

Phytoplankton community in lake Ebony, Pantai Indah Kapuk, North Jakarta

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Abstract. Lake Ebony is an ornamental lake in coastal area of North Jakarta, located at 6°6'18"S-6°6'35"S and 106°44'39"E-106°44'56"E. Phytoplankton community in Lake Ebony lives in high organic materials received from domestic waste. A spatio-temporal observation at five sites was carried out to understand the spatial distribution of phytoplankton at each group of time of observation and the succession of phytoplankton. Spatial analysis was carried out to map the distribution pattern of plankton, using ArcGIS 10.1 with IDW (Inverse Distance Weighted) interpolation method. Spatial clustering was determined by Canberra Index. The succession of phytoplankton was shown by graph of Frontier succession models, SDI (rate of succession), and SIMI. There were two clustered groups of site. Based on graph of Frontier succession, phytoplankton in Lake Ebony was at Stage 2 and 3 with the rate of succession ranged from 0.008 to 0.003, and value of SIMI ranged from 0.68 to 0.97. There was different spatial distribution pattern of phytoplankton in three groups of observation time, with low rate of succession.

1. Introduction

Lake Ebony is one of ornamental lake in residential place of Bukit Golf Mediterania, Pantai Indah Kapuk (PIK), North Jakarta (6°6.572'S and 106°44.755'E). The lake is laid in northern part of PIK, facing Java Sea. This shallow waters roles as water pool and part of polder system, and completed with sewage water treatment plant (STP) for residential wastewater came through it and surrounded by a supporting channel as addition drainage to throw water directly to the sea. The channel receives water from STP and residence ditches. Unfortunately, the overflow from the channel, with high organic content, enters to the lake.

High organic content of wastewater leads to increasing of nutrients for phytoplankton growth. The organic materials are decomposed by heterotrophic bacteria becoming inorganic nutrients compounds or bioavailable nutrients. Those are nutrients that can be directly absorbed by phytoplankton.

The performance of phytoplankton growth could change along with the variation of water quality [1-4] since of its species specific requirement. The change of nutrients concentration will effect on the quantity or density of phytoplankton. Furthermore, the change of nutrients composition, especially N:P ratio will effect on the quality or species composition of phytoplankton.

Hence, the composition, density, and the biomass of phytoplankton varied spatially and temporally or succession [5,6]. Therefore, succession shows the influence of water quality towards phytoplankton community [7]. Then, the succession is the change of species relative abundance of a phytoplankton community [5] or the change of dominance species, the biomass, and the density of phytoplankton [2].



2. Material and Methods

2.1. Data collection

The study was carried out in one year with monthly observation, from April 2014 to March 2015. The water samples for phytoplankton and water quality, including nutrient analysis were taken from five sampling sites of Lake Ebony, Bukit Golf Mediterania, Pantai Indah Kapuk (PIK), North Jakarta (Figure 1). One year observation, based on [5], is adequate to study temporal variation of phytoplankton.

The principles of sampling technique, measurement, and water analysis were following [8]. The water quality parameters comprised of temperature, transparency, conductivity, pH, salinity, DO, ammonium, nitrite, nitrate, and orthophosphate. Meanwhile, the identification of phytoplankton was based on [9-13].

