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Seasonal Variations on Species Composition and Abundance of Marine Dinoflagellates in the Response of Environmental Parameters at Rakhine, Mon and Northern Tanintharyi Waters

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ABSTRACT

A total of 69 taxa of dinoflagellates at Rakhine coastal waters, 8 taxa at Mon coastal waters, and 29 taxa at northern Tanintharyi coastal waters were recorded in the present study. Regarding the percentage composition of dinoflagellates, Gonyaulacoid and Peridinoid were noted as the most abundant groups in dinoflagellates. A wide range of salinity fluctuations was noticed in the present study due to the effects of the monsoon cycle in the Indian Ocean. The maximum salinity, 34‰ was recorded in pre-monsoon months whereas the minimum value, 14‰ was detected in monsoon season. The highest pH value, 9.0 was observed in monsoon months. The concentrations of PO_4-P, NH_3-N, and NO_3-N were normally high during pre-monsoon months. The cell abundance of dinoflagellates at all stations was high during pre-monsoon months indicated that a mesotrophic environment favor species richness and dense.

1. INTRODUCTION

Phytoplankton are known as primary producers since they are the functional base of all marine ecosystems [1]. The other producers (secondary and tertiary) depend on phytoplankton directly or indirectly for food [2, 3]. There are some reasons why phytoplankton biodiversity in the oceans is needed to understand especially in Myanmar waters. In other words, the marine food web is significantly depended on it [4]. Also, phytoplankton are responsible for half of the planetary photosynthesis [5, 6]. This process has resulted in the reduction of carbon dioxide. If this blooming of cells was taken placed, dissolved oxygen (DO) in seawater can be depleted. The changes in wind directions and currents in the Bay of Bengal and the Andaman Sea were the main factors that made variations in the dinoflagellate community.

Dinoflagellates exhibit a wide range of divergence in morphology and size [7]. They are very diverse and have some important characters in species identification and probably represent a complex of ecological strains. In the Indian Ocean, the annual winter cooling, wind-driven upwelling, and vertical diffusion of nutrients have been recognized as the most important physical mechanisms for nutrient input into the euphotic zone [8]. The southwest monsoon period which starts from June to September is the main source of climatic variations in the study areas. Physical and chemical factors are suggested to influence the dinoflagellates community [9]. The Bay of Bengal area is subjected to increasing anthropogenic pressure and is characterized as mesotrophic concerning nitrate concentration. A gradual increase in the nitrate concentration along with a simultaneous decrease in the dissolved oxygen (DO) has been observed over the years.

The characterization that was based on the Assessment of Estuarine Trophic Status (ASSETS) model [10] indicates that the current status is poor and the environment is degrading [11]. It was suggested that the process of diffusion by itself is inadequate to meet the nutrient demands of phytoplankton, especially in the top 50 meters. The phytoplankton population determines the productivity of estuarine and marine ecosystems [12]. Phytoplankton requires a diverse array of minimal nutrients for growth and maintenance [13, 14]. The present study aims to know the seasonal species composition of dinoflagellates along Rakhine, Mon, and northern Tanintharyi waters, and to get an understanding of the factors affecting changes in the cell abundance of marine dinoflagellates in accordance with the environmental parameters and nutrient concentrations.

2. MATERIALS AND METHODS

2.1 Sampling sites

The sampling sites were plotted by hand-held Global Positioning System (GPS). It is part of the Bay of Bengal and down south of Rakhine Coastal Region (Figure 1). Eight sampling stations were plotted at Rakhine coastal waters such as Wetthe (Lat. 17º 08´ 34.474" N, Long. 94º 27´51.226" E) as station-1; Upper part of MaGyi tidal creek (Lat. 17º 04´13.485" N, Long. 94º 28´58.017" E) as station-2; Lower part of MaGyi tidal creek (Lat. 17º 03´59.57" N, Long. 94º 27´44.269" E) as station-3; MaGyi area (coastal) (Lat. 17º 04´30.183" N, Long. 94º 27´9.482" E) as station-4; Kyauk-Mong-Nama, down-south of MaGyi (Lat. 17º 00´12.76" N,

Long. 94º 27′2.525" E) as station-5; Phoe-Kala Island, near Chaungtha beach (Lat. 16º 57′ 20.217" N, Long. 94º 25′18.164" E) as station-6; Ngwe-Saung Beach (Lat. 16º 52.490" N, Long. 94º 22′15.88" E) as station-7; and Chit-thu Island, down-south of Ngwe-Saung Beach (Lat. 16º 49′6.243" N, Long. 94º 23′8.757" E) as station-8. Station-9 is situated at Double Island, Setse Beach (Lat. 15º 57′6.897" N, Long. 97º 37′3.231" E) in Mon coast and station-10 sited at Hmaw-Yit pagoda of Kampani area (Lat. 14º 07′5.426" N, Long. 98º 06′7.168" E) in Tanintharyi coast (Figures 2 and 3).

