International Journal of Environment and Climate Change

Volume 14, Issue 5, Page 395-403, 2024; Article no.IJECC.117635
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Monthly Variations of Dinoflagellates in Relation to the Water Parameters Along Purnagad Estuary, Ratnagiri, Maharashtra, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijecc/2024/v14i54199

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/117635

Original Research Article

Received: 14/03/2024
Accepted: 19/05/2024
Published: 28/05/2024

ABSTRACT

Water samples were collected from Purnagad estuary, southwest coast of India. The monthly surface water sampling was carried out during high tide to find out the variations in physicochemical parameters and distribution of dinoflagellates. Samples were collected for one year period during 2022–2023. Dinoflagellates and water quality parameters were investigated to changes of dinoflagellates community. Variation in atmospheric temperature 21.9 - 37.2 ^{0}C, water temperatures varied from 25.4 - 37 ^{0}C, salinity varied from 0-37.6 psu, pH ranges between 7-8.8, dissolved oxygen 3.2-10.8 mgl^{-1}, nitrate varied from 0.1747 - 0.1796 mgl^{-1}, nitrite concentration varied from 0.0076 - 0.0228 mgl^{-1}, phosphate values varied from 0.1038 mgl^{-1} to 0.3899 mgl^{-1}, Silicate was

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Cite as: *Mestry, C. M., Adsul, A. D., Pawase, A. S., Sawant, M. S., Pawar, R. A., & Ghode, G. S. (2024). Monthly Variations of Dinoflagellates in Relation to the Water Parameters Along Purnagad Estuary, Ratnagiri, Maharashtra, India. International Journal of Environment and Climate Change, 14(5), 395–403. https://doi.org/10.9734/ijecc/2024/v14i54199*

varied from 0.0050 - 0.6031 mgl^{-1}. A quantitative approach was employed, involving the collection of quantitative data through field sampling and laboratory analysis. During the study 22 species of dinoflagellates were encountered among which *Ceratium fusus* was dominant. Relatively high density and diversity of dinoflagellates were discovered in May as compared to the other months. Temperature showed a positive correlation with the dinoflagellate community showing its importance in dinoflagellate growth.

Keywords: Dinoflagellates; species diversity; estuary.

1. INTRODUCTION

In the near-shore and continental shelf areas of the marine environment, dinoflagellates are an important group of unicellular protists found in various kinds of aquatic habitats, next to diatoms [1]. Dinoflagellates are a type of primarily unicellular creatures that belong to the Phylum Pyrrhophyta. They are distinguishable from other groups by several unique qualities, including organelles, coloring, flagellar insertion, and features of the nucleus. There are currently about 2400 identified species of dinoflagellates [2]. 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 [3]. Dinoflagellates are neither plants nor animals, many of them exhibit characteristics associated with plants, including the ability to photosynthesize, have walls made of cellulose, and produce starch, which is used as an energy storage material [4].

Estuaries are highly productive, dynamic, semi-enclosed water bodies 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 [5-9]. The fluctuations in river water mixing with seawater, which produce turbidity, nutrient gradients, and salinity [10] indicate the complexity of a river estuary. Estuaries are dynamic environments that change constantly. They have been recognized 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. A 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-chemical parameters of water in the Purnagad estuary, southwest coast of India.