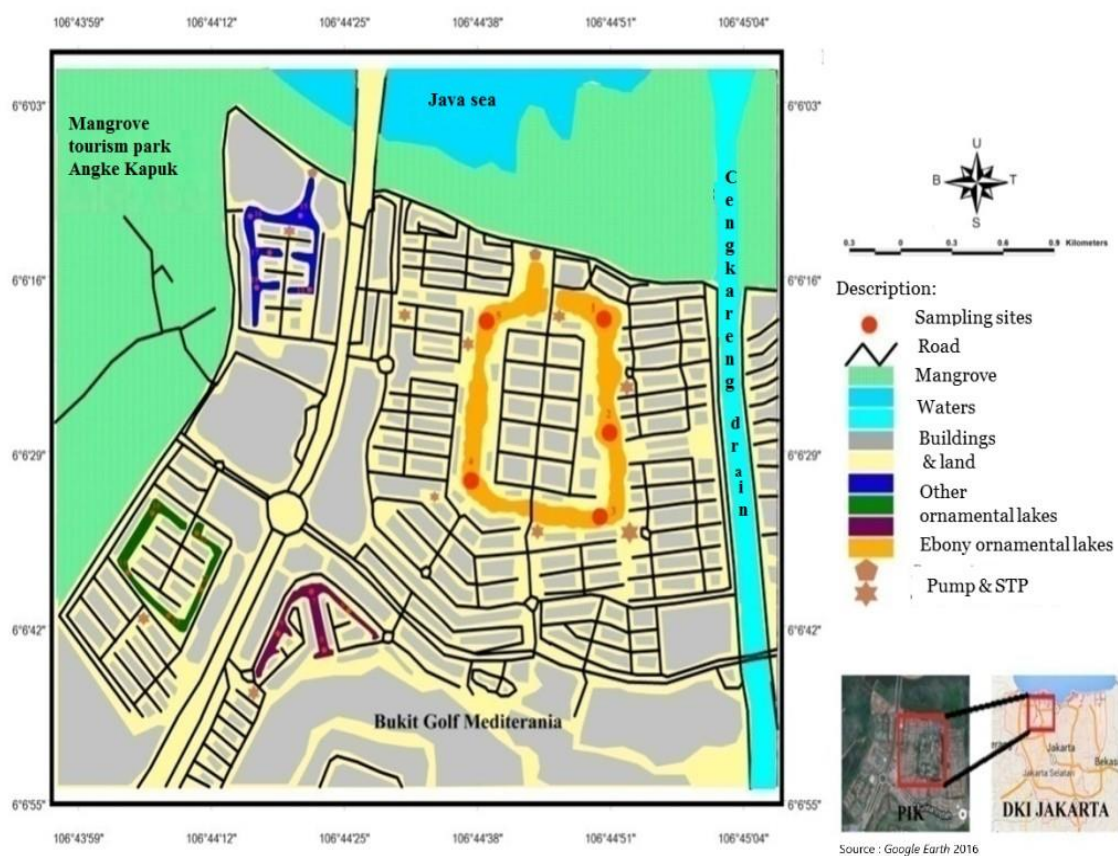


Figure 1. Location of sampling site in Lake Ebony.

2.2. Data analysis

The community structure of phytoplankton was determined by the calculation of several diversity indices, such as Shannon-Wiener diversity index, Evenness index, and Simpson dominance index [14]. Furthermore, the density of phytoplankton and water quality were analyzed spatially and temporally. The spatial analysis of phytoplankton was meant to study the distribution of species density; and the temporal analysis was meant to study the phytoplankton succession.

There was a pre-analysis to determine group of observation time, using Stander's Similarity Index (SIMI) [15]. For each group of observation time, there was analysis of phytoplankton distribution. There was also a spatial analysis to determine group of sampling sites using Canberra Similarity Index [16] based on water quality data.

Another spatial analysis was estimating phytoplankton distribution using ArcGIS 10.1 software with interpolation method. Interpolation method is a mathematical function to estimate values of locations with lack of data. Contextually, in ArcGIS spatial analysis, this method is used to give a prediction of each raster pixel values based on limited data of sampling sites.

The interpolation method in this study is IDW (Inverse Distance Weighted). This method uses an assumption that the result of interpolation is more similar to the nearest sampling site data than the furthest. According to [17], IDW method has higher accuracy than other methods, such as kriging or spline method.

There were also other analyses to understand the succession of phytoplankton in Lake Ebony. The analyses comprise of plot of Frontier's graph models [18] and the rate of succession, using Summed Difference Index or SDI [5].

3. Results

3.1. Phytoplankton composition and density

Figure 2 and 3 illustrates one year variation of phytoplankton densities and number of species in Lake Ebony, spatially and temporally. The phytoplankton density of Site 4 is very much lower than that of other sites, while the number of species of each site was relatively similar. In temporal, monthly condition of those two biological parameters relatively varied.

