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SPECIES SUCCESSION OF PHYTOPLANKTON IN RELATION TO SOME PHYSICO-CHEMICAL PARAMETERS IN MYEIK ARCHIPELAGO, SOUTHERN MYANMAR

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Abstract

Phytoplankton samples were collected from ten designated sampling stations from Kywe Ku bridge (Lat. 12º 31´ N and Long. 98º 47´ E) to Done Pale Aw (Lat. 12º 21´ N and Long. 98º 02´ E) covering inshore, nearshore and offshore, Myeik coastal waters from June 2011 to February 2013. A total of 135 phytoplankton species were identified. In the inshore water (Station 1 and Station 2), the species succession was evident by 8 species of diatoms. In the nearshore water (Station 3, Station 4, Station 5, Station 6 and Station 7), fifteen species of diatoms and one species of dinoflagellate were recorded as species succession. In the offshore water (Station 8, Station 9 and Station 10), there were twenty species of diatoms in the species succession. The quantity of physico-chemical parameters were: water temperature 25-30ºC, salinity 4-34‰, pH 7.1-8.2, phosphate 0.01-1.33 mg/l, nitrate 0.01-0.99 mg/l and transparency 0.51-9.0 m in the Myeik coastal waters. The diatoms were more dominant than the dinoflagellate in any season and their densities were always near 90%. The composition of dominant diatoms showed the different situations from the inshore, nearshore to offshore coastal waters. The succession of phytoplankton was positively correlated with some environmental factors such as transparency and temperature, however, the negative correlation was found with nitrate, phosphate, salinity, pH and rainfall in Myeik Archipelago.

Keywords: Offshore, inshore, nearshore, phytoplankton, succession.

Introduction

Myanmar coastline stretches about 2400 km from the Naff River mouth to Kawthaung city, facing the Bay of Bengal and the Andaman Sea in the west which is a southeastern part of the Bay of Bengal. This Bay is a semi-enclosed tropical basin located in the northern Indian Ocean. Since Myanmar has tropical monsoon climate, Myanmar coastal area is influenced by strong

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monsoon regimes. Myeik, in the southern part of Myanmar is an archipelagic region with an area that has 34,340 sq km and consist of over 800 islands. The coasts facing the Andaman Sea are especially noteworthy in terms of marine production. Around these regions, rich terrestrial nutrients are supplied from numerous rivers and there are extensive mangrove forests, which cover 425,000 hectares, the third largest mangrove extent in Southeast Asia. Phytoplankton also needs nutrients to grow. They need a wide variety of chemical elements but the two critical ones are nitrogen and phosphorous since they are needed in quite large amounts but are present in low concentrations in seawater. Nitrogen and phosphorous are like the fertilizers to land plants and are used to make proteins, nucleic acids and other cell parts the phytoplankton need to survive and reproduce. Therefore phytoplankton needs nutrients in well defined ratios. The physico-chemical parameters and quantity of nutrients in water play significant role in the distributional patterns and species composition of plankton. Coastal and near-shore waters are more productive regions in the marine environment due to nutrient add by means of regeneration, upwelling and land run-off.

In aquatic habitats, the environmental factors include various physical properties of water such as solubility of gases and solids, the penetration of light, temperature, and density. The chemical factors such as salinity, pH, hardness, phosphates and nitrates are very important for growth and density of phytoplankton on which zooplankton and some higher consumer depend on their existence. The turbidity may exert a further control on phytoplankton. The inorganic micro-nutrients considered as limited factors affecting the growth of phytoplankton. Natural phytoplankton populations respond to environmental changes in various ways. Variation in phytoplankton community composition depends on the availability of nutrients, temperature and light intensity.

Phytoplankton species succession undergoes the changes due to change in the physical, chemical and biological factors. The influence of environmental factors on species succession varies significantly with physical factors like temperature and light intensity being the most important and chemical factors like pH, salinity, and nutrient level being the most important. The relative abundance of species succession groups vary seasonally and geographically.

Nitrogen and phosphorus may all well limit species succession. Variation in phytoplankton community composition depends on the availability of nutrients, temperature and light intensity. The seasonal stratification of water columns determines the general availability of the resources light and nutrients for species succession. Succession shifts in phytoplankton community structure are mainly due to change in environmental variables such as nutrients and other physico-chemical variables which influence the distribution and abundance of plankton communities. The phytoplankton is the direct indicators of human intervention in the marine environment. Any extreme changes in their population or composition can be taken as an alarm signal to check the source of pollution in the system. Phytoplankton species undergo the changes in their distribution due to change in the physical, chemical and biological factors.

The objectives of this study are: 1) to identify the taxonomic and nomenclatural knowledge of diatoms and dinoflagellate species from Myeik coastal waters; 2) to recognize the dominant species in Myeik coastal waters; 3) to know the changes of the physico-chemical characters in relation to species succession in Myeik coastal waters; and 4) to understand phytoplankton communities in relation to some environmental parameters in Myeik coastal waters.