2. MATERIALS AND METHODS

2.1 Study Area and Sampling

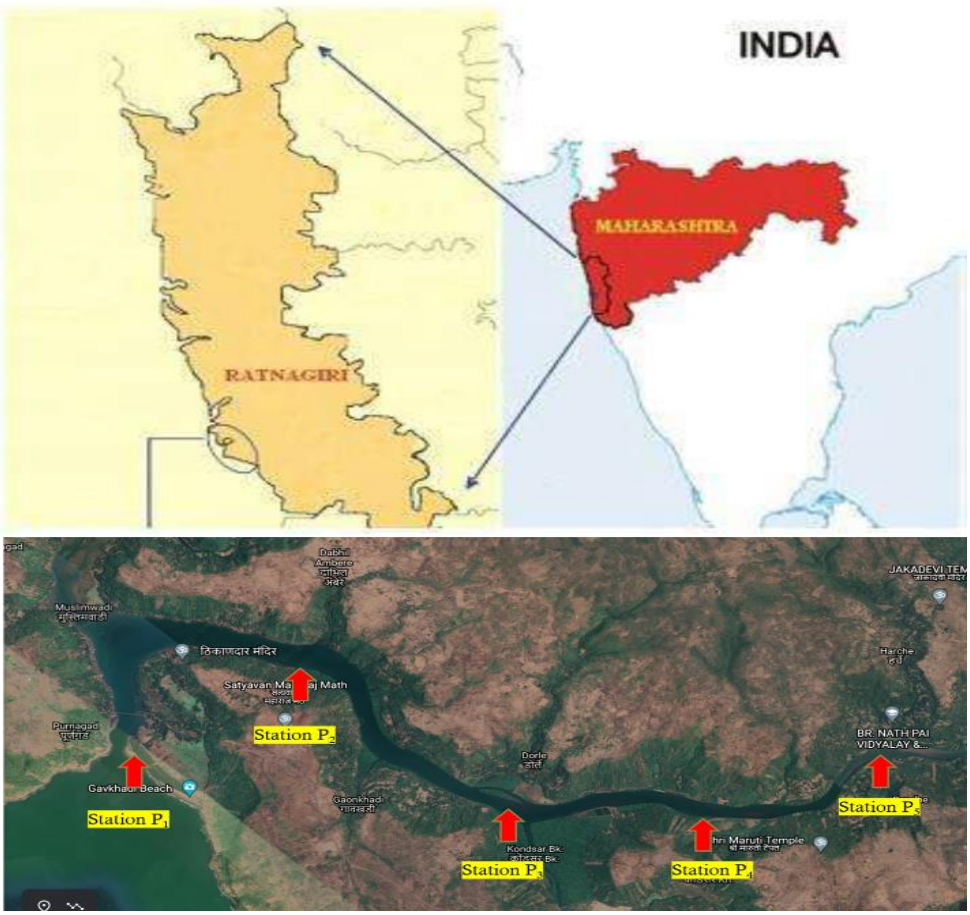
The west coast of India experiences intense rainfalls during the monsoon months of June–September, the summer season (February–May), and winter season (October-January). The study was carried out in the estuarine and coastal locations of Purnagad. Based on the salinity gradient, sampling was conducted at five sampling stations (Map. 1) in Purnagad estuary. The tidal amplitude Surface samples were collected monthy from these locations during the high tide times from February 2022 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, and silicate, were analyzed by adopting the standard methods [11-15].

2.3 Dinoflagellate Assemblage

Monthly samplings for quantitative and qualitative analyses of dinoflagellates were collected from the estuarine water surface during high tide and filtered by the 60µ plankton net. The collected dinoflagellate samples were preserved in Lugols iodine and 5% neutralized formalin solution for counting and identification of genera and species with Sedgwick-Rafter plankton counting chamber and examined microscopically. Cells were enumerated and expressed as $ind.l^{-1}$. Santhanam et al., [16] Newell and Newell, [17] Yamaji, [18] Wood, [19] and Claudia et al., [20]. Biodiversity indices such as the Shannon index, species richness, evenness and dominance were calculated [21].



Map 1. Sampling locations at Purnagad estuary, Ratnagiri

3. RESULTS ABND DISCUSSION

3.1 Physico-Chemical Parameters

Atmospheric temperature was maximum in May (37.2 ^{0}C) and minimum in January (21.9 ^{0}C). Water temperatures with the minimum during the winter in December (25.4 ^{0}C) and a maximum of 37 ^{0}C was recorded during the summer in April. The maximum salinity of 37.6 psu was found in May and zero salinity was recorded during monsoon season in July and August. The pH was recorded maximum (8.8) in April while minimum (7) in August. The highest (10.8 mgl^{-1}) dissolved oxygen was observed in February and lowest (3.2 mgl^{-1}) in April and May respectively (Graph 1).

