

Monthly variations of dinoflagellates in relation to the water parameters along Purnagad estuary, Ratnagiri, Maharashtra, India

ABSTRACT

A study was carried out in the surface water samples collected in five locations at Purnagad estuary, southwest coast of India, 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 °C, water temperatures varied from 25.4 - 37 °C, salinity varied from 0-37.6 psu, pH ranges between 7-8.8, dissolved oxygen 3.2-10.8 mg l⁻¹, nitrate varied from 0.1747 - 0.1796 mg l⁻¹, nitrite concentration varied from 0.0076 - 0.0228 mg l⁻¹, phosphate values varied from 0.1038 mg l⁻¹ to 0.3899 mg l⁻¹, Silicate was varied from 0.0050- 0.6031 mg l⁻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

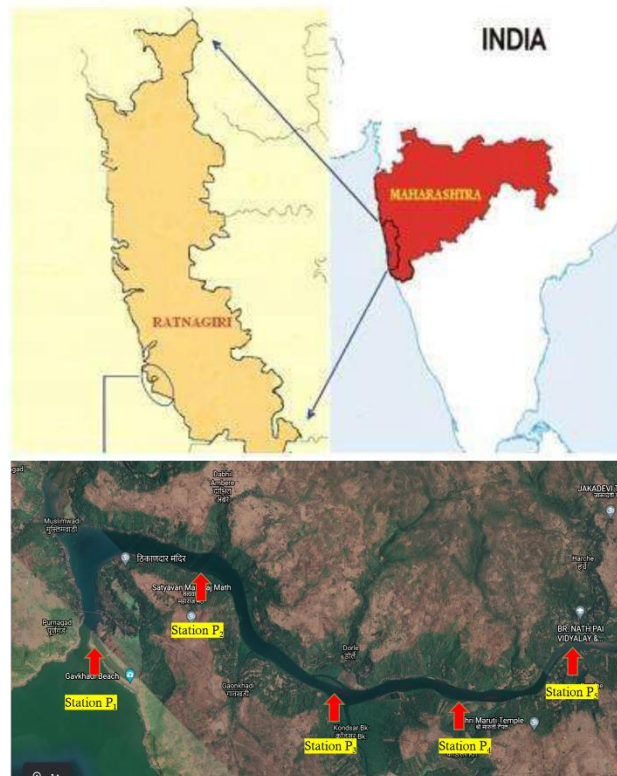
1.0 INTRODUCTION

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 (Sahu et al., 2014). 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 (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 photosynthesize, 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 Mcluskay, 2002; Mcluskay and Elliott, 2007; Whitfield et al., 2002; Chicharo et al., 2006; Tweedley et al., 2019). The fluctuations in river water mixing with seawater, 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 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.

2.0 MATERIAL AND METHODS

2.1. Study area and sampling



Map.1 Sampling locations at Purnagad estuary, Ratnagiri

The west coast of India experiences intense **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 **monthly** from these locations during the high **tidetimes** 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 (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 the 60 μ 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., 1987, Newell and Newell, 1963, Yamaji, 1979, Wood, 1968 and Claudia et al., 2017). Biodiversity indices such as **the 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 May** (37.2 °C) and minimum **in January** (21.9 °C). Water temperatures with the minimum during the winter **in December** (25.4 °C) and **a maximum** of 37 °C was recorded during the summer **in April**. The maximum salinity of 37.6psu 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 mg l⁻¹) dissolved oxygen was observed **in February** and lowest (3.2 mg l⁻¹) **in April** and May respectively (Graph 1).