Most of the sampling sites are influenced by the freshwater influx. Some sampling sites are situated near the mouth of a tidal creek, rocky shore with a muddy bottom, coarse sand area, and near mangrove forest respectively.

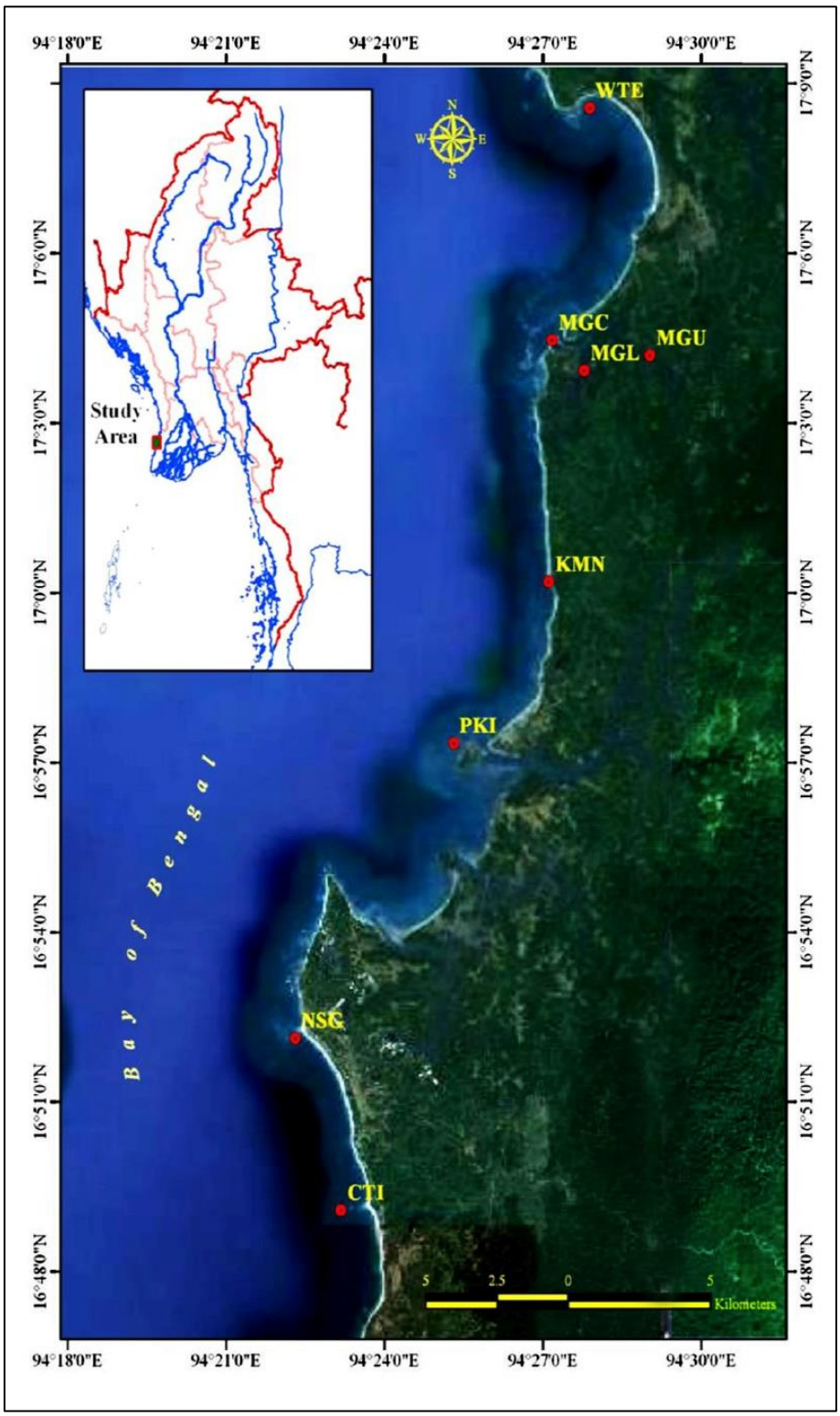

Figure 1. Sampling stations at Rakhine coastal water

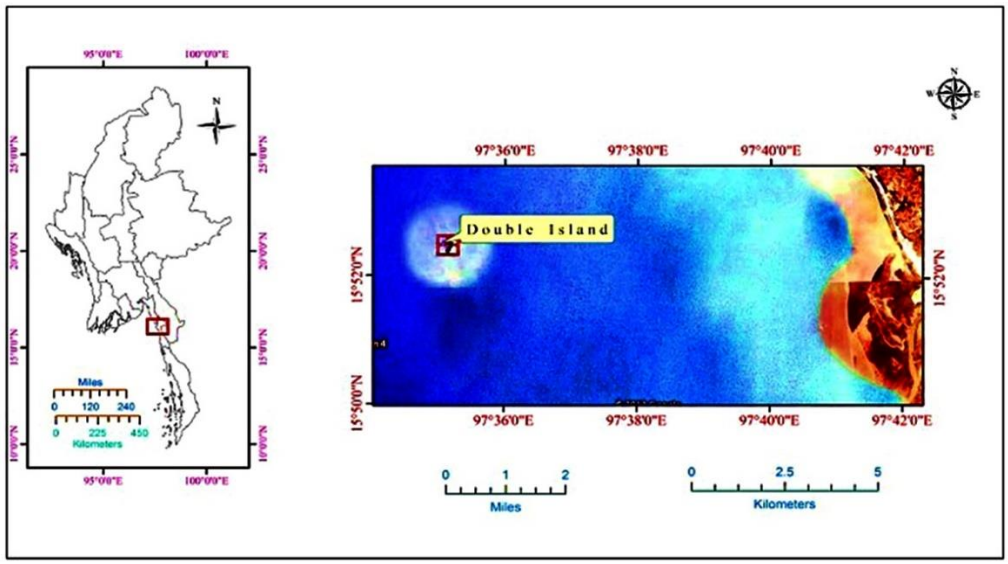