Materials and Methods

Myeik coastal waters are situated in the southern part of Taninthayi (Tenasserim) strip fronted by the Andaman Sea, in the northeastern part of the

Bay of Bengal. This study area comprises 10 Stations: 1) The Kywe Ku Bridge Station, 2) Kyauk Phyar River mouth, 3) Kywe Ku-Pahtaw, 4) Pahtaw-Pahtet, 5) A Saung Kaung 6) Masan-pa, 7) East of Ka Lar Kyun, 8) Kattalu, 9) Sha Aw and 10) Done Pale Aw (Figure. 1).

The Kywe Ku bridge Station is located in the Northeast of Myeik at Latitude 12° 30´ N and Longitude 98° 45´ E. Kyauk Phyar river mouth lies at Latitude 12° 31´ N and Longitude 98° 42´ E in the West of Kywe Ku bridge and Northeast of Myeik. Kywe Ku-Pahtaw is situated the Northern part of Myeik at Latitude 12° 31´ N and Longitude 98° 35´ E. Pahtaw-Pahtet is located in the West of Myeik at Latitude 12° 27´ N and Longitude 98° 36´ E. A Saung Kaung lies in the South of Myeik at Latitude 12° 24´ N and Longitude 98° 37´ E. Moreover Masan-pa is situated in the Southwest of Myeik at Latitude 12° 24´ N and Longitude 98° 31´ E. East of Ka Lar Kyun is located in the West of Myeik from Latitude 12° 27´ N and Longitude 98° 31´ E. Kattalu lies North of Myeik at Latitude 12° 30´ N and Longitude 98° 28´ E. Sha Aw is situated in the West of Myeik and North of Thayawthadargyi Kyun at Latitude 12° 25´ N and Longitude 98° 05´ E. Done Pale Aw is located in the West of Myeik, the North of Daung Kyun and East of Thayawthadangyi Kyun at Latitude 12° 21´ N and Longitude 98° 02´ E.

The samples were collected monthly (June 2011–February 2013) from the waters of Kywe Ku Bridge (Latitude 12° 30´ N and Longitude 98° 45´ E) to Done Pale Aw (Latitude 12° 21´ N and Longitude 98° 02´ E) comprising of ten stations (Fig. 1). These samples were collected with a 20 µm mesh size standard plankton net (2 feet long and 25 cm wide) and then towed from the horizontal water (10 m) from an anchored boat for 5 minutes. Sampling was carried out between 10:00 am and 1:30 pm during the neap tide. Each sample was preserved into 2 % formalin/sea water mixture and stored in the Department of Marine Science, Myeik University. The materials used were either examined fresh or preserved in formalin. The data represented salinity, temperature, transparency, pH, rainfall, nitrate and phosphate of each location.

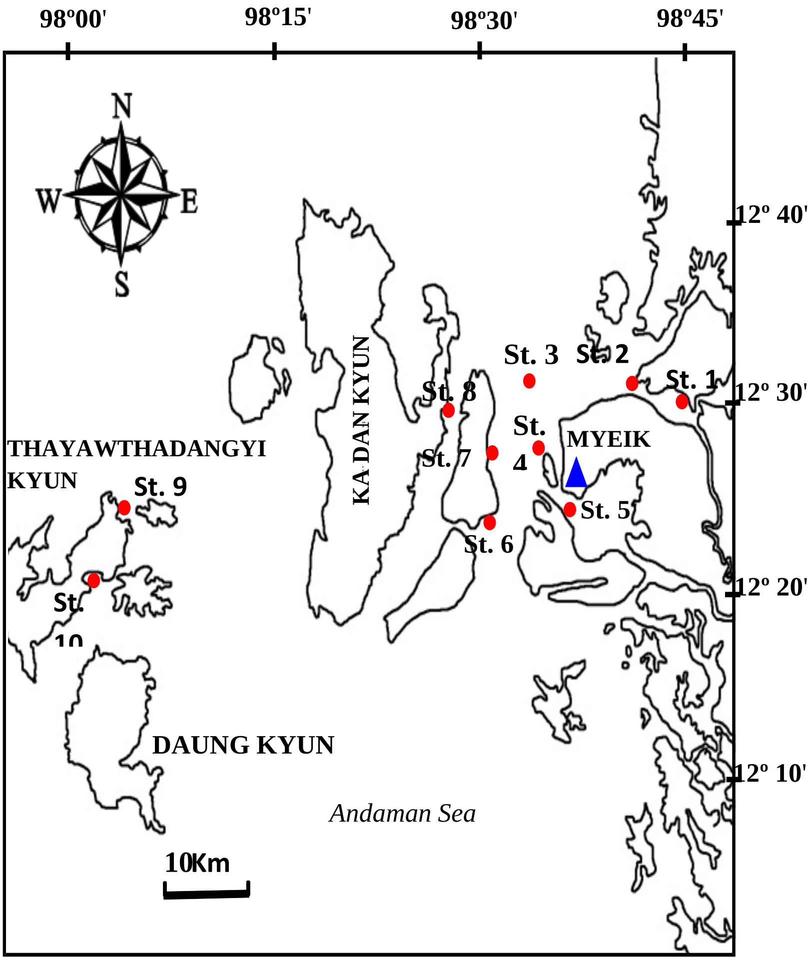


Figure. 1. Map showing the location of Myeik coastal areas and sample collection sites: Station 1 (Kywe Ku Bridge), Station 2 (Kyauk Phyar River mouth), Station 3 (Kywe Ku-Pahtaw), Station 4 (Pahtaw-Pahtet), Station 5 (A Saung Kaung), Station 6 (Masan-pa), Station 7 (East of Ka Lar Kyun), Station 8 (Kattalu), Station 9 (Sha Aw) and Station 10 (Done Pale Aw).