Nutrients like, maximum nitrate concentration (0.1796 mg l^{-1}) were found in January while minimum (0.1747 mg l^{-1}) in October. The lowest nitrite concentration (0.0076 mg l^{-1}) was recorded in June while the highest (0.0228 mg l^{-1}) in January. Phosphate values varied from 0.1038 mg l^{-1} to 0.3899 mg l^{-1} in February to January respectively. Silicate was maximum (0.6031 mg l^{-1}) in February and minimum (0.0050 mg l^{-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 (Gopinathan, 1972), *Ceratium furcaw* was infrequently found in May, similar result found in Cochin estuary (Dayala et al., 2014). *Ceratium fusus* (14%) was recorded maximum in numbers in Feb, May, June, July and November, with similar results observed along Tuticorin (Asha et al 2018). *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 (Rajashekhar and Rai, 2014). *Ceratium gibberum* was occasionally found in May, similarly in the Cochin water (Sanilkumar, 2009). *Ceratium tripos* was infrequently observed in May and July similar result were found along the Mahanandi estuary (Naik et al., 2009). *Dinophysis caudata* (9%) was rarely found in Feb, May, and January, a similar result was found along the Nethravati – Gurupura estuary (Shruthi and Rajashekhar, 2013). *Dinophysis tripos* (8%) was observed in Feb and November, similarly along Cochin water (Sanilkumar, 2009). *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. 2020) along Kochi waters. *Peridinium* sp. was found in January. *Peridinium oceanicum* was recorded in 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 May and November along Purnagad estuary (Yamaji, 1979). *Peridinium rectum* was observed only in November, similarly along Veraval coast, Gujarat (Temkar et al., 2015). *Prorocentrum compressum* was observed in May, July and November, similarly in Cochin water (Sanilkumar, 2009). *Prorocentrum micans* was reported in February and May corresponding result found in Nethravati – Gurupura estuary (Shruthi and Rajashekhar, 2013). *Proto-peridinium crassipes* was found in May and November, similarly in Georgia, Russian Federation and Ukraine, (Slobodnik et al, 2018). *Proto-peridinium latissimum* (7%) was found in July, October and November, similarly along the southwestern Gulf of Mexico (Okolodkov et al., 2008). *Proto-peridinium quinquecorne* was recorded in November, similarly along Cochin estuary (Dayala et al., 2014). *Proto-peridinium 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 (Sahu et al., 2013). *Pyrocystis noctiluca* was reported in May, similar result found along Mandovi estuary, Goa (Pednekar et al., 2014). *Pyrophacus horologium* was observed in May, June and July, similar result recorded along Cochin water (Sanilkumar, 2009), (Table no.1), (Fig.1).

Dinoflagellates were dominant in May (509 ind. l^{-1}) both quantitatively and qualitatively (Sahu et al., 2014). It was found that high temperature and salinity are favourable 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 23

Species	Months	F-22	M-22	A-22	M-22	J-22	JI-22	A-22	S-22	O-22	N-22	D-22	J-23
<i>Ceratium breve</i>		-	-	-	+	+	-	-	-	-	-	-	-
<i>Ceratium furca</i>		-	-	-	+	-	-	-	-	-	-	-	-
<i>Ceratium fusus</i>		+	-	-	+	+	+	-	-	-	+	-	-
<i>Ceratium gibberum</i>		-	-	-	+	-	-	-	-	-	-	-	-
<i>Ceratium tripos</i>		-	-	-	+	-	+	-	-	-	-	-	-
<i>Dinophysis caudata</i>		+	-	-	+	-	-	-	-	-	-	-	+
<i>Dinophysis tripos</i>		+	+	-	-	-	-	-	-	-	-	-	-
<i>Gymnodinium catenatum</i>		-	-	-	+	-	-	-	-	-	-	-	-
<i>Ornithocercus serratus</i>		-	-	-	-	+	-	-	-	-	-	-	-
<i>Peridinium</i> sp.		-	-	-	-	-	-	-	-	-	-	-	+
<i>Peridinium oceanicum</i>		-	-	-	-	-	+	-	-	-	+	+	-
<i>Peridinium ovatum</i>		-	-	-	+	-	-	-	-	-	+	-	-
<i>Peridinium rectum</i>		-	-	-	-	-	-	-	-	-	+	-	-
<i>Prorocentrum compressum</i>		-	-	-	+	-	+	-	-	-	+	-	-