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

3.2 Qualitative and Quantitative Distribution of Dinoflagellates Along Purnagad Estuary

Ceratium breve was uncommonly found in May and June, similarly in Cochin backwater [22]. *Ceratium furca* was infrequently found in May, similar result found in Cochin estuary [23]. *Ceratium fusus* (14%) was recorded maximum in numbers in Feb, May, June, July and November, with similar results observed along Tuticorin [24]. *Ceratium fusus* (203 no. l^{-1}) was found to be the most abundant species at Purnagad estuary, due to wide ranges of water temperatures, salinities along Kerala coast [25]. *Ceratium gibberum* was occasionally found in May, similarly in the Cochin water [26]. *Ceratium tripos* was infrequently observed in May and July similar result were found along the Mahanandi estuary [27]. *Dinophysis caudata* (9%) was rarely found in

Feb, May, and January, a similar result was found along the Nethravati – Gurupura estuary [28]. *Dinophysis tripos* (8%) was observed in Feb and November, similarly along Cochin water [26]. *Gymnodinium catenatum* (9%) was dominated in May, similarly along southern Brazil (Tavares et al., 2009). *Ornithocercus magnificus* was found maximum in number in June, similar result reported by Lavanya Ratheesh et al. [29] along Kochi waters. *Peridinium* sp. was found in January. *Peridinium oceanicum* was recorded in July and November, similar result found along Bay of Bengal [30]. *Peridinium ovatum* (11%) was second abundant species (166 no. l^{-1}) in May and November along Purnagad estuary [18]. *Peridinium rectum* was observed only in November, similarly along Veraval coast, Gujarat [31]. *Prorocentrum compressum* was observed in May, July and November, similarly in Cochin water [26]. *Prorocentrum micans* was reported in February and May corresponding result found in Nethravati – Gurupura estuary [28]. *Protoperidinium crassipes* was found in May and November, similarly in Georgia, Russian Federation and Ukraine, [32]. *Protoperidinium latissimum* (7%) was found in July, October and November, similarly along the southwestern Gulf of Mexico (Okolodkov et al., 2008). *Protoperidinium quinquecorne* was recorded in November, similarly along Cochin estuary [23]. *Protoperidinium venustum* in June, similar result found along Vietnamese coastal waters (Luom et al., 2017). *Pyrocystis lunula* was observed in July, similar result along east coast of India [1]. *Pyrocystis noctiluca* was reported in May, similar result found along Mandovi estuary, Goa [33]. *Pyrophacus horologium* was observed in May, June and July, similar result recorded along Cochin water [26] (Table no.1), (Fig.1).

Dinoflagellates were dominant in May (509 ind.l^{-1}) both quantitatively and qualitatively [1]. It was found that high temperature and salinity are favourable to the growth of dinoflagellates [34]. (Graph 2), (Graph 3), (Fig. 1).

3.3 Correlation with Environmental Parameter

Environmental factors such as atmospheric temperature showed correlation with dinoflagellates (r = 0.625) [1]. pH was correlated with dinoflagellate (r = 0.672) [35]. Salinity was negatively correlate with dissolved oxygen (r = -0.639) [36,25]. The phosphate was positively correlate with nitrate (r = 0.813), relationship of nitrate and phosphate was favourable for phytoplankton abundance [37] (Table no.2).

