Distribution of dinoflagellates along Purnagad estuary, Ratnagiri, Maharashtra

Abstract

A study was carried out in the Purnagad estuary, southwest coast of India, to find out the distribution of dinoflagellates. Samples were collected for one year period during 2022–2023. During the study 22 species of dinoflagellates were encountered among which *Ceratium fusus* was dominant. Relatively high density and diversity of dinoflagellates were encountered in the month of May as compared to the other months. Temperature showed a positive correlation with dinoflagellate community showing its importance in dinoflagellate growth.

Keywords. Dinoflagellates. Species diversity. estuary

1.0 Introduction

In the near-shore and continental shelf areas of the marine environment, dinoflagellates are an important group of protists that are found in various kinds of aquatic habitats, next to diatoms(Sahu et al., 2014). Dinoflagellates are a type of primarily unicellular creatures that belong to the division or Phylum Pyrrhophyta. They are distinguishable from other groups by a number of unique qualities, including organelles, colouring, flagellar insertion, and features of the nucleus. Dinoflagellates and ciliates are the two most diverse groups of algae. There are currently about 2400 identified species of dinoflagellates (Gomez, 2012b). Environmental molecular surveys uncover more groups of primitive dinoflagellates that are not as well-documented, and tens of thousands of new species are published each year (Guillou et al., 2008). Dinoflagellates are neither plants nor animals, many of them exhibit characteristics associated with plants, including the ability to photosynthesise, have walls made of cellulose, and produce starch, which is used as an energy storage material (Carty et al., 2015).

Estuaries are highly productive, dynamic, semi-enclosed waterbodies that are intermittently or permanently connected to the sea. They are nourished by freshwater from river inflows, which produces a unique salinity gradient and unique biota characteristics(Elliott and Mclusky, 2002; Mclusky and Elliott, 2007; Whitfield et al., 2002; Chicharo et al., 2006; Tweedley et al., 2019). The fluctuations in river water mixing with sea water, which produce turbidity, nutrient gradients, and salinity (Svetlichny, 2019), indicate the complexity of a river estuary. Estuaries are dynamic environments that change constantly. They have been recognised as dynamic ecosystems due to their physical characteristics. They get an influx of freshwater during the monsoon, which results in periodic variations in the concentration of nutrients and salinity. A salinity gradient consequently develops along the estuary.Very poor paper has been published on the physico-chemical characteristics in relation to the dinoflagellates in Purnagad estuary (Map. 1) Ratnagiri. Hence the present study was conducted to study the monthly distribution of dinoflagellates and physico-chemcial parameters of water in the Purnagad estuary, southwest coast of India.

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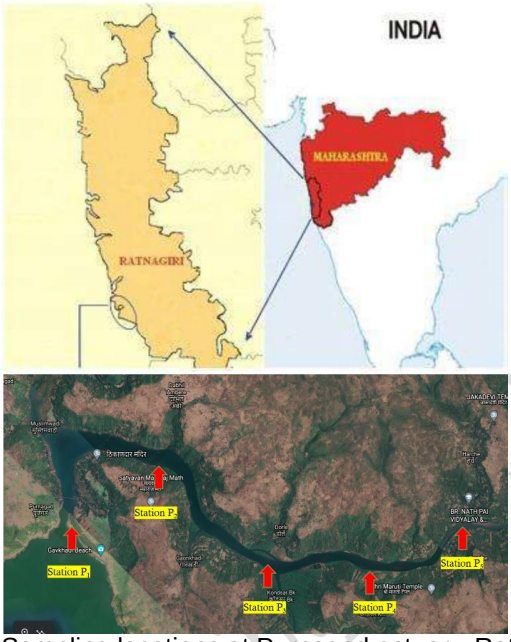
2.0 Material and methods

2.1. Study area and sampling



Map.1 Sampling locations at Purnagad estuary, Ratnagiri

The west coast of India experiences intense rain falls during the monsoon months of June–September, the summer season (February–May) and winter season (October-January). The study was carried out in the estuarine and coastal locations of Purnagad. Based on salinity gradient, sampling was conducted at five sampling stations (Map. 1) in Purnagad estuary. The tidal amplitude Surface samples were collected ~~every~~ monthly from these locations during the high tide-times from February2022 to January 2023.