<i>Prorocentrummicans</i>	+	-	-	+	-	-	-	-	-	-	-	-
<i>Protoperidinium crassipes</i>	-	-	-	-	-	-	-	-	-	+	-	-
<i>Protoperidiniumlatissimum</i>	-	-	-	-	-	+	-	-	-	+	-	-
<i>Protoperidiniumquinquecorne</i>	-	-	-	-	-	-	-	-	-	+	-	-
<i>Protoperidiniumvenustum</i>	-	-	-	-	-	+	-	-	+	+	-	-
<i>Pyrocystis lunula</i>	-	-	-	-	-	+	-	-	-	-	-	-
<i>Pyrocystis noctiluca</i>	-	-	-	+	-	-	-	-	-	-	-	-
<i>Pyrophacus horologium</i>	-	-	-	+	+	+	-	-	-	-	-	-

*+(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

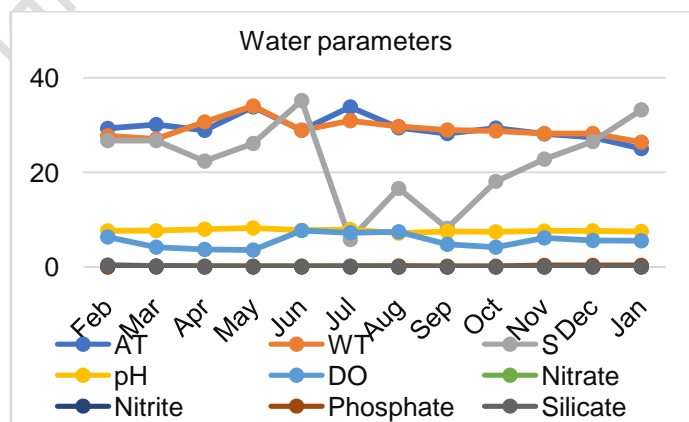
Correlations										
	A.T	W.T	S	pH	DO	NO ₃	NO ₂	PO ₄	Si	D
A.T	1									
W.T	.782**	1								
S	-0.1	0.045	1							
pH	.604*	.650	0.402	1						
DO	-0.063	-0.218	-.639*	-0.38	1					
NO ₃	-0.354	-0.343	0.365	-0.067	0.232	1				
NO ₂	-.576*	-0.407	0.461	-0.158	0.001	0.548	1			
PO ₄	-.648*	-0.522	0.422	-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).

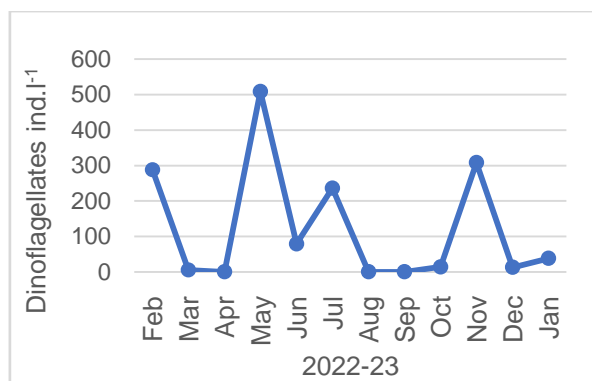
* Correlation is significant at the 0.05 level (2-tailed).