Table 1. Monthly plankton abundance along Purnagad estuary during February 2022-January 23

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)*

Table 2. Correlation between physico-chemical parameters and dinoflagellates along Purnagad estuary during February 2022-January 23

	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).*
**A.T- Atmospheric temperature, W.T- water temperature, S- salinity, DO-dissolved oxygen, NO3-nitrate, NO2-nitrite, PO4- phosphate, Si- silicate, D-Dinoflagellates*

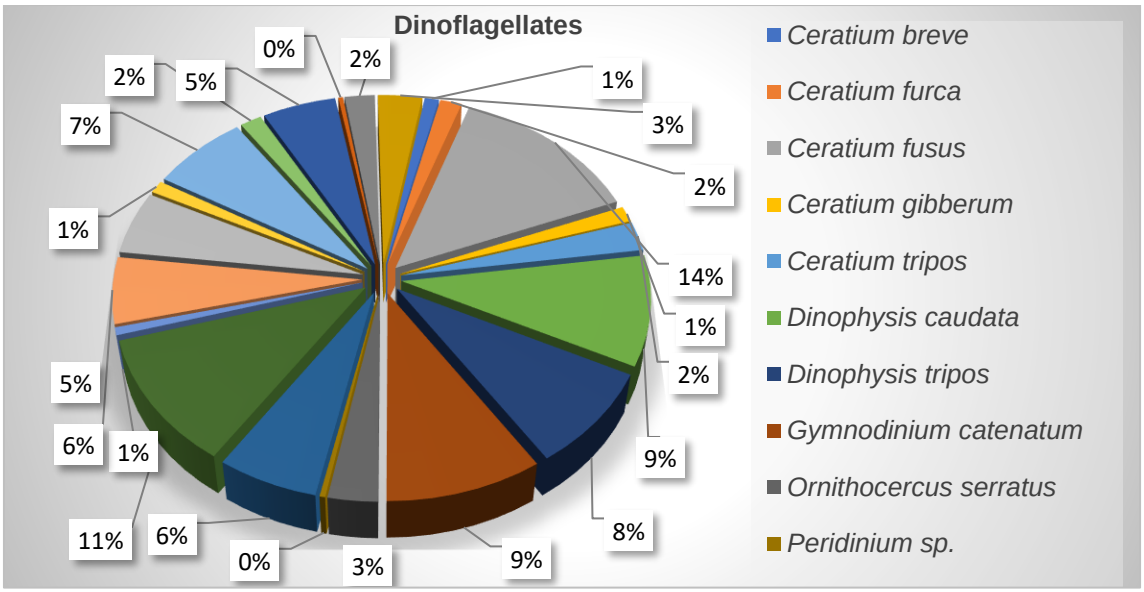
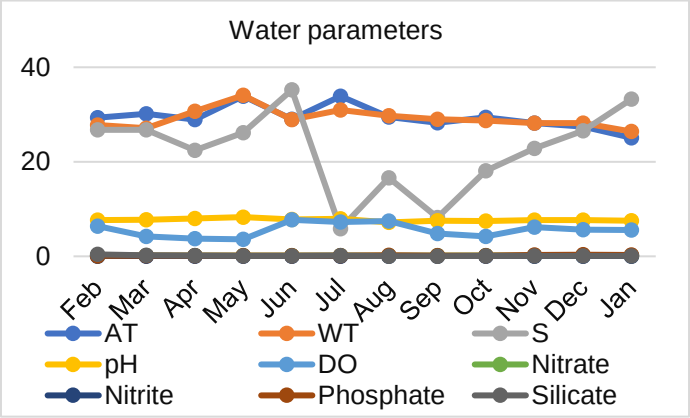
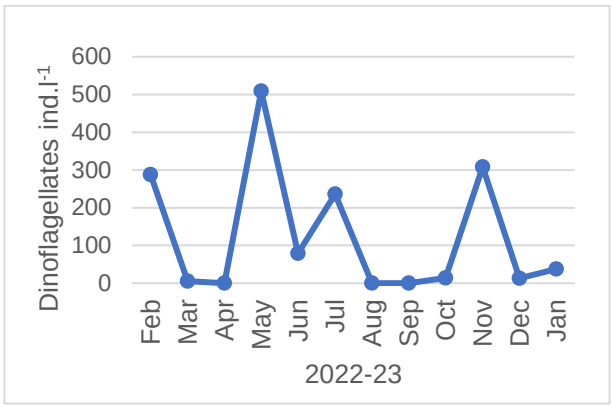