Identification of phytoplankton collected from Myeik coastal waters was done according to the following reference books; Heurck (1896), Allen and Cupp (1930), Hendey (1964), Patrick and Reimer (1966), Shirota (1966), Weber (1966), Sournia (1968), Yamaji (1971), Chandy *et al.* (1992), Hasle and Syvertsen (1997), Steidinger and Tangen (1997), Botes (2001) and Han Shein and Kyi Win (2012). This study basically followed the classification system used by Guiry (2010, 2011, 2012, 2013 and 2014). The phytoplankton species were counted under Nikon light microscope for the measurements of phytoplankton abundance. The formula is simply the basic geometry formula. Results were expressed in the number of cells/m^3. The filtered volume of water entering the phytoplankton can be calculated as follows:

$$V= \pi r^2 l$$

Where,V= the volume of water that passes through the net

r= the radius of the hoop at the front of the net,

l= the distance through which the net was hauled, that was 10 m.

Results

Species succession in relation to some environmental factors by stations of the inshore, nearshore and offshore waters

Phytoplankton, species succession relevant to some physic-chemical characters of some water bodies at Myeik coastal waters was studied for three years (2011-2013). A total of 135 taxa belonging to 66 genera from 40 families, 26 orders, 4 classes and 2 phyla of phytoplankton were recorded from the study areas. Among them, 116 species and 55 genera, under Bacillariophyta (diatoms) and 19 species consisting of 12 genera, under Dinoflagellata (dinoflagellates) were observed. Some physic-chemical factors such as mixing of water mass, temperature, salinity, pH, phosphate, nitrate, transparency and rainfall affect the succession of phytoplankton in the study period.

Species succession in the inshore water (Station 1 and Station 2)

The seasonal variation of ecological response of phytoplankton in the Myeik coastal waters was presented. The species succession was evident by 8 species of diatoms, namely, *Cyclotella striata, Pleurosigma normanii, Odontella sinensis, Odontella mobiliensis, Thalassiosira excentrica, Thalassionema nitzschioides, Thalassionema frauenfeldii* and *Melosira nummuloides*. The succession of *Pleurosigma normanii* was recorded when temperature was 28ºC and salinity 29‰, during the post monsoon season (February 2012). This species decreased from premosoon to monsoon season (June to July). *Melosira nummuloides* 1500 cell/m^3 was observed when temperature was 27ºC and salinity 28‰ during the postmonsoon season (December 2011). The greatest abundance of *P. normanii* 2219 cell/m^3 was recorded in (February 2012) (Table. 1) (Figure. 2).

The most dominant *C. striata* was recorded only in the postmonsoon (January to February). The species succession of *T. excentrica* was found in December during 2011, however, October in 2012. *Odontella mobiliensis* mostly occurred during premonsoon to monsoon season. The species appeared to adapt to the salinity 4-26‰ and temperature 25-28ºC during the study period. The succession of *Odontella sinensis* was found only in the monsoon season. The main species *Thalassionema nitzschioides* and *Thalassionema frauenfeldii* did not show any seasonal fluctuation.

The amount of physico-chemical parameters were: water temperature 25-28ºC, salinity 4-29‰, pH 7.1-7.3, phosphate 0.01-1.33 mg/l, nitrate 0.01-0.99 mg/l and transparency 0.68-1.00m in the inshore water. A noteworthy feature in the observations was that nutrient concentration in the inshore water during months of June and July were higher than other months.