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

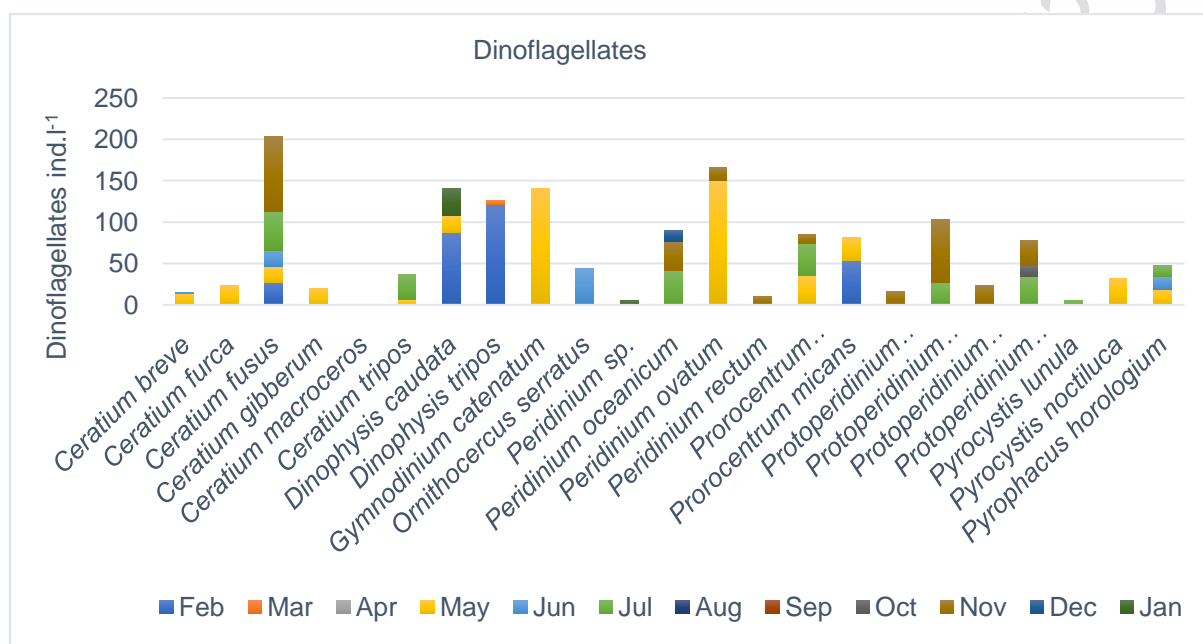
Environmental factors such as atmospheric temperature showed correlation with dinoflagellates ($r = 0.625$) (Sahu et al., 2014). pH was correlated with dinoflagellate ($r = 0.672$) (Yoo, 1991). Salinity was negatively correlate with dissolved oxygen ($r = -0.639$) (Supriatna and Mahmudi, 2021 and Rajashekhar 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