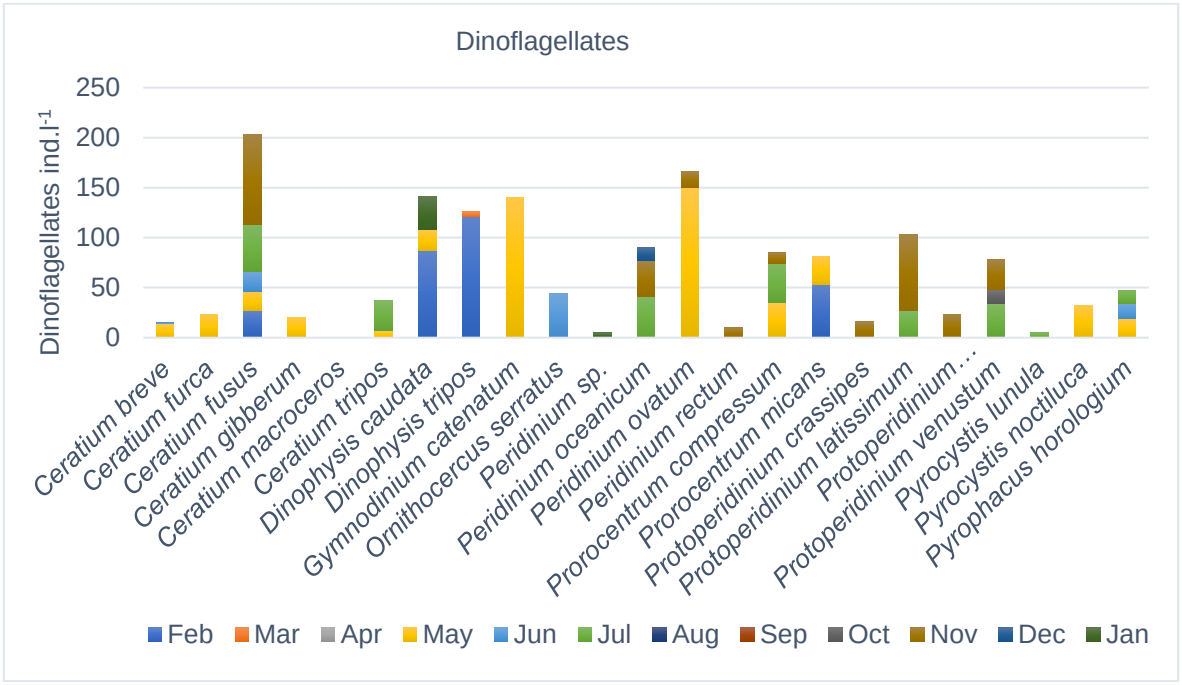
Fig. 1. Percentage distribution of different phytoplankton divisions in the Purnagad estuary during 2022-23



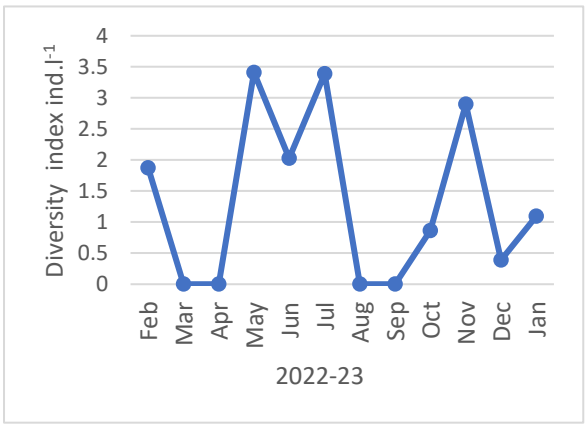
Graph 1. Monthly water parameters recorded along Purnagad estuary, during 2022-23
A.T- Atmospheric temperature, W.T- water temperature, S- salinity, DO-dissolved oxygen