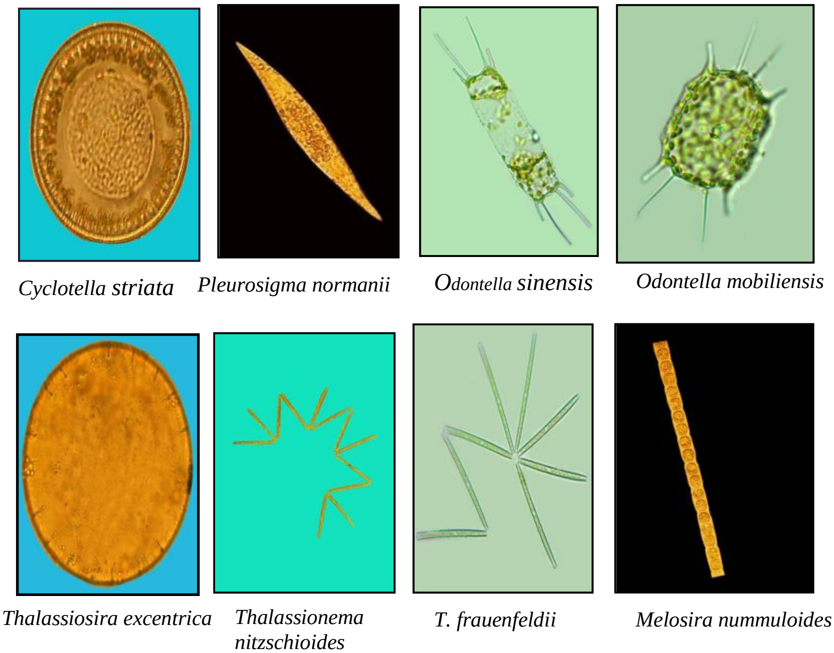


Figure 2. The dominant species in the inshore water during the study period.

Species succession in the nearshore water (Station 3, Station 4, Station 5, Station 6 and Station 7)

Sixteen species of phytoplankton was occurred as the species succession in the near shore of Myeik coastal waters such as *Rhizosolenia imbricata* together with *Guinardia flaccida* and *Proboscia alata* in the postmonsoon season while there was high temperature (26-28°C); and salinity (30-32‰) and then low rainfall (0-160 mm). The species *Chaetoceros curvisetus* was common together with *Thalassionema nitzschioides, Thalassionema frauenfeldii* and *Ditylum sol* in the all seasons. They were denser in the postmonsoon season than the other. A dinoflagellate, *Ceratium furca* was dominantly observed from June to November. The high level of

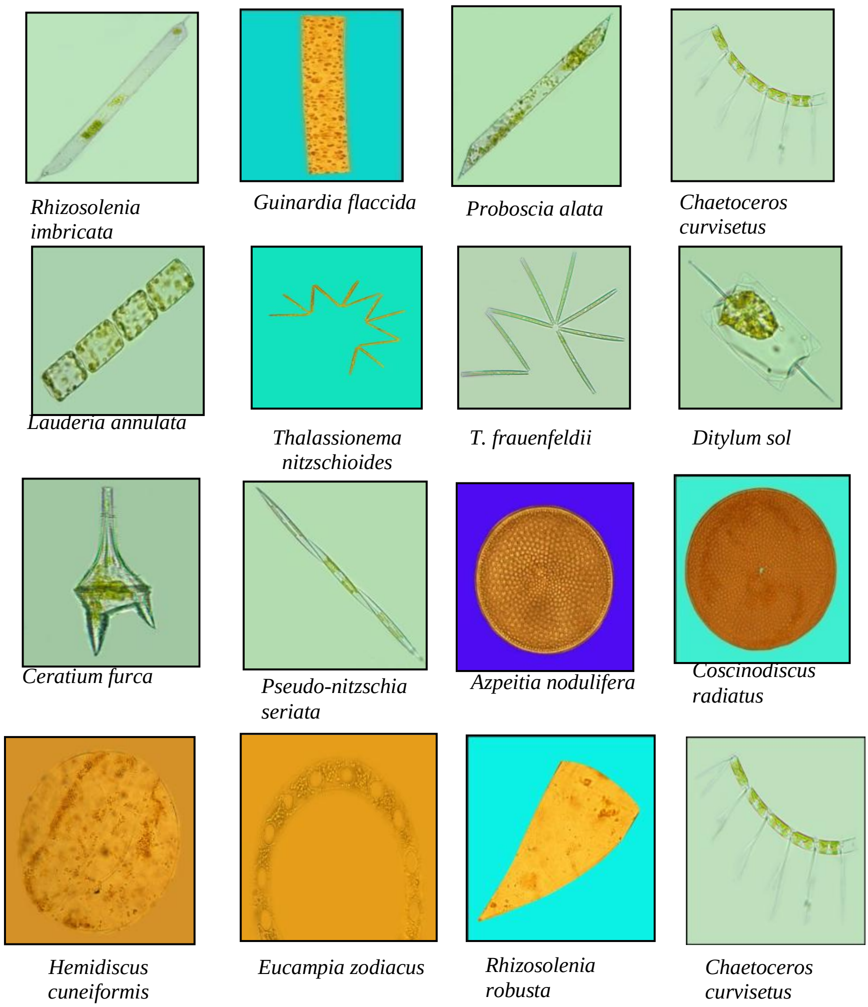


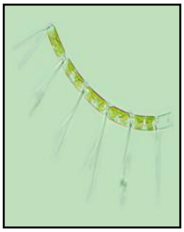
Figure 3. The dominant species in the nearshore water during the study period.

Azpeitia Nodulifera Coscinodiscus radiatus, Odontella sinensis and *Odontella mobiliensis* were common recorded in postmonsoon season. *C. radiatus* (21389 cell/m^3) was the most dominant species in (December, 2011) (Table. 2) (Figs. 3,6,7). Moreover *Pseudo-nitzschia seriata* was common found from premonsoon to monsoon season while there were high nutrient (maximum phosphate 0.31 mg/l and nitrate 0.05 mg/l). In addition, *Hemidiscus cuneiformis* and *Eucampia zodiacus* were abundant in the postmonsoon while the maximum water transparency was 1.56 m.