2.2. Environmental parameters-Field data like atmospheric and surface water temperatures, salinity, dissolved oxygen and pH were measured during the sampling. Nutrients like inorganic phosphate, nitrate, nitrite, silicate, were analyzed by adopting the standard methods (Strickland and Parsons, 1972; AOAC, 2006; APHA, 2005; Andrew et al., 2005 and Rice et al.,2012).

2.3. Dinoflagellate assemblage - Monthly samplings for quantitative and qualitative analyses of dinoflagellates were collected from the estuarine water surface and filtered by ~~using~~ the 60µ plankton net. The collected dinoflagellates samples were preserved in Lugols iodine and 5% neutralized formalin solution for counting ~~dinoflagellate cells~~ and identification of genera and species with Sedgwick-Rafter plankton counting chamber and examined microscopically.Cells were enumerated and expressed as no.l^{-1}. (Santhanam et al., 1987, Newell and Newell, 1963, Yamaji, 1979, Wood, 1968 and Claudia et al., 2017). Biodiversity indices such as Shannon index, species richness, evenness and dominance were calculated (Bakus, 2007)

3.0 Results abnd Discussion

3.1. Physico-chemical parameters

Atmospheric temperature was maximum in the month of May (37.2 ^{0}C) and minimum in the month of January (21.9 ^{0}C). Water temperatures with the minimum during the winter in the month ofDecember (25.4^{0}C) and the maximum of 37^{0}C was recorded during the summer month of April. The maximum salinity of 37.6 psu was found in May and zero salinity were recorded during monsoon season in the months of July and August.The pH was recorded maximum (8.8) in the month of April while minimum in the month of August. Highest dissolved oxygen was observed in the month of February and lowest in the months of April and May respectively (Graph 1).

Nutrients like, maximum nitrate concentration (0.1796 mgl^{-1}) was found in the month of Januarywhile minimum (0.1747 mgl^{-1}) in in the month of October. The Lowest nitrite concentration (0.0076 mgl^{-1}) was recorded in the month of June while highest (0.0228 mgl^{-1}) in the month of January.Phosphate values was varied from 0.1038 mgl^{-1} to 0.3899 mgl^{-1} in the month of February to January respectively.Silicate was maximum (0.6031 mgl^{-1}) in the month of February and minimum (0.0050 mgl^{-1}) in the month of October (Graph 1).

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3.2 Qualitative and quantitative distribution of dinoflagellates along Purnagad estuary

Ceratium breve was uncommonly found in the month of May and June, similarly in Cochin backwater (Gopinathan, 1972), *Ceratium furca* was infrequently found in the month of May,similar result found in Cochin estuary (Dayala et al.,2014).*Ceratium fusus*(14%)was recorded maximum in numbers in the months of Feb, May, June, July and November,similar result observed in along Tuticorin (Asha et al 2018). *Ceratium fusus* (203 no. l^{-1}) was found to be the most abundant speciesat Purnagad estuary, due to wide ranges of water temperatures, salinities along Kerala coast (Rajashekhar and Rai, 2014). *Ceratium gibberum* was occasionally found in the month of May, similarly in the Cochin water (Sanilkumar, 2009).*Ceratium tripos* was infrequently observed in the months of May and July similar result found along Mahanandi estuary (Naik et al.,2009).*Dinophysis caudata* (9%) was rarely found in the months of Feb, May and January, similar result was found along Nethravati – Gurupura estuary (Shruthi and Rajashekhar, 2013).*Dinophysis tripos*(8%) was observed in the months of Feb and November, similarly along Cochin water (Sanilkumar, 2009).*Gymnodinium catenatum* (9%) was dominated in the month of May, similarly along southern Brazil (Tavares et al.,2009).*Ornithocercus magnificus* was found maximum in number in the month of June,similar result reported by (Lavanya Ratheesh et al. 2020) along Kochi waters. *Peridinium* sp.was found in the month of January.*Peridinium oceanicum* was recorded in the month of July and November, similar result found along Bay of Bengal (Mishra et al., 2005). *Peridinium ovatum*(11%) was second abundant species (166 no. l^{-1}) in the months of May and November along Purnagad estuary (Yamaji, 1979).*Peridinium rectum*was observed only in the month of November, similarly along Veraval coast, Gujarat(Temkar et al.,2015). *Prorocentrum compressum*was observed in the months of May, July and November, similarly in Cochin water (Sanilkumar, 2009). *Prorocentrum micans*was reported in the months of February and May corresponding result found in Nethravati – Gurupura estuary(Shruthi and