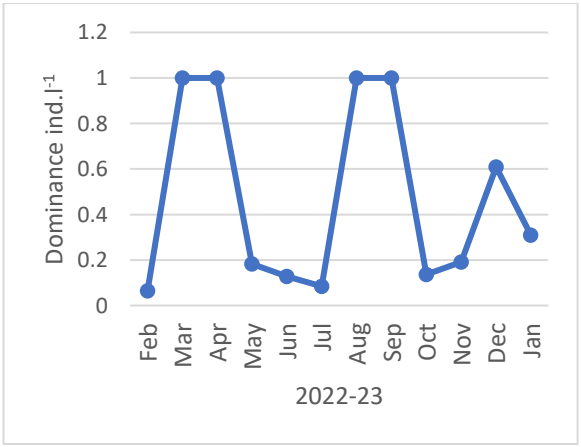


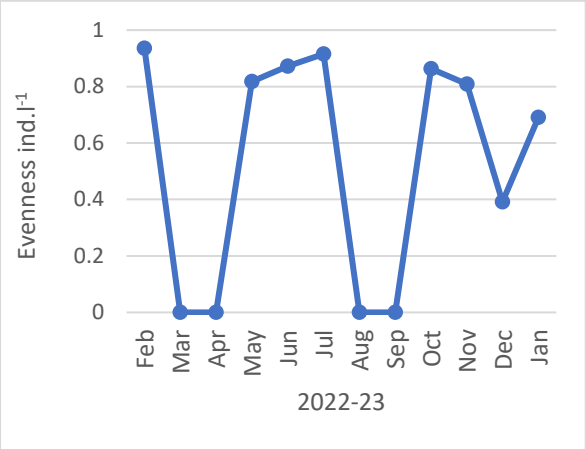
Graph 2. Monthly quantitative variations of dinoflagellates recorded during 2022-23

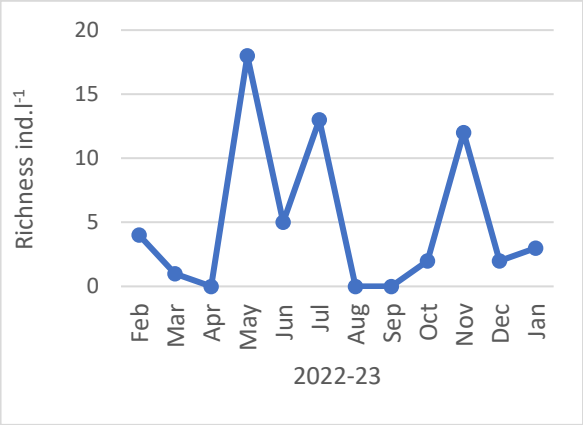


Graph 3. Monthly quantitative variations of dinoflagellates recorded during 2022-23









Graph 4. Monthly variations of dinoflagellates species diversity, dominance, evenness and richness recorded 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 lowest values of diversity indices were recorded during March, April, August and September but were higher during other periods. Higher values of dominance were reported in March, April, August and September while minimum in February, July and October. The maximum evenness values were recorded in February while minimum in March, April, August, and September. The maximum richness values were recorded in May, July and November. The low richness was recorded in April, August and September. (Graph 4) [38].

4. CONCLUSION

In conclusion, dinoflagellates communities in the present study were influenced by the annual riverine runoff and the associated changes in the physicochemical variables. The dinoflagellate community structure at Purnagad estuary was found to constitute 22 species during the one 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). Temperature was one of the important parameters that positively influenced the dinoflagellate community. The present investigation suggests that the baseline information on the dinoflagellates is useful for preparing data sheet on fish production report of Purnagad area.

ACKNOWLEDGEMENTS

Authors wish to thanks the authorities of College of Fisheries, Shirgaon, Ratnagiri (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli) for providing me all the necessary facilities as well as for giving the needful support during the course of the investigation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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