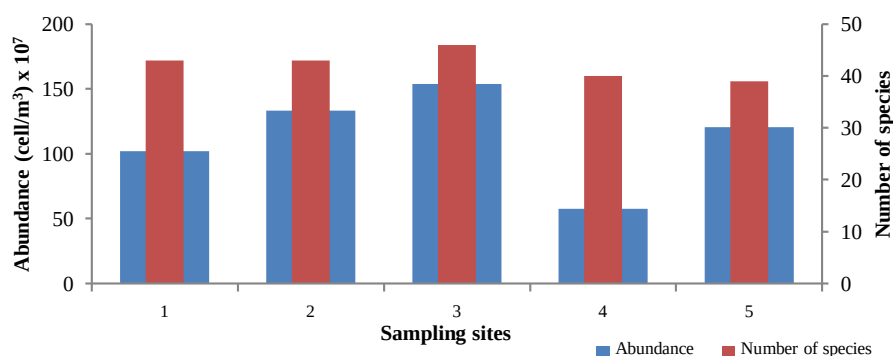


Figure 2. Spatial density and number of species of phytoplankton in Lake Ebony.

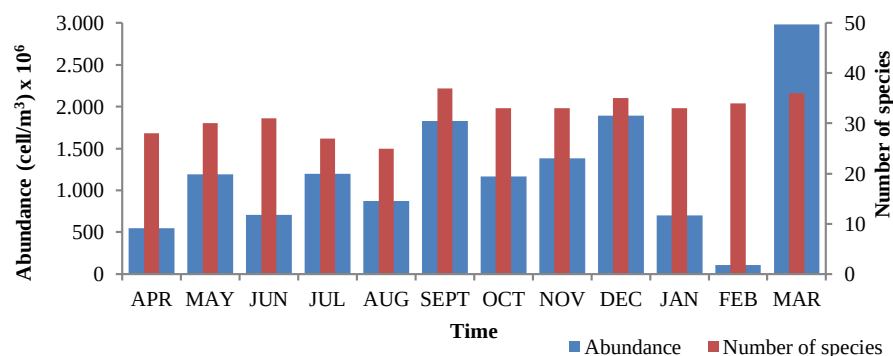


Figure 3. Temporal density and number of species of phytoplankton in Lake Ebony.

There were found five class of phytoplankton with 48 species in total; seven species belong to Cyanophyceae, 14 species of Bacillariophyceae, 20 species of Chlorophyceae, 4 species of Euglenophyceae, and 3 species of Dinophyceae. The monthly composition of phytoplankton density and number of species varied (Figure 4a and 4b). The density of phytoplankton was mainly dominated by

Chlorophyceae, but the highest number of species was Cyanophyceae, followed by Chlorophyceae. The community structure of phytoplankton was characterized as freshwater influenced by saline water.