Figure 2. Sampling station at Mon coastal water

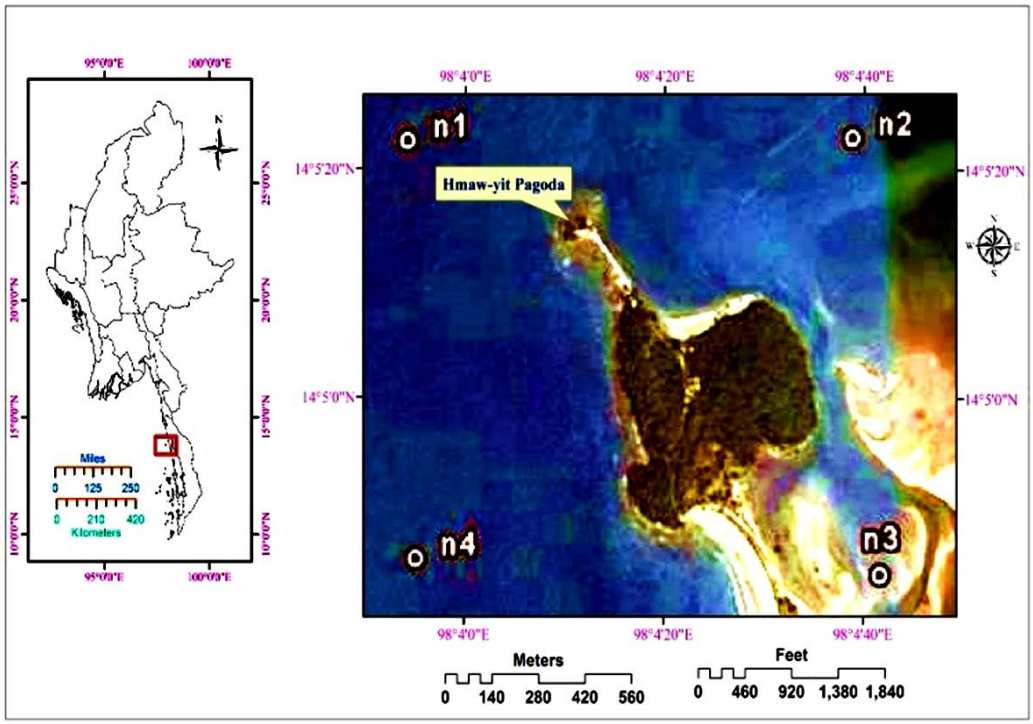

Figure 3. Sampling stations at Tanintharyi coastal water

2.2 Morphospecies group (taxonomic)

The present study follows the methods of Taylor et al. [15] and Guiry [16] for taxonomic identification. Dinoflagellates were separated into five morphospecies groups for ecological purposes.