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Rajashekhar, 2013). *Protoperidinium crassipes* was found in the months of May and November, similarly in Georgia, Russian Federation and Ukraine, (Slobodnik et al, 2018).*Protoperidinium latissimum*(7%)was found in the months of July, October and November, similarly along the southwestern Gulf of Mexico (Okolodkov et al., 2008).*Protoperidinium quinquecorne* was recorded in the month of November, similarly along Cochin estuary (Dayala et al.,2014). *Protoperidinium venustum*in the month of June, similar result found along Vietnamese coastal waters (Luom et al., 2017).*Pyrocystis lunula*was observed in the month of July, similar result along East Coast of India (Sahu et al., 2013).*Pyrocystis noctiluca*was reported in the month of May, similar result found along Mandovi estuary, Goa (Pednekar et al., 2014). *Pyrophacus horologium* was observed in the months of May, June and July, similar result recorded along Cochin water (Sanilkumar, 2009), (Table no.1), (Fig.1).

Dinoflagellates were dominant in the month of May (509 no.l^{-1}) both quantitatively and qualitatively (Sahu et al., 2014).It was found that high temperature and salinity are favorable to the growth of dinoflagellates (Taylor, 1973), (Graph 2), (Graph 3), (Fig. 1).

Table no.1- Monthly plankton abundance along Purnagad estuary during February 2022-January 2023

Months / Species	F-22	M-22	A-22	M-22	J-22	Jl-22	A-22	S-22	O-22	N-22	D-22	J-23
Ceratium breve	-	-	-	+	+	-	-	-	-	-	-	-
Ceratium furca	-	-	-	+	-	-	-	-	-	-	-	-
Ceratium fusus	+	-	-	+	+	+	-	-	-	+	-	-
Ceratium gibberum	-	-	-	+	-	-	-	-	-	-	-	-
Ceratium tripos	-	-	-	+	-	+	-	-	-	-	-	-
Dinophysis caudata	+	-	-	+	-	-	-	-	-	-	-	+
Dinophysis tripos	+	+	-	-	-	-	-	-	-	-	-	-
Gymnodinium catenatum	-	-	-	+	-	-	-	-	-	-	-	-
Ornithocercus serratus	-	-	-	-	+	-	-	-	-	-	-	-
Peridinium sp.	-	-	-	-	-	-	-	-	-	-	-	+
Peridinium oceanicum	-	-	-	-	-	+	-	-	-	+	+	-
Peridinium ovatum	-	-	-	+	-	-	-	-	-	+	-	-
Peridinium rectum	-	-	-	-	-	-	-	-	-	+	-	-
Prorocentrum compressum	-	-	-	+	-	+	-	-	-	+	-	-
Prorocentrum micans	+	-	-	+	-	-	-	-	-	-	-	-
Protoperidinium crassipes	-	-	-	-	-	-	-	-	-	+	-	-
Protoperidinium latissimum	-	-	-	-	-	+	-	-	-	+	-	-
Protoperidinium quinquecorne	-	-	-	-	-	-	-	-	-	+	-	-
Protoperidinium venustum	-	-	-	-	-	+	-	-	+	+	-	-
Pyrocystis lunula	-	-	-	-	-	+	-	-	-	-	-	-
Pyrocystis noctiluca	-	-	-	+	-	-	-	-	-	-	-	-
Pyrophacus horologium	-	-	-	+	+	+	-	-	-	-	-	-

+(Present), -(Absent)

3.3 Correlation with environmental parameter

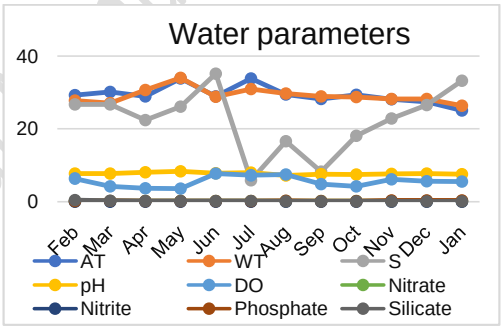
Table no. 2- Correlation between physico-chemical parameters and dinoflagellates along Purnagad estuary during February 2022-January 23
A.T- Atmospheric temperature, W.T- water temperature, S- salinity, DO-dissolved oxygen, NO_3-nitrate, NO_2-nitrite, PO_4- phosphate, Si- silicate, D-Dinoflagellates