On the other hand, *Rhizosolenia robusta* was also important, occurring in only December, 2012 during high salinity and low rainfall. The quantity of physico-chemical parameters were: water temperature 25-28ºC, salinity 10-33‰, pH 7.1-7.9, phosphate 0.01-0.41 mg/l, nitrate 0.01-0.06 mg/l and transparency 0.51-1.99 m in the nearshore water. The species succession changes were recognized as associated with changing environmental conditions.

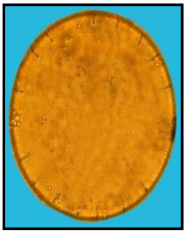
Species succession in the offshore water (Station 8, Station 9 and Station 10)

A total 12 species of phytoplankton were dominant according to the monsoon. *Chaetoceros curvisetus* and *Odontella sinensis* were major alga to be succeeded the whole year round but the most dominant in the postmonsoon season at high salinity, (30-34‰) and high temperature (26-30ºC).

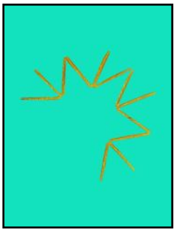


Chaetoceros curvisetus

Coscinodiscus radiatus



Thalassiosira excentrica



Thalassionema a nitzschioides

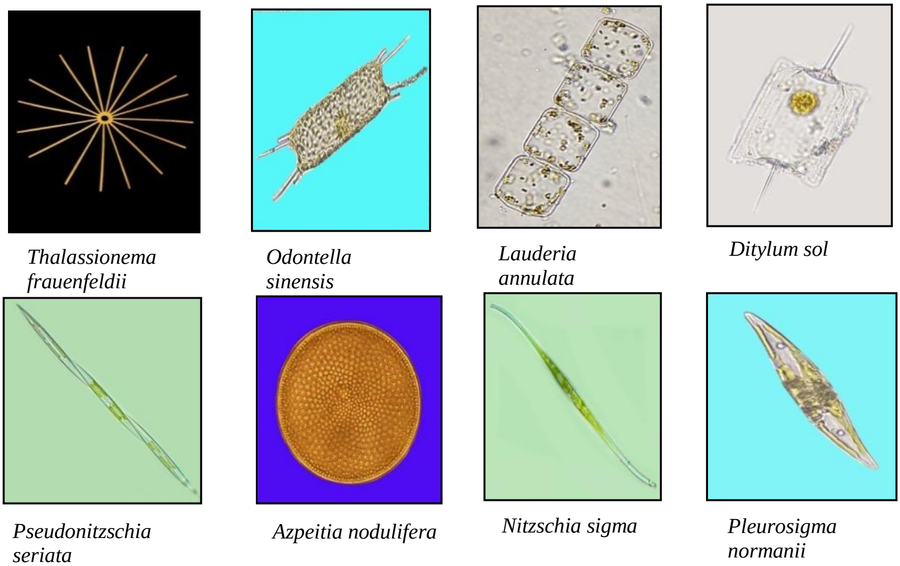


Figure 4. The dominant species in the offshore water during the study

The massive diatoms bloom with high density of *Coscinodiscus radiatus*, *Thalassiosira excentrica*, *Thalassionema frauenfeldii* and *Thalassionema nitzschioides* were detected under conditions of raised nutrient concentration from the premonsoon to monsoon season while temperature 26-29ºC and salinity18-32% .

Moreover, *Lauderia annulata* together with *Ditylum sol* and *Pseudonitzschia* were dominantly found only in the postmonsoon season while temperature was 26-29ºC and salinity, 32-34‰. The maximum dominance of *Azpeitia nodulifera* together with *Nitzschia sigma* appeared in November and they had a toleration of temperature 28-30ºC and salinity 30-31‰. In addition, *Chaetoceros curvisetus* showed the succession in postmonsoon season. This species was the most dominant species (5623 cell/m^3) in February, 2012 (Table. 3) (Figure. 4).

The amount of physico-chemical parameters were: water temperature 26-30ºC, salinity 18-34‰, pH 7.1-8.2, phosphate 0.01-0.87 mg/l, nitrate 0.01-0.18 mg/l and transparency 0.76-9.0 m in the offshore water. The diatoms were more dominant in any season and their densities were always near 90%. The composition of dominant diatoms showed the different situations from the inshore, nearshore to offshore coastal waters (Tables. 1-3).

Discussion

The phytoplankton community of the study area's water inhabited 90 species of Bacillariophyceae, 25 species of Coscinodiscophyceae, 19 species of Dinophyceae, and 1 species of Dictyochophyceae.