2.3 Sample collection, preservation, and identification

Samples were collected seasonally. Since monsoon is the major climate changing-agent, the study period was divided into three seasons which is based on temperature records sold by the Meteorological Department. Months from February to May were grouped as pre-monsoon period, June to September as the monsoon period and October to January as the post-monsoon period, respectively.

Standard plankton net 20 µm aperture, 30 cm in diameter, 90 cm in length, and bucket diameter of 3.5cm, was used for qualitative analysis. For the quantitative analysis, the present study follows the method of LeGresley and McDermott [17] and Sournia [18]. Sub-samples were taken from the known volume and count with Sedgwick-Rafter cell counting [19]. The duration of the surface haul was 10 minutes for each attempt, and all the sampling procedure in this study was based on Sournia [18]. Formaldehyde solution was prepared according to Andersen and Throndsen [19] and immediately added to the samples with a final concentration of 4% [18]. Phytoplankton species identification was done according to the literature reported by Hasle et al. [20]. Micrometry of cells was measured by ocular-meter which is calibrated with the stage micrometer. Micrographs were captured by Digital Camera for Microscope (DCM 130, 1.3M pixels).

2.4 Environmental parameters

Salinity was immediately measured at sampling sites with a refractometer (AO) which is temperature compensated. pH values were determined *in situ* with Hanna meter. For the determination of nutrients such as PO_4-P, NO_3-N, and NH_3-N, the water samples were sent to the Ministry of Fishery and Livestock in Thakatha, Yangon.

3. RESULTS AND DISCUSSION

3.1 Species composition

During the study period, a total of 69 taxa at Rakhine coastal waters, 8 taxa at Mon coastal waters, and 29 taxa at Taninthayi coastal waters were recorded respectively.

At Rakhine coastal waters, Gonyaulacoid species were the most diverse group, 53% in species composition followed by Peridinoid 18%, Dinophisoid 13%, Prorocentroid 11%, and Gymnodinoids and Noctilucoids with 5% in descending order (Figure 4).

At Mon coastal waters, Gonyaulacoid species preoccupied 50% in percentage composition of the morphospecies group. Peridinoid 38% and Prorocentroid 10% placed second and third positions in population structure. Dinophisoid 2% was the least diverse group in this area (Figure 5).

The morphospecies groups consist of Gonyaulacoid 46%, Dinophisoid 23%, Peridinoid 15%, Prorocentroid 8%, and Gymnodinoids 8% in species composition at Tanintharyi coastal waters (Figure 6).

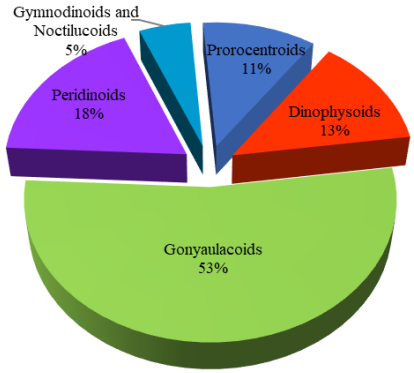

Figure 4. Percentage composition of morphospecies group of dinoflagellates at Rakhine coastal water

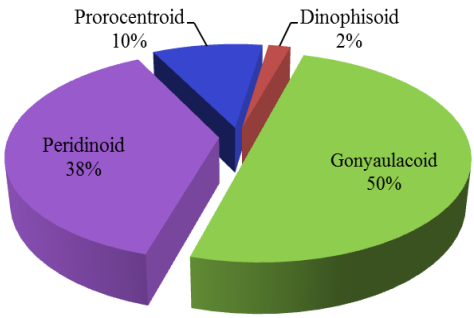

Figure 5. Percentage composition of morphospecies group of dinoflagellates at Mon coastal water