Correlations

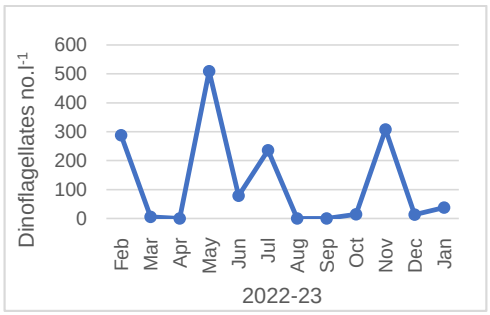
	A.T	W.T	S	pH	DO	NO_3	NO_2	PO_4	Si	D
A.T	1									
W.T	.782**	1								
S	-0.1	0.045	1							
pH	.604*	.650*	0.402	1						
DO	-0.063	-0.218	-.639*	-0.38	1					
NO_3	-0.354	-0.343	0.365	-0.067	0.232	1				
NO_2	-.576*	-0.407	0.461	-0.158	0.001	0.548	1			
PO_4	-.648*	-0.522	0.422	-0.331	0.091	0.486	.813**	1		
Si	0.26	-0.122	0.104	0.306	0.067	0.412	-0.28	-0.396	1	
D	.625*	.640*	0.364	.672*	-0.1	0.023	-0.215	-0.272	0.314	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

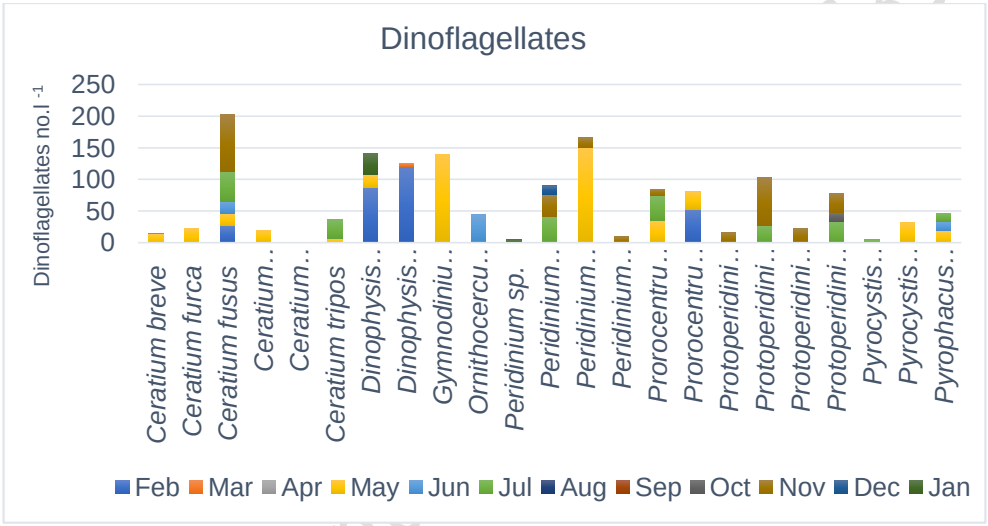
Environmental factors such as atmospheric temperature showed correlation with dinoflagellates(r = 0.625) (Sahu et al., 2014). pHwas correlated with dinoflagellate (r = 0.672) (Yoo, 1991). Salinity was negatively correlate with dissolved oxygen (r = -0.639) (Supriatna and Mahmudi, 2021 andRajashekhar and Rai, 2014).The phosphate was positively correlate with nitrate (r = 0.813), relationship of nitrate and phosphate was favourable for phytoplankton abundance (Marsela et al., 2021), (Table no.2).



Graph 1- Monthly water parameters recorded along Purnagad estuary, during 2022-23
A.T- Atmospheric temperature, W.T- water temperature, S- salinity, DO-dissolved oxygen



Graph 2- Monthly quantitative variations of dinoflagellates recorded during 2022-23



Graph 3- Monthly quantitative variations of dinoflagellates recorded during 2022-23