The total phytoplankton community during this proliferation was composed mainly of diatoms (21 species) and dinoflagellate (1 species) dominated by namely, *Azpeitia nodulifera*, *Cyclotella striata*, *Chaetoceros curvisetus*, *Ceratium furca*, *Ditylum sol*, *Eucampia zoodiacus*, *Guinardia flaccida*, *Hemidiscus cuneiformis*, *Lauderia annulata*, *Coscinodiscus radiatus*, *Melosira nummuloides*, *Nitzschia sigma*, *Odontella sinensis*, *Odontella mobiliensis*, *Pleurosigma normanii*, *Proboscia alata*, *Pseudonitzschia seriata*, *Rhizosolenia imbricata*, *R. robusta*, *Thalassiosira excentrica*, *Thalassionema frauenfeldii* and *T. nitzschioides* were recorded during the study period (Tables. 1-3) (Figure.2).

Table. 1. The abundance (cell/m^3) of the species succession at inshore water from June (2011) to February 2013.

Sr. No.	Species	2011 year							2012 year										2013 year	
		J	J	A	S	O	N	D	J	F	J	J	A	S	O	N	D	J	F
1	*Cyclotella striata*	459	520	611	458	518	489	540	750	850	220	450	350	200	510	380	450	650	750
2	*Melosira nummuloides*	1000	1050	1206	1054	1135	1056	1500	1300	1450	300	600	950	1000	900	1000	1000	1250	1420
3	*Odontella mobiliensis*	750	850	951	850	900	785	350	250	350	550	800	500	750	450	650	630	300	360
4	*O. sinensis*	680	650	764	720	678	640	500	450	650	400	350	650	650	500	600	450	338	450
5	*Pleurosigma normanii*	1587	1650	1824	1634	1458	1367	2000	2100	2219	1200	1000	950	1200	1268	1200	1200	1800	1800
6	*Thalassionema frauenfeldii*	1067	1150	1223	1036	1009	986	1000	900	1000	850	750	1000	750	980	750	980	750	1202
7	*T. nitzschioides*	985	1000	1206	984	896	950	1200	1100	980	800	750	850	600	750	800	900	1090	1000
8	*Thalassiosira excentrica*	467	577	577	569	469	510	650	550	670	550	500	350	350	700	350	350	550	600

Table. 2. The abundance (cell/m^3) of the species succession at nearshore water from June (2011) to February 2013.

Sr. No.	Species	2011 year							2012 year										2013 year	
		J	J	A	S	O	N	D	J	F	J	J	A	S	O	N	D	J	F
1	*Rhizosolenia imbricata*	0	0	0	0	0	0	6000	7764	5800	1	1	1	0	1	1	5600	7500	5691
2	*R. robusta*	18	13	15	12	10	15	540	774	650	15	9	8	13	8	13	550	650	600
3	*Guinardia flaccida*	0	0	0	0	0	0	2000	2517	2401	1	1	1	1	0	1	1560	2240	1890
4	*Proboscia alata*	4	3	10	8	10	4	950	1004	850	3	5	8	9	9	6	860	980	790
5	*Azpeitia nodulifera*	1465	1580	2097	2010	1900	1850	200	203	180	1309	1356	1289	1980	1750	1670	190	198	167
6	*Chaetoceros curvisetus*	1950	2412	2000	2500	2000	2450	2200	2450	2500	1896	1982	1780	2350	1850	2365	1950	2243	2300
7	*Thalassionema frauenfeldii*	650	798	760	550	489	800	200	458	430	635	765	720	490	420	783	190	435	410
8	*T. nitzschioides*	1050	1117	950	800	759	1000	400	506	450	1034	1005	935	750	723	980	350	456	432
9	*Ditylum sol*	370	450	560	600	450	389	1292	1308	1200	250	380	400	560	520	270	1100	1254	1256
10	*Ceratium furca*	750	900	850	650	750	825	200	50	10	650	759	755	550	650	750	170	44	8
11	*Coscinodiscus radiatus*	118	100	98	100	98	120	21389	8834	9000	101	87	90	89	80	110	15000	7500	8500
12	*Odontella sinensis*	84	50	65	75	85	75	594	2279	2500	79	45	55	65	89	69	502	1890	2389
13	*Odontella mobiliensis*	50	65	84	65	50	60	1650	1732	1236	35	58	80	65	60	56	1509	1567	1400
14	*Pseudo-nitzschia seriata*	800	910	750	560	450	850	100	193	200	750	850	686	450	380	750	89	170	160
15	*Hemidiscus cuneiformis*	10	3	5	3	5	3	492	1189	1000	9	5	7	5	7	5	389	1097	987
16	*Eucampia zodiacus*	5	6	7	8	5	8	11	856	750	4	5	8	6	5	7	9	750	650

rom June (2011) to February 2013.

