 0.0144 at downstream, midstream and upstream respectively which pointed out that the upstream site had very low abundance while downstream and midstream site have moderate abundance of phytoplankton. Stefanidou *et al.* (2020) also reported low evenness from Coastal Mediterranean Lagoons. Alpha diversity indices were also calculated from Kadalundi estuary, Kerala, India (Ali Akshad *et al*. 2019). From the Table 2, it has been shown that Jaccard and Sorensen indices give different coefficient values for the same pair of distinct sampling sites but they reflect both, the same information. Indeed, downstream and upstream pair was top with a similarity coefficient of 0.633 and 0.775 for Sorenson and Jaccard's index respectively. Furthermore, all the values obtained for different pairs of sampling sites are above the average (0.5) and are greater than or equal to 0.60, which means that more than half of the total species belonging to each of the sites are common.

Varied phytoplankton abundance was regulated by riverine inputs. Surrounding runoff can be considered a crucial factor in the area of this study, since agricultural activities nearby utilize fertilizers rich in nitrogen, which alters the structure of the phytoplankton communities.The inverse correlation between abundance and richness of diatoms supports the hypothesis that the diversity and the rate of renovation of phytoplankton communities are inversely correlated (Glibert 2016).The mouth site of the river has low transparency leads to better adaptation of some blue-green algae as well as some diatoms orders Coscinodiscales, Chaetocerales and Thalassiosirales. Dinoflagellates have less capacity to adapt tohigh transparency conditions (Glibert 2016).The phenomenon of ecology revealed the community composition during different seasons: lower abundance of dinoflagellates found during rainy period in the estuarine ecosystems possibly due to the fluvial zone having low transparency (Blanco-Libreros 2009).While, dinoflagellates exhibited higher abundance during the dry season in riverine ecosystem, perhaps due to the discharging of water reduction linked to the decrease in precipitation (Córdoba-Mena *et al.* 2020).

Table 1. Geographical locations of selected sites.

Sites	Latitude	Longitude	Altitude
Downstream	20°4120′N	72°8325′E	950 m
Midstream	20°3876′N	72°8630′E	685 m
Upstream	20°3748′N	72°8740′E	330 m

Phytoplankton abundance was seasonally fluctuated from sampling sites in this estuary. Highest abundance was reported during summer with 796 No/L in the midstream. From the Colombian Caribbean Sea, abundance of phytoplankton was reported maximum during dry season (Córdoba-Mena *et*

Table 2. Jaccard and Sorensen's Similarity Index among sampling sites.

Sites	Downstream	Midstream	Upstream	Beta diversity index
Downstream	1	0.726	0.775	Jaccard's Similarity Index
Midstream		1	0.745	
Upstream			1	
Downstream	1	0.570	0.633	Sorensen's Similarity Index
Midstream		1	0.593	
Upstream			1	

Table 3. ANOVA: Two-factor without replication (Abundance).

Groups	Count	Sum	Average	Variance		
Downstream	3	1263	421	50169		
Midstream	3	1723	574.3333	51858.33		
Upstream	3	934	311.3333	31034.33		
Winter	3	1353	451	16639		
Summer	3	1910	636.6667	25281.33		
Monsoon	3	657	219	12124		
Source of variation	SS	df	MS	F	p-value	F crit
Rows	104706.9	2	52353.44	61.92417	0.000979	6.944272
Columns	262741.6	2	131370.8	155.3866	0.000161	6.944272
Error	3381.778	4	845.4444			
Total	370830.2	8				

al. 2020). In the downstream site phytoplankton abundance was 438 No/L, 636 No/L and 189 No/L cells in the respective seasons of winter, summer and monsoon. The midstream site had highest abundance in all three seasons with 586 No/L in winter, 796 No/L in summer and 341 No/L in monsoon. The lowest abundance was found from the upstream site during monsoon with 127 No/L. During winter and summer the abundance was measured 329 No/L and 478 No/L respectively in the upstream site. Analysis of variance for abundance was computed and it is revealed the significant phytoplankton abundance in this estuary ($p< 0.05$) (Table 3). Bacillariophyceae had highest abundance during all three seasons in all the sampling sites (Fig. 4). Similar finding was found from the tropical estuary Colombian, Caribbean Sea (Córdoba-Mena *et al.* 2020). The lowest abundance was reported by Raphidophyceae in downstream site with 10 No/L and 18 No/L cells during winter and summer respectively. It was not recorded during monsoon season from downstream site. In case of the sites midstream and upstream, Chrysophyceae had lowest abundance with average of 26 No/L and 17 No/L respectively. The seasonal abundance of various phytoplankton taxa was given in Fig. 4. According to abundance, Bacillariophyceae (231 No/L) was the dominant followed by Cyanophyceae (58 No/L), Chlorophyceae (49 No/L), Dinophycaae (34 No/L), Euglenophyceae (22 No/L), Chrysophyceae (16 No/L) and Raphidophyceae (9 No/L) in the downstream site. From the midstream site, average abundance of Bacillariophyceae, Cyanophyceae, Chlorophyceae, Dinophyceae, Euglenophyceae and Chrysophyceae were 305 No/L, 83 No/L, 65 No/L, 53 No/L, 40 No/L and 26 No/L respectively. Average abundance of 170 No/L of Bacillariophyceae, 24 No/L of Dinophyceae, 42 No/L of Chlorophyceae, 33 No/L of Cyanophyceae, 22 No/L of Euglenophyceae and 17 No/L of Chrysophyceae was reported from upstream site (Fig. 4).

CONCLUSION

In conclusion, the estuary exhibits poor phytoplankton diversity. The maximum diversity was reported from downstream followed by midstream and Upstream sites. Phytoplankton diversity and abundance was fluctuated spatially and temporally. Bacillariophyceae was the dominant in context of diversity and abundance.The maximum abundance was found from midstream followed by downstream and upstream and temporally maximum abundance was found during summer followed by winter and monsoon.Raphidophyceae (*Chattonella* sp.) only listed out from downstream site and only during winter and summer; during monsoon it was not recorded. This study will help for intended work of biodiversity of various upper level aquatic organisms from this estuarine ecosystem.

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