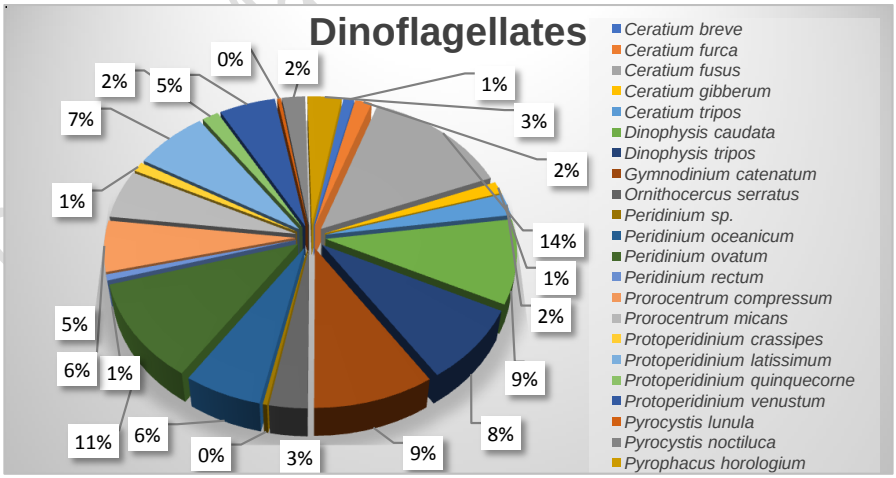


Fig.1- Percentage distribution of different phytoplankton divisions in the Purnagad estuary during 2022-23.

3.4 Species richness and diversity indices

The range of species diversity, dominance, evenness and richness were 0 - 3.4096, 0.0644-1, 0-0.9356, 0 – 18 respectively. The ~~least~~ lowestvalues of diversity indices were recorded during March, April, August and September but were higher during other periods. Higher values of dominance were reported in the months of March, April, August and September while minimum in the months of February, July and October. The maximum richness values were recorded in the months of May, July and November. The low richness was recorded April, August and September. Graph 2 (Graph 4).

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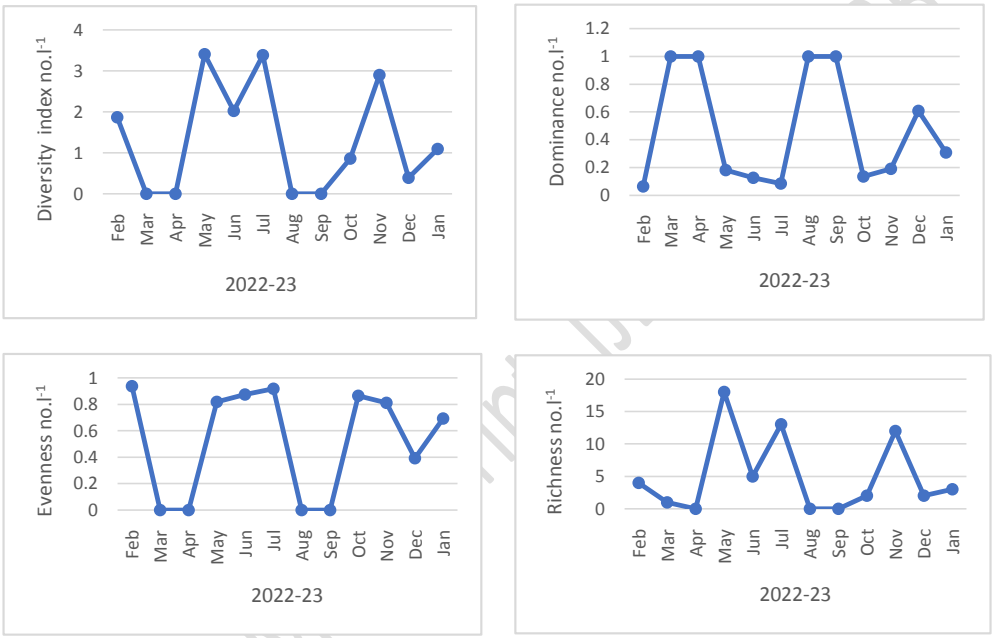

Graph 4 – Monthly variations of dinoflagellates species diversity, dominance, evenness and richness recorded during2022-23.

4.0 Conclusion

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The dinoflagellate community structure at Purnagad estuary was found to constitute 22 species during theone year of study. The species that was found to be most prevalent was *Ceratium fusus. Prorocentrum* (six species) was the most diversified genus among all the species, followed by *Ceratium* (five species).Temperaturewas one of the important parameters that positivelyinfluenced the dinoflagellate community.

7.0 Reference

Comment [w87]: References should be corrected according to the journal format.

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