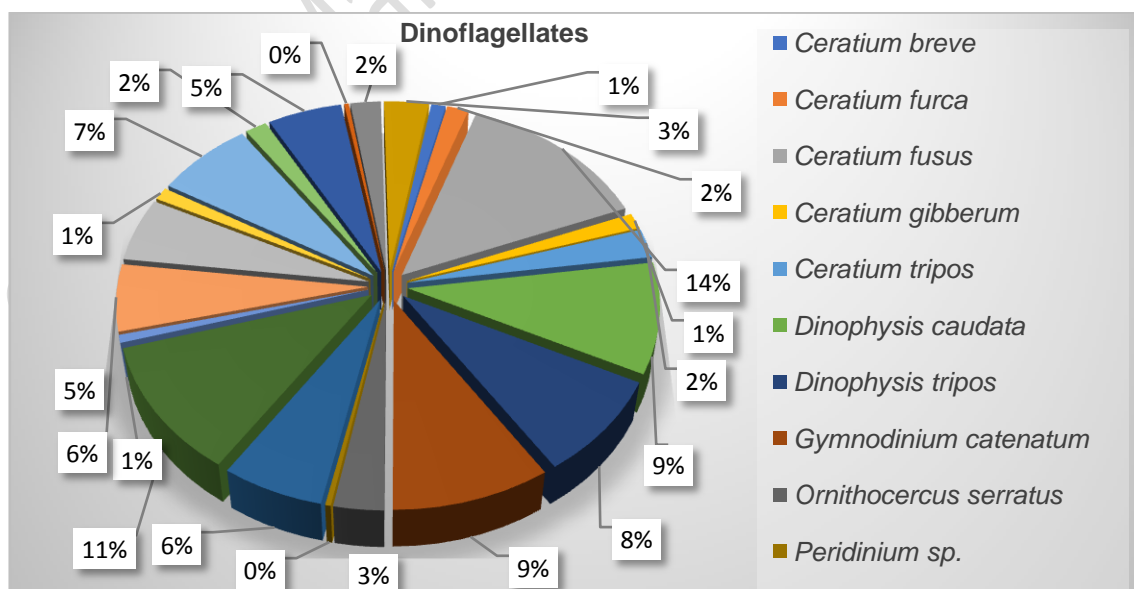
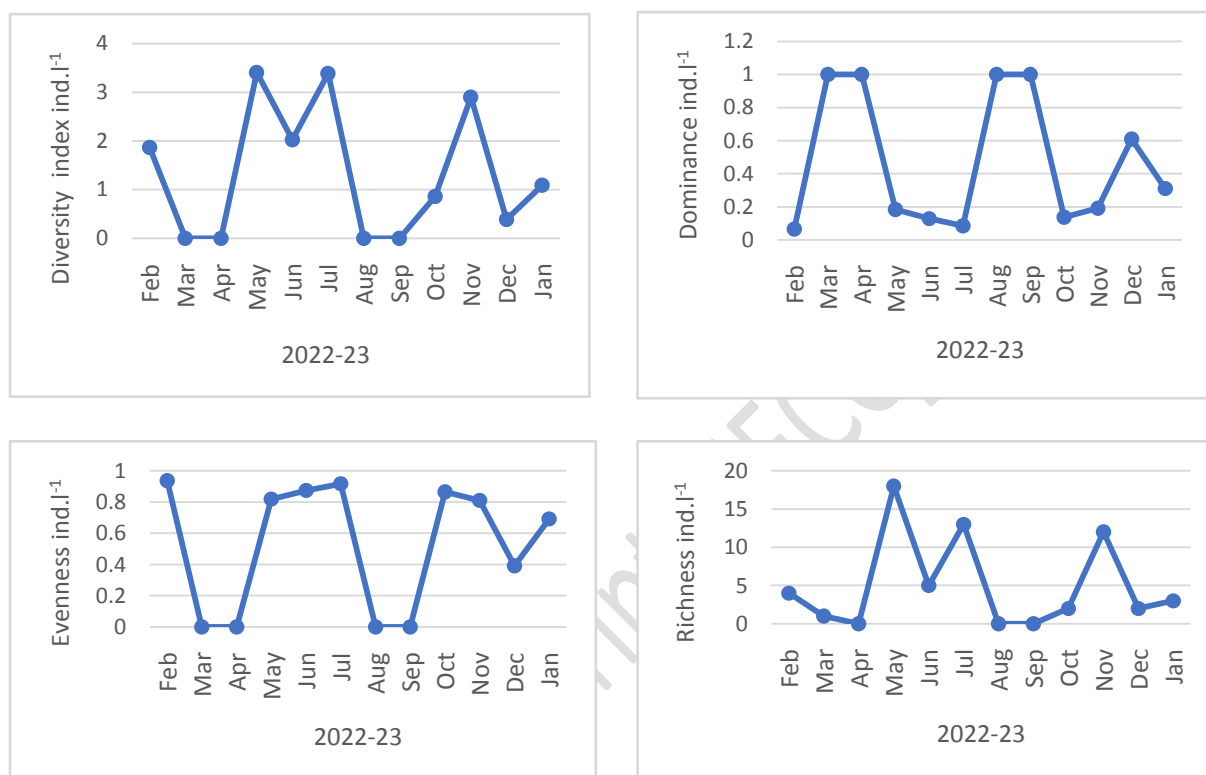


Fig.1- Percentage distribution of different phytoplankton divisions in the Purnagad estuary during 2022-23.

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 **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).



Graph 4 – Monthly variations of dinoflagellates species diversity, dominance, evenness and richness recorded during 2022-23.

4.0 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.

7.0 REFERENCE

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