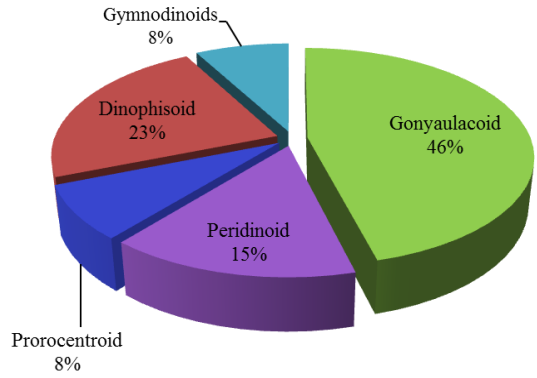

Figure 6. Percentage composition of morphospecies group of dinoflagellates at Tanintharyi coastal water

Concerning the percentage composition of morphospecies groups of dinoflagellates at 10 stations along Rakhine, Mon, and northern Taninthayi coastal waters, five morphospecies groups were recorded at Rakhine, four morphospecies groups such as Prorocentriod, Gonyaulacoid, Peridinoid, and Dinophisoid were recorded at Double Island surrounding areas of Mon coastal waters, and five morphospecies groups were recorded at northern Taninthayi coastal waters (Figures 4-6).

3.2 Cell abundance of dinoflagellates in relation to the environmental parameters

Salinity values were recorded in the range of 24-34‰ in pre-monsoon, 14-27‰ in monsoon, and 24-32‰ in post-monsoon seasons (Table 1). Concerning the pH, the value was normal in most of the study areas. Fluctuations take placed due to seasonal changes. A high pH value of 9.0 was found at Rakhine coastal waters during the monsoon period. At Hmaw-yit pagoda area of northern Tanintharyi waters, a low pH value of 5.3 was recorded in the pre-monsoon period (Table 2).

Regarding the nutrient concentrations, the PO_4-P content was recorded as 0.05-0.38, 0.01-0.07 and 0.03-0.26 mgL^{-1} in pre-monsoon, monsoon and post-monsoon months, respectively (Table 3). Concerning the NH_3-N concentration, the values showed no significant seasonal variations; 0.04-0.09 mgL^{-1} in pre-monsoon, 0.01-0.05 mgL^{-1} in monsoon and 0.03-0.07 mgL^{-1} in post-monsoon seasons (Table 4). In relation to the determination of NO_3-N content in the waters, the values showed in the range of 0.02-0.05 mgL^{-1} in pre-monsoon, 0.01-0.03 mgL^{-1} in monsoon and 0.01-0.04 mgL^{-1} in post-monsoon (Table 5).

Table 1. Salinity (in part per thousand, ppt)

No.	Stations	Period		
		Pre-monsoon	Monsoon	Post-monsoon
1.	Station 1-8	29-34	17-26	28-31
2.	Station 9	24-33	14-24	24-30
3.	Station 10	33-34	19-27	30-32

Table 2. pH

No.	Stations	Period		
		Pre-monsoon	Monsoon	Post-monsoon
1.	Station 1-8	7.8-8.6	6.8-9.0	7.5-8.7
2.	Station 9	7.8-8.5	6.8-7.2	7.6-8.8
3.	Station 10	5.3-8.0	7.4-7.8	8.3-8.6

Table 3. PO_4-P (mgL^{-1})

No.	Stations	Period		
		Pre-monsoon	Monsoon	Post-monsoon
1.	Station 1-8	0.07-0.38	0.01-0.06	0.03-0.21
2.	Station 9	0.05-0.03	0.01-0.03	0.04-0.17
3.	Station 10	0.08-0.21	0.01-0.07	0.05-0.26

Table 4. NH_3-N (mgL^{-1})

No.	Stations	Period		
		Pre-monsoon	Monsoon	Post-monsoon
1.	Station 1-8	0.04-0.08	0.01-0.03	0.04-0.06
2.	Station 9	0.04-0.07	0.01-0.02	0.03-0.05
3.	Station 10	0.05-0.09	0.01-0.05	0.05-0.07

Table 5. NO_3-N (mgL^{-1})

No.	Stations	Period		
		Pre-monsoon	Monsoon	Post-monsoon
1.	Station 1-8	0.03-0.05	0.01-0.02	0.02-0.04
2.	Station 9	0.02-0.04	0.01-0.03	0.01-0.04
3.	Station 10	0.02-0.05	0.01-0.02	0.02-0.04

Seasonal fluctuations in cell abundance occurred among morphospecies groups dinoflagellate at Rakhine, Mon, and northern Tanintharyi coastal waters were shown in Tables 6-8. The maximum cell abundance, 13305 $CellsL^{-1}$ was found in Station-10, Hmaw-yit pagoda station of Kampani, northern Taninthayi coastal waters during the pre-monsoon season (Table 8). The minimum value was found at Station 9, Double Island of Setse, Mon coastal waters where cell abundance was 859 $CellsL^{-1}$ (Table 7). The moderate cell abundance, 1306-4856 $CellsL^{-1}$ was noticed at Rakhine coastal waters throughout the study period (Table 6).