		2012 year							2013 year	
J	F	J	J	A	S	O	N	D	J	F
560	5623	350	453	360	869	950	1100	3946	4380	5300
0	0	980	1000	1350	1220	1316	1200	7	2	1
3	0	570	560	790	690	850	790	2	5	1
380	441	320	180	470	350	367	226	350	350	380
500	662	260	330	390	370	259	175	430	402	560
450	2100	104	139	250	195	180	165	1490	1500	1950
000	1284	133	122	124	110	98	235	890	990	1100
790	2008	27	22	37	20	32	29	1800	1750	1870
020	1077	18	18	15	8	8	3	900	1005	1067
70	100	1	98	99	85	68	548	87	63	98
250	350	85	45	65	55	45	569	230	220	330
380	500	100	46	39	30	27	22	389	400	459

dard deviation of some waters quality parameters from ten stations in Myeik coastal

Mean and Standard deviation

In the present investigation, some environmenta actors such as temperature 25-30ºC, salinity 4-34‰, pH 7.1-8.2, phosphate 0.01-1.33 mg/l, nitrate 0.01-0.99 mg/l, transparency 0.38-9 m and rainfall 0-1082 mm occurred in Myeik coastal waters. The physico-chemical factors and their values, affect the succession of phytoplankton in the study areas. Raymont (1963) described that some species have fairly specific requirements for temperature, salinity and nutrients. So the present study seemed to agree with the observation of Raymont (1963). That author recorded that *T. nitzschioides* was extremely euryhaline with a salinity range from 4 to 34‰. That was agreement with *T. nitzschioides* in this study.

Kyi Win and Han Shein (1987) mentioned that phytoplankton such as *Biddulphia mobiliensis, B. sinensis* and *Pleurosigma spp.* were fairly abundant in Setse, Thanbyuzayat, Mon State. Their result more or less matched with the result from Myeik coastal waters (Present study).

Boonyapiwat (1997) described that the greatest phytoplankton bloom occurred by the highest cell density of *Skeletonema costatum* in the postmonsoon season near the end of Peninsular Malaysia. However *Chaetoceros curvisetus, Coscinodiscus radiatus, Pleurosigma normanii,* and *Rhizosolenia imbricata* were abundantly found in this season from Myeik coastal waters.

Paul *et al*. (2001) observed that *T. frauenfeldii, T. nitzschioides, Chaetoceros lorenzianum* and *C. curvisetus* were abundant in the months of September-October. This result agreed with the result of the present study (nearshore and offshore waters).

The effect of temperature on phytoplankton growth seemed to be direct. It seems that certain phytoplankton was stenothermal. Other species seemed to be eurythermal and were tolerant of a wide temperature range. Temperature was the most important factor affecting diatom and dinoflagellate growth, even more than nutrients, and that phytoplankton abundance directly varied with it. The optimum temperature for diatom development was dependent on the type of flora present. The surface temperature was to some extent responsible for the change in the phytoplankton, species succession.

Paul *et al*. (2001) mentioned that *Skeletonema costatum* preferred the water temperature of 28-30ºC. Therefore that observation was quite similar to the finding of the present study. They also reported that the highly diverse centric diatoms such as *Coscinodiscus sp., Chaetoceros sp.* and

Thalassionema frauenfeldii were recorded. So this observation matched with the present study (nearshore water).

Matondkar *et al*. (2002) pointed out that *Rhizosolenia sp.* and *Chaetoceros sp.* were related to their preference for higher salinity from Mandovi and Zuari estuaries. Therefore that result was similar to the observation of the present study (nearshore water). They also described that *Thalassiosira sp*. reflected their preference for the saline region but Selvaraj *et al*. 2003 stated that *Thalassiosira sp*. preferred the intertidal waters of Cochin. This result somewhat agreed with the observation of the present study at Station 4 during this period.

Boonyapiwat *et al*. (2007) reported that the succession of diatom species were mainly in the southern part of Myanmar waters. This author described that the dinoflagellate species, *Ceratium furca* was dominant in Station 2 near the Bay of Bengal. In the present study, this species was also dominant at Station 1 and Station 6 too. Touliabah *et al.* (2010) described that phytoplankton succession was relevant to some physico-chemical characters of some water bodies at Jeddah (Saudi Arabia). Ozbay (2011) suggested that nitrate was the limiting factor for phytoplankton growth. Their observations agreed to the present study.

Palleyi *et al*. (2011) reported that the dominant species recorded at different sampling stations belonged to the genera *Coscinodiscus, Rhizosolenia, Thalasionema, Chaetocerous, Melosira* and *Pleurosigma* from Dharmra river estuary of Odisha coast, Bay of Bengal. That result was similar to some result at some stations in the present study. Rathod (2011) reported that *Thalassionema nitzschioides* was the predominant species in Indian Ocean. It was found that this statement was the same for Myeik coastal waters (Present study). Fonge *et al*. (2012) described that the most frequent species was *Pseudo-nitzschia seriata* from Cameroon. This result more or less matched the result of the present study.

Sahu *et al*. (2012) reported that the productivity and community composition of dinoflagellates were expected to be very scanty in most of the coastal waters from Southeast coast of India. That report somewhat agreed with the observation of the present study. Su Myat (2013) described that *Coscinodiscus radiatus, Cyclotella striata, Lauderia annulata, Guinardia striata* and *Pleurosigma normanii* were commonly detected in the postmonsoon season (December) from the southern part of Myanmar. Therefore her observations more or less coincided with the result of the present study in some stations. Thida Nyunt (2013) showed that *Coscinodiscus sp*. and *Pleurosigma sp*. were the most abundant diatoms species in Kyaikkhami Station. This result was similar to that of the present study at the stations of 1, 3, 4 and 9 Station.

A succession of species was evident with *Cyclotella striata, Melosira nummuloides, Odontella sinensis, Odontella mobiliensis, Pleurosigma normanii, Thalassiosira excentrica, Thalassionema frauenfeldii* and *T. nitzschioides* were generally most abundant diatoms of the inshore water (Table. 1) (Figs. 2,5).

Moreover, *Azpeitia nodulifera, Chaetoceros curvisetus, Ceratium furca, Ditylum sol, Eucampia zoodiacus, Guinardia flaccida, Hemidiscus cuneiformis, Coscinodiscus radiatus, Odontella sinensis, Odontella mobiliensis, Proboscia alata, Pseudonitzschia seriata, Rhizosolenia imbricata, R. robusta, Thalassionema frauenfeldii* and *T. nitzschioides* were the important species in the nearshore water (Table. 2) (Fig.3).

However, *Azpeitia nodulifera, Chaetoceros curvisetus, Ditylum sol, Lauderia annulata, Coscinodiscus radiatus, Nitzschia sigma, Odontella sinensis, Pleurosigma normanii, Pseudonitzschia seriata, Thalassiosira excentrica, Thalassionema frauenfeldii* and *T. nitzschioides* were abundantly occurred in the offshore water during the study period (Table. 3) (Fig. 4).

The maximum standard deviation of temperature at 1.498 was recorded at Station 3 whereas the minimum deviation 0.577 was recorded at Station 8.

As regard the maximum and minimum of salinity were as follows: maximum at Station 1: 9.633 and minimum at Station 10: 3.964. For pH the maximum and minimum were: 0.299 at Station 9 and 0.048 at Station 4 (Table. 4).

The maximum standard deviation of phosphate at 0.456 was recorded at Station 1 whereas the minimum deviation 0.022 was recorded at Station 2. Standard deviations from maximum to minimum for nitrate at different stations were at follow: maximum deviation at Station 1: 0.342 and minimum deviation at Station 6: 0.009. For water transparency the maximum and minimum were: 0.998 at Station 9 and 0.091 at Station 1 (Table. 4).

The nearshore upwelling zone not only had a high yield of nutrients, but also was a high primary production area for phytoplankton and inversely related to zooplankton. The quantities of phytoplankton may be related to the concentrations of nutrients available, consequent on vertical mixing. Ozbay (2011) suggested that nitrate was the limiting factor for phytoplankton growth from the Kars River, Turkey.

At the present study, the peaks of the phytoplankton were mainly due to flourishing of Bacillariophyceae, which contributed 67% of the total phytoplankton community during the postmonsoon season. Gopinathan (1972) described the peak of phytoplankton abundance observed during the postmonsoon season from Cochin backwater. This result was similar to the present study. The structure of phytoplankton communities depended not only on grazing pressure but also on nutrient according to Ozbay 2011.

Patrick and Remier (1966) described that nutrients in the sea were received by drainage from land or were brought to the surface from deep water. In present investigation, the high nutrient concentration in the nearshore waters was due to rainfall and drainage from rivers and streams. The changes and fluctuation in the rainfall occurring within the seasons and from season to season were also chiefly responsible for the blooming and abundance of phytoplankton especially during premonsoon and postmonsoon periods. Seasonal variations in temperature, salinity, rainfall and nutrients levels all play a major part in phytoplankton species succession.

Conclusions

A study on species succession of phytoplankton in ten different stations of Myeik coastal waters was conducted. Among 135 phytoplankton species, 22 species of diatoms and 1 dinoflagellate were occurred as species succession. The diatoms represented as the dominant group followed by the dinoflagellates as the second group. Therefore Myeik coastal waters are rich waters for the marine organisms to survive and create a productive area.

The different species of plankton revealed various degrees of tolerance to the fluctuations of physical and chemical parameters. In general, the sequential change of the dominant species of phytoplankton occurred in 2-3 times per year in the Myeik coastal waters.

The phytoplankton abundance was positively related to some environmental factors such as transparency and temperature, however, the negative correlation was found when correlated with nitrate, phosphate, salinity, pH and rainfall in the Myeik coastal waters. The peculiar water transparency (9 m) was found at offshore water (Station 9) in February, 2013. The heavy rainfall (1082 mm) was recorded in July, 2011 in Myeik.

The significant seasonal variations of phytoplankton succession were found to be regulated by the changes of seawater characteristics related to the monsoon phenomenon. The abundance and community structure of phytoplankton species seemed to be affected directly or indirectly by environmental factors of Myeik coastal waters. The influences of drastic seasonal change on the diversities of diatoms and dinoflagellates off Myeik coastal waters were recognized. Moreover, the occurrence of high diversities of phytoplankton species in Myeik coastal waters seems to be related by highly enriched organic and inorganic nutrients from various marine environments such as mangrove forests and the runoff of numerous rivers along the coastlines. This study contributes a baseline result for the sustainability of fisheries in Myeik coastal waters.

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