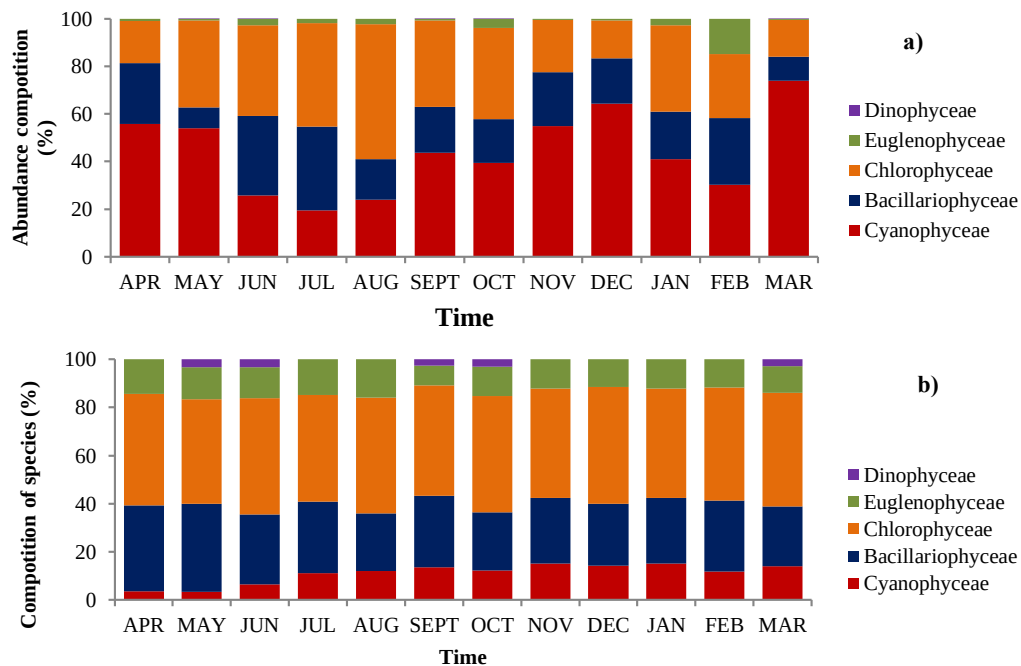


Figure 4. Composition of phytoplankton; a) density and b) number of species.

3.2. Nutrients and water quality

Nutrients condition in Lake Ebony and water quality varied temporally (Figure 5 and Table 1). Quite similar pattern occurred between ammonia and ammonium, and between nitrate and nitrite. The phosphorous also fluctuated, but in different level of concentration. The lowest turbidity occurred in the least depth of waters. However, the light transparency was relatively low.

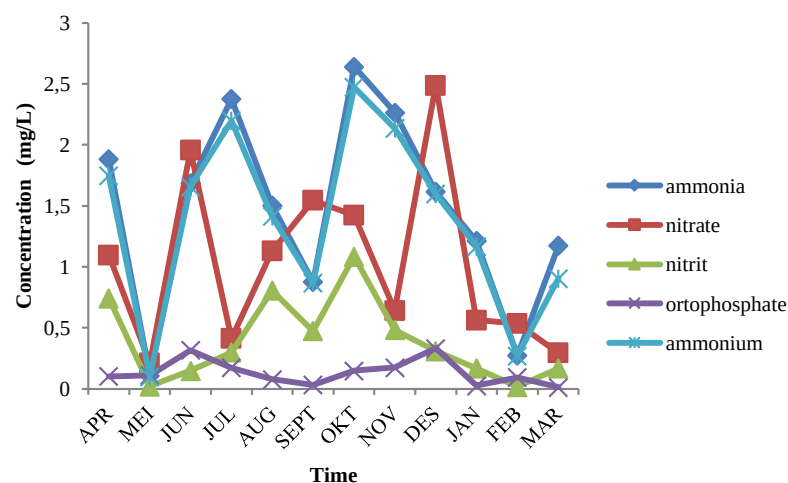


Figure 5. Nutrients concentration of Lake Ebony.

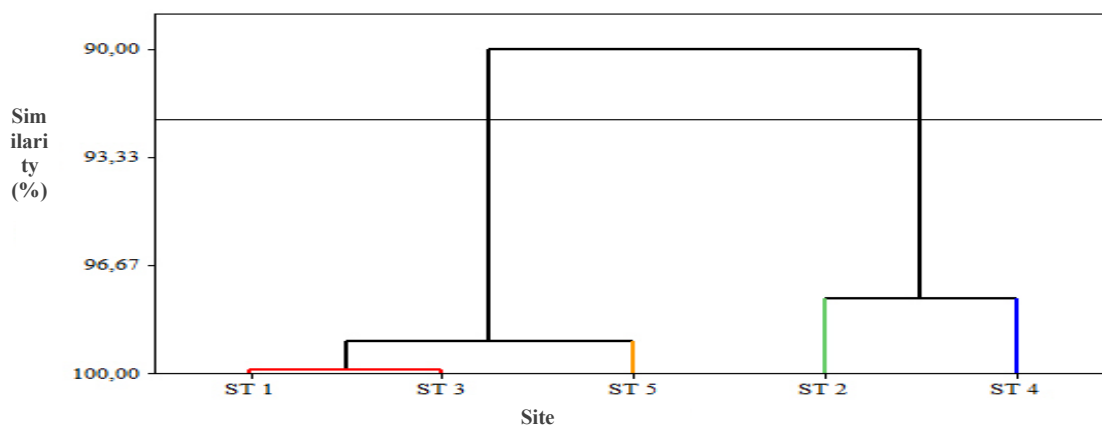
Table 1. Water quality of Lake Ebony.