Table 6. Cell abundance (cells L^{-1} at Rakhine coastal water)

No.	Morphospecies group	Stations 1-8		
		Pre-monsoon	Monsoon	Post-monsoon
1	Prorocentriod	467	177	350
2	Dinophysoid	395	191	391
3	Gonyaulacoid	3353	560	1571
4	Peridinoid	515	285	578
5	Gymnodinoid	126	93	167
Total Cell Density		4856	1306	3057

Table 7. Cell abundance (cells L^{-1} at Mon coastal water)

No.	Morphospecies group	Station 9		
		Pre-monsoon	Monsoon	Post-monsoon
1	Prorocentriod	155	76	146
2	Dinophysoid	133	2	39
3	Gonyaulacoid	866	59	590
4	Peridinoid	1784	722	1982
Total Cell Density		2938	859	2757

At all study areas, species composition of dinoflagellate showed different from one another. In Rakhine coastal waters, the Gonyaulacoids group occupied more than 50% in species composition. As well, the Gonyaulacoids group stood as the most dominant group in Mon and northern Tanintharyi coastal waters. Peridinoid and Dinophysoids were noted as dominant groups after Gonyaulacoids. Members of the Gymnodinoids group had not been observed at Double Island of Setse, Mon coastal waters. Gonyaulacoid and Peridinoid showed more abundant in dinoflagellate species groups.

Table 8. Cell abundance (cells L^{-1} at Tanintharyi coastal water)

No.	Morphospecies group	Station 10		
		Pre-monsoon	Monsoon	Post-monsoon
1	Prorocentriod	1525	2325	2439
2	Dinophysoid	4450	3210	3462
3	Gonyaulacoid	5245	5175	2225
4	Peridinoid	2085	750	2740
Total Cell Density		13305	11460	10866

The salinity of the study areas was varied. It went up to a high level (33-34‰) in the pre-monsoon period and down to the minimum level in the monsoon period due to heavy rainfall (Table 1). pH values varied seasonally. The maximum value stretched to 9.0 was detected in monsoon months (Table 2). Regarding the nutrient concentrations, the values of PO_4-P, NH_3-N, and NO_3-N were higher in pre-monsoon months (Tables 3-5) which in turn affect a positive relationship between cell abundance of dinoflagellates indicated that a mesotrophic environment favor for species richness and dense. The present study indicates that cell abundance of dinoflagellates at all stations was high during the premonsoon period. Low cell density was mostly recorded in the monsoon period. Among the stations, Station-10 has the maximum cell abundance all the year-round (Figure 7).

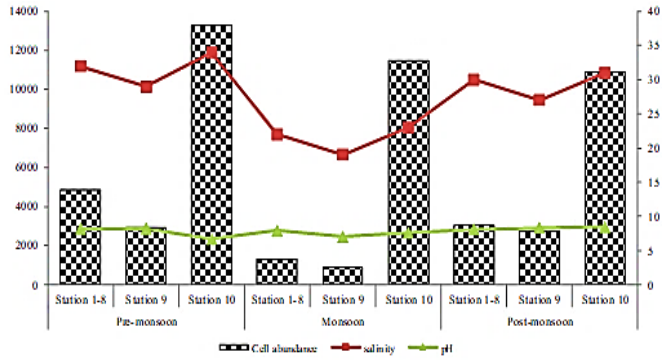

Figure 7. Cell abundance of dinoflagellates in relation to salinity and pH among 10 stations during pre-monsoon, monsoon and post-monsoon seasons at Rakhine, Mon and northern Tanintharyi coastal waters

4. CONCLUSIONS

Each morphospecies group consists of different numbers of individual species. Changes in species composition and abundance of dinoflagellates in one area to another place were made by the influences of seasonal variations of physicochemical parameters. Gonyaulacoids stood as the most dominant group in the species composition of dinoflagellates. Peridinoid and Dinophysoids were noted as dominant groups after Gonyaulacoids. High species density was observed during the pre-monsoon period in the study areas. This is similar to the occurrence patterns of phytoplankton in the

Indian Ocean. Thus, a natural history of water masses of the study areas is also important in the dominance of microalgae assemblages.

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