Suitability of the various diversity index of phytoplankton in Garden House-Coastal Ornamental Lake, Pantai Indah Kapuk, North Jakarta

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Abstract. Diversity is one of biotic community description within an ecosystem. A lot of diversity index has been developed. However, there is no consensus to suit the proper index to use. This study aimed to assess the suitability of the various diversity index of phytoplankton as community description, related to the water condition in coastal ornamental-lake of Garden House, Pantai Indah Kapuk, Jakarta. This research was conducted in July to December 2015 for sampling, laboratory analysis, and conformity assessment of diversity index (Margalef, Shannon, Simpson, McIntosh, and McIntosh evenness Index) that was based on the criterion of Discriminant Capacity approach. The results showed that there were 26 genera of phytoplankton from five classes, with density ranged from 8.9×10^3 to 7.6×10^9 cell/m^3, and was dominated by Cyanophyceae. Based on the criteria of Discriminant Capacity, McIntosh Index was the most appropriate diversity index to describe phytoplankton community in this lake. Furthermore, the low value of McIntosh index showed that the population of phytoplankton communities was not distributed homogeneously. Related to water quality, the phytoplankton community was closely correlated to pH, salinity, nitrate, nitrite, and orthophosphate.

1. Introduction

Garden House ornamental-lake is laid in Garden House Cluster of Bukit Golf Mediterania Residence, Pantai Indah Kapuk, northern coast of Jakarta. The waters are about 11615 m^2 in wide, and relatively shallow (70 cm). It is used as flood control and for aesthetics purpose, and also completed by sewage treatment plant (STP) for residence's waste water.

Meanwhile, a load of waste water, especially organic materials, sometimes exceeded the capacity of STP. This could lead the change of water quality of the lake, and also the coastal area when the outflow flooded into. The waste water could influence the condition of the waters, especially the high organic content that will transform into the nutrient. The nutrient augmentation and the change of nutrient proportion lead the change of community structure of phytoplankton.

Diversity is one of the biotic community, such as phytoplankton, that is used to describe the community stability within an ecosystem [1]. The determination of diversity index is also used in environmental monitoring or conservation. A lot of diversity index has been developed. However, there is no consensus to suit the proper index to use [2].

There are three approaches to determining the diversity, the richness index, species abundance models, and species proportional abundance index [3]. This study focused on the third approach that consists of many indexes. An evaluation is necessary since not all of the index could well-describe a community condition [4].

The species proportional abundance approach is relatively simple and applicable. Through this approach, the species richness and its evenness are well informed, that could vary the community description [5]. Several indexes of this approach are Shannon Index, Simpson Index, and McIntosh Index.

This study aimed to assess the suitability of the various diversity index of phytoplankton as community description, related to the water condition in coastal ornamental-lake of Garden House, Pantai Indah Kapuk, Jakarta.

2. Material and methods

There were five stations as sampling points in Garden House ornamental lake. The samples were taken monthly in six months, including plankton and water for water quality analysis [6]. The phytoplankton identification was conducted using identification book [7, 8, 9]. The cell counting was using one mL SRC [6].

Data analysis consisted of cluster analysis based on Canberra index [10] of water quality, several diversity index (based on species richness and proportional abundance approach), the evaluation of suitability of diversity index, PCA (Principal Component Analysis), and correlation between phytoplankton and water quality (Pearson's correlation) [11].

Those diversity indexes are Margalef Index, representatives the species richness approach; Shannon Index, Simpson Index, McIntosh Index, and McIntosh Evenness Index [3]. The effectiveness of those indexes was evaluated using discriminant capacity approach [4, 12].

3. Results

3.1. Phytoplankton abundance and composition

Phytoplankton species abundance and composition is necessary information to describe its community condition. The highest rate of abundance and number of species were found in Station 2, with about 661x10^6 cell/m^3 and 22 species (figure 1). The highest proportion of abundance was shown by Cyanophyceae and number of species was shown by Chlorophyceae (figure 2 and 3).

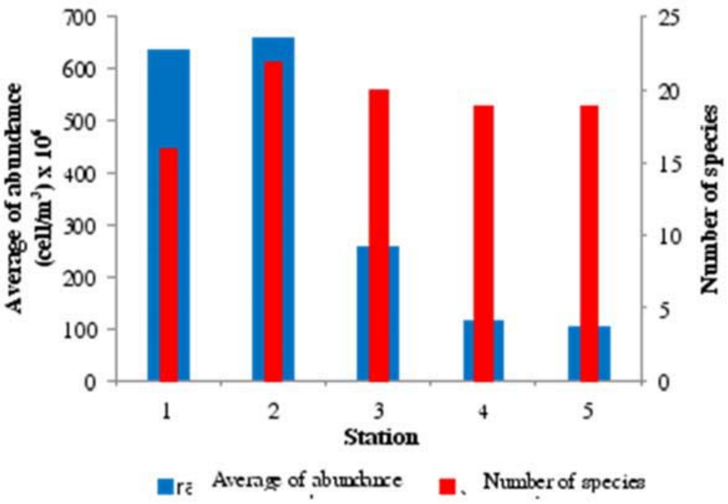

Figure 1. Average of abundance and number of phytoplankton in Garden House ornamental lake.

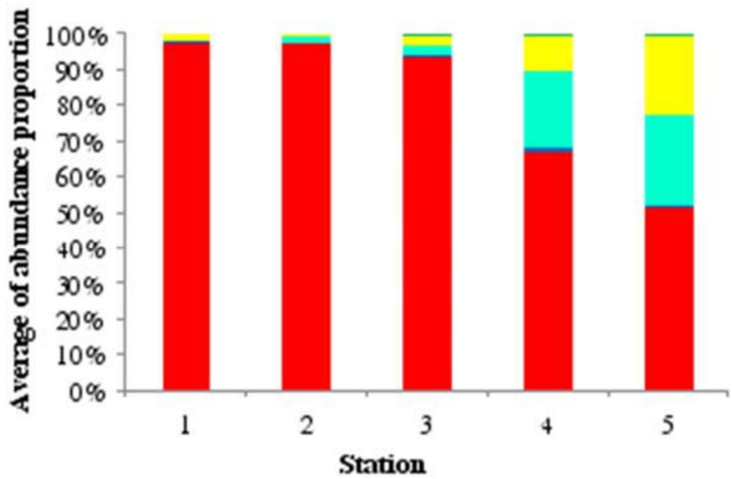

Figure 2. Proportion of abundance of phytoplankton in Garden House ornamental lake.

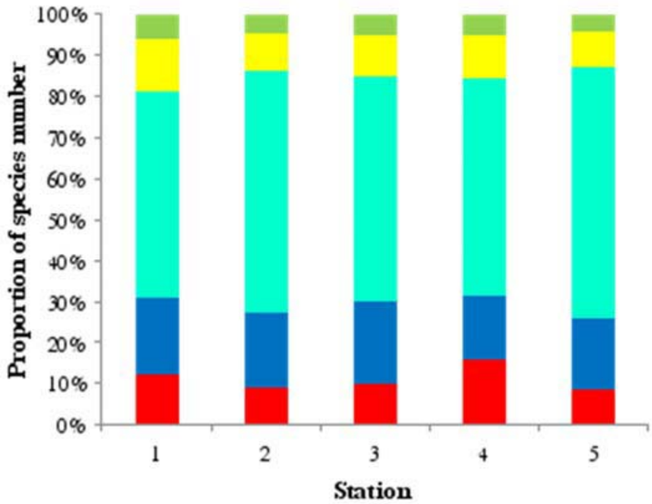

Figure 3. Proportion of number of phytoplankton in Garden House ornamental lake.

3.2. Water quality characteristic of Garden House ornamental lake

Bioavailable nutrients, such as ammonium, nitrite, nitrate, and orthophosphate, are essential to the growth and development of phytoplankton community. The concentration of those nutrients was fluctuated (figure 4). Furthermore, the physical characteristic indicated typically shallow water characteristic, with a very high TSS value at Station 5 (table 1).

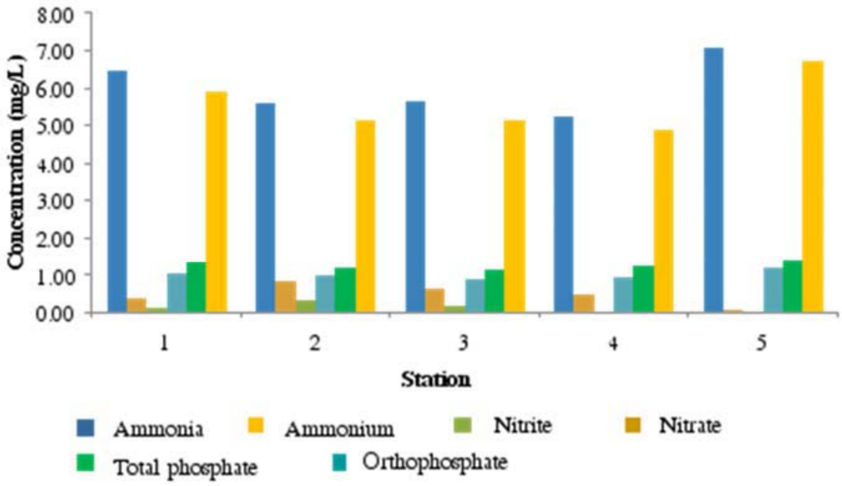

Figure 4. Bioavailable nutrients in Garden House ornamental lake.

Based on water quality characteristic, there was a determination of similarity index that was used as the base of cluster analysis. Figure 5 shows three clusters or groups of the station based on water quality of Garden House ornamental lake. Those were Group 1 (Station 1, 2, and 3), Group 2 (Station 4), and Group 3 (Station 5).

Table 1. Water quality characteristic of Garden House Ornamental Lake.

No	Parameters	Station				
		1	2	3	4	5
1	Depth (m)	0.75± 0.04	0.68± 0.30	0.45±0.18	0.79±0.07	0.64±0.11
2	Turbidity (NTU)	52.57±25.63	48.48±28.13	41.30±12.96	60.20±20.27	91.43±53.96
3	TSS (mg/L)	50.50±23.30	64.00±61.37	57.83±18.14	73.83±48.40	91.67±72.80
4	Temperature (^{o}C)	29.82±0.78	29.22±0.90	29.32±0.90	29.52±0.90	29.78±0.97
5	pH	8.05±0.45	8.09±0.23	8.10±0.30	7.96±0.44	7.80±0.63
6	Salinity (‰)	1.62±0.34	1.60±0.36	1.62±0.38	1.53±0.36	1.57±0.28
7	DO (mg/L)	3.75±0.61	4.37±1.35	5.43±0.99	4.03±1.76	3.58±2.75
8	BOD_5 (mg/L)	15.75±9.07	15.25±8.37	16.07±8.82	14.70±9.12	18.27±11.28

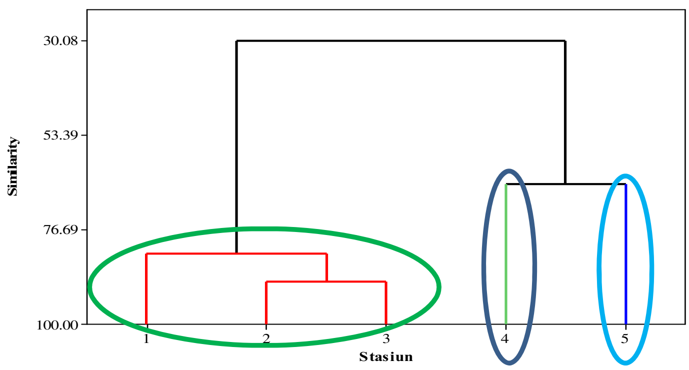

Figure 5. Groups of the station based on water quality.

3.3. The evaluation of diversity index

Discriminant capacity shows the suitability of the diversity index in describing the condition of phytoplankton community structure in Garden House. The value of the discriminant capacity of each phytoplankton diversity index is laid in Table 2. It is shown that the order from the highest to the lowest values, temporal and spatially. From both orders, it is concluded that the most suitable diversity index is McIntosh (Mc) with relatively high values at both approaches.

Table 2. Discriminant capacity of each diversity index.

Diversity Index	Value	
	Temporally	Spatially
Simpson index	61.471	25.784
McIntosh index (McE)	46.711	24.724
McIntosh index (Mc)	42.128	23.305
Shannon index (H')	34.600	18.312
Shannon index (E)	31.853	15.941
Margalef index	26.134	1.2320

3.4. Phytoplankton community structure in Garden House ornamental lake

Based on the best diversity index, there are values of McIntosh Index of phytoplankton in Garden House ornamental lake of each clustered station (Table 3). It seems that the diversity values are fluctuated along the observation.

Table 3. McIntosh Index of Beach group of station.

	Month					
	1	2	3	4	5	6
Group 1	0.0092	0.3207	0.2574	0.3435	0.2639	0.4090
Group 2	0.3925	0.4722	0.4226	0.4559	0.3919	0.4432
Group 3	0.2530	0.4458	0.2995	0.4188	0.4086	0.2949

3.5. The relationship between phytoplankton community and water quality

The principal component analysis was used to describe the relationship between phytoplankton community and water quality of each group of the station. Biplot of the relationship between phytoplankton and water quality is shown in figure 6.

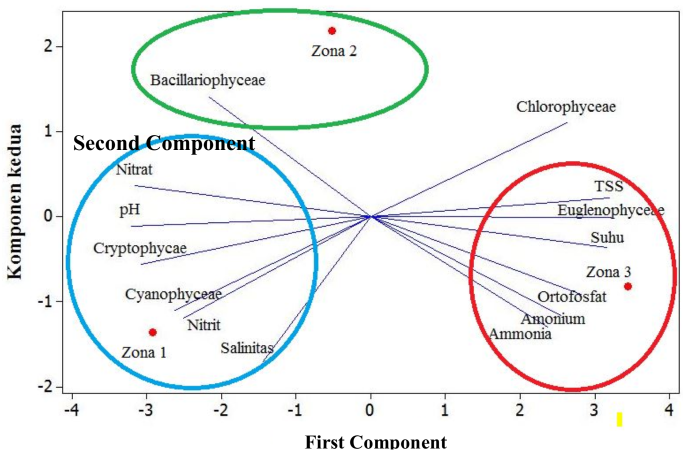

Figure 6. Biplot of the relationship between phytoplankton and water quality.

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The description of the biplot was furthermore tested to determine their correlations. The result showed that most classes of phytoplankton were highly correlated to pH, salinity, nitrate, nitrite, orthophosphate, ammonium and temperature. Those results were shown in table 4.

Table 4. Correlation between phytoplankton and water quality.

Class	pH	Salinity	Nitrate	Nitrite	Orthophosphate
Cyanophyceae	0.849	0.881	-	0.998	-
Bacillariophyceae	-	-	0.803	-	-
Euglenophyceae	0.983	-	-	-	0.880
Cryptophycae	-	-	0.883	0.929	-

4. Discussion

Nutrient concentration in Garden House ornamental lake was relatively high with high TSS condition, especially Station 5 that located near from STP unit. The organic material that was decomposed into nutrients will lead abundance and composition of phytoplankton, proper to the concentration and composition. In this study, the most abundance of phytoplankton was Cyanophyceae, especially at Station 5. The least density was direct by the operational of the pedal wheel that station 5.

The high density of Cyanophyceae indicated that the waters were in eutrophic states. Cyanophyceae often found in organically polluted waters [13. 14]. Meanwhile, the number of species was relatively low. *Oscillatoria* sp., *Spirulina* sp., and *Merismopedia* sp. were found in relatively high density. Those species were often dominated by organically polluted waters [15], and indicated nutrient enrichment [16].

One of important test to determine the most effectiveness of diversity index is the calculation of discriminant capacity [3]. The higher the discriminant capacity value. The higher the effectiveness of diversity index. The McIntosh Index showed high discriminant capacity, both temporal and spatially. The value indicated