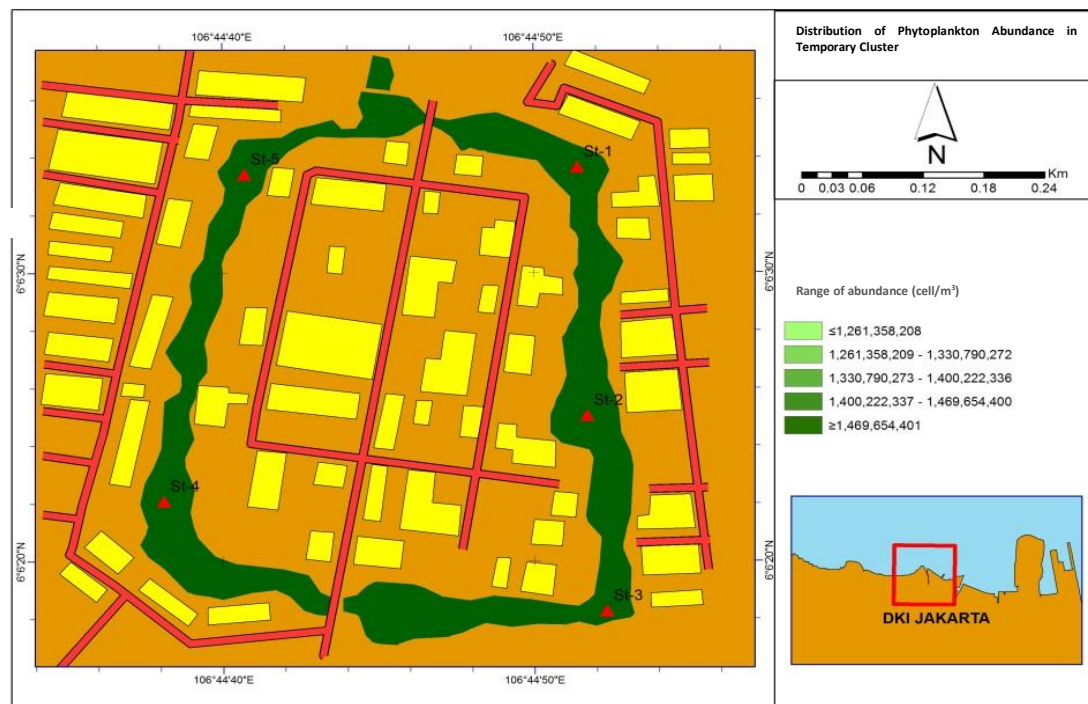
Parameters	Temperature	DO	Depth	Transparency	Turbidity	Conductivity	pH	Salinity
Time	°C	mg/L	cm	Cm	NTU	µmHos/cm	-	PSU
Apr	30±0.4	6±1.2	99±2.1	25±5	48±20.0	3808±216	8±0.0	1±0.9
May	31±0.3	4±1.5	98±1.7	27±7	84±69.7	3567±121	8±0.5	1±0.6
Jun	30±0.4	4±1.6	101±1.9	30±3	89±154.0	2734±262	7±0.7	1±0.4
Jul	30±0.2	4±1.3	96±1.2	23±6	138±134.5	4201±196	8±0.3	2±0.0
Aug	30±0.4	6±2.0	95±1.8	27±5	47±13.6	3403±281	8±0.3	1±0.9
Sept	30±0.3	5±0.7	108±1.4	28±2	113±54.4	4620±370	7±0.4	2±0.4
Okt	30±0.4	5±2.8	105±1.3	15±2	57±6.6	5289±142	8±0.0	2±0.6
Nov	31±0.4	5±1.2	74±2.5	14±3	26±11.1	5140±806	8±0.1	2±0.0
Dec	30±0.6	5±0.9	92±2.3	24±2	36±5.7	3709±539	7±0.3	2±0.0
Jan	29±0.3	4±0.9	81±1.3	25±5	42±9.7	4439±375	7±0.8	2±0.4
Feb	26±0.4	4±0.3	97±0.8	25±4	56±27.3	1231±296	7±0.4	1±0.0
Mar	31±0.7	9±4.2	97±1.8	21±4	75±30.9	3581±638	8±0.7	1±0.9

3.3. Spatial distribution of phytoplankton

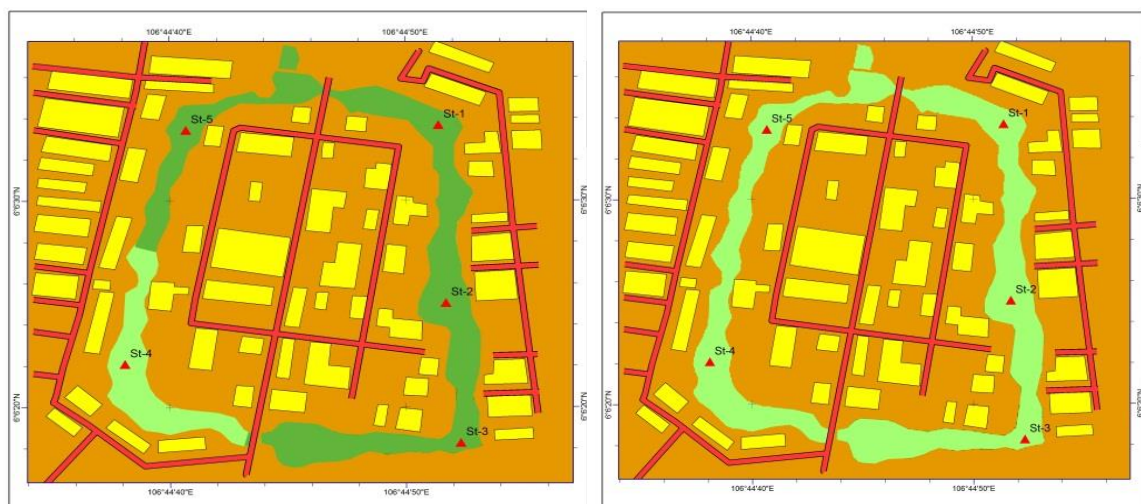
The density and composition of phytoplankton varied, both spatial and temporal. As a whole, there were 48 species of phytoplankton that were found in Lake Ebony. The most abundant species was *Merismopedia* (Cyanophyceae), followed by *Cyclotella* (Bacillariophyceae), and *Scenedesmus* (Chlorophyceae). In group of class, Cyanophyceae and Chlorophyceae dominated.

In order to get the description of spatial distribution of phytoplankton, there was a pre-analysis of temporal cluster, resulting in three groups of time (Figure 6), depicting . Then for those three groups there were three illustrations of phytoplankton distribution in Lake Ebony waters (Figure 7a, 7b, and 7c).

**Figure 6.** Temporal clustering of Lake Ebony.



(a)

**Figure 7.** Phytoplankton distribution of Lake Ebony at a) Time 1, b) Time 2, and c) Time 3.

3.4. Succession pattern of phytoplankton

The varied density and composition of phytoplankton indicated that there was a succession phenomenon. In order to understand the phenomenon, preliminary analysis was conducted, to get an illustration on spatial zonation (group of sampling sites) of Lake Ebony first. The result shows that there were two groups (Zone 1 and Zone 2) of sampling sites (Figure 8).

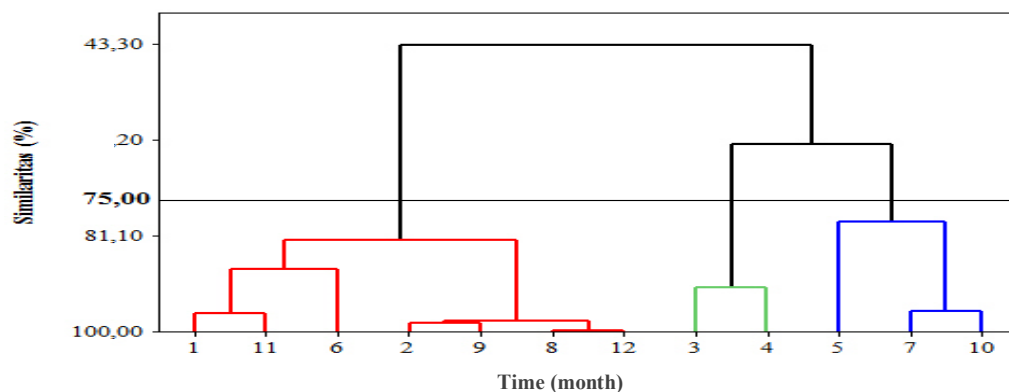


Figure 8. Group of sampling sites of Lake Ebony.

Furthermore, the analyses of succession were performed for each of those groups. The first analysis was rank-frequency Frontier Graph, as the illustration of succession pattern resulting in two stadia of succession, Stadium 2 for Zone 1 and Stadium 3 for Zone 2 (Figure 9).

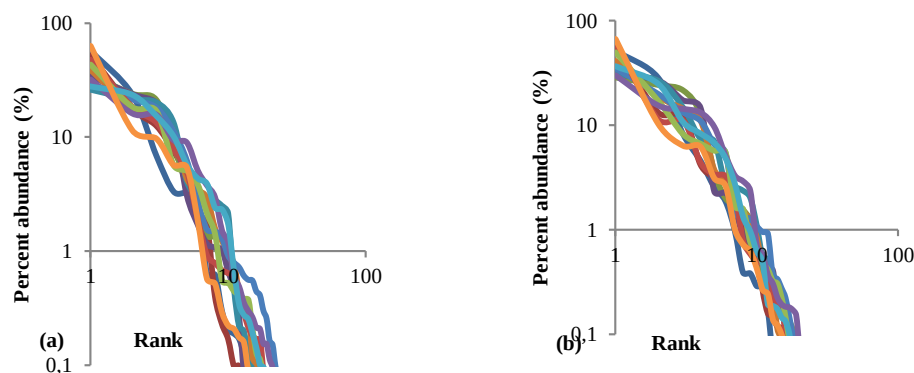


Figure 9. Succession pattern on rank-frequency plot: (a) Stadium 2; (b) Stadium 3.

The rate of succession and the inter-time difference of species for the two zones were illustrated in Figure 10a and 10b. It is shown that the rate of phytoplankton succession of Zone 2 was higher than of Zone 1. Furthermore, the relatively less inter-time difference of species occurred in Zone 1.

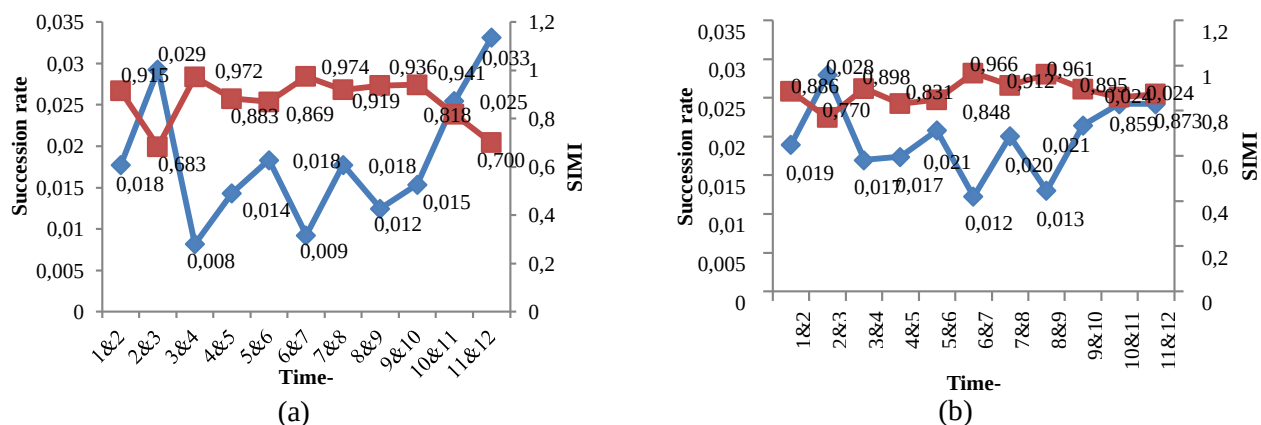


Figure 10. Rate of succession and inter-time difference of Phytoplankton of Lake Ebony in a) Zone 1 and b) Zone 2.

3.5. Community structure of phytoplankton

Diversity Index usually used to describe the community structure of phytoplankton. The most common diversity indexes are Shannon-Wiener diversity index (H'), Evenness index (E) and Simpson dominance index (C). The value of those indexes for phytoplankton in Lake Ebony is laid in Table 2. Nodominance species occurred. The level of evenness was low to moderate, and low diversity.

Lake Ebony receives overflow from supporting channel with high content of organic materials that will be transformed into inorganic nutrients in decomposition process. The nutrients will be utilized by phytoplankton.

High density and number of species at most of sampling sites indicates that the nutrients have high concentration. High density of Cyanophyceae also indicates high content of organic materials. In this condition, Cyanophyceae appears in high content of organic materials and high concentration of nutrients or eutrophic condition. This condition is supported by [19-22] which mentioned that Cyanophyceae predominant in eutrophic waters.

The spatial distribution shows different pattern in time. Furthermore, the density was higher in the middle of the time of observation. It is presumed that it was correlated to weather or season. In detail, each of time periods has different profile of phytoplankton distribution among sites or sampling sites. At the Time 1 and 2, the phytoplankton was distributed evenly in all sampling sites. Meanwhile, at the Time 3, the phytoplankton was less concentrated in Southwest part of the waters. This was presumed that the wind direction influences the position of concentrated population of the community. In this case, the wind blew to the East part of waters.

Table 2. Diversity Index of phytoplankton (a) Zone 1 and (b) Zone 2 in Lake Ebony.

Time (a)	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
H'	1.32	1.47	1.73	1.71	1.98	1.88	2.03	1.65	1.76	2.08	2.05	1.31
E	0.40	0.48	0.55	0.55	0.62	0.52	0.59	0.47	0.51	0.60	0.58	0.38
C	0.39	0.33	0.23	0.23	0.18	0.22	0.18	0.29	0.26	0.18	0.18	0.43
Time (b)	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
H'	1.36	1.47	1.82	1.76	1.92	1.77	1.96	1.44	1.70	2.07	1.84	1.27
E	0.46	0.46	0.55	0.57	0.63	0.53	0.58	0.44	0.49	0.62	0.55	0.37
C	0.36	0.37	0.21	0.22	0.20	0.24	0.20	0.40	0.30	0.17	0.22	0.47

The community structure has synchronization with the succession stadium. The stadium 2 and 3 were characterized by less dominance of species [18], but the phytoplankton community was relatively stable. It means that the composition of the community will not change rapidly with the change of water quality or other environmental conditions.

Community structure in Stadium 2 shows a stable condition, lowering diversity, with relatively high productivity [18]. The well-developed phytoplankton in Lake Ebony were Cyanophyceae (*Microcystis* sp., *Merismopedia* sp., *Anabaena* sp.), Bacillariophyceae (*Melosira* sp., *Stephanodiscus* sp., *Cyclotella* sp.), Chlorophyceae (*Scenedesmus* sp., *Pediastrum* sp., *Chlamydomonas* sp.). Those species are highly tolerated to high concentration of organic materials [23].

With Stadium 2 and 3, the phytoplankton community shows low rate of succession, hence there was a relatively similar species inter-time of observation. The density was not significantly different, and the predominance species was not change inter-time of comparison.

4. Conclusion

There were 48 species of phytoplankton in Lake Ebony from five classes, Cyanophyceae, Bacillariophyceae, Chlorophyceae, Eulenophyceae, and Dinophyceae. The most abundant species was from Cyanophyceae as indicator of eutrophic waters. There was different spatial distribution pattern of phytoplankton in three groups of observation time, with low rate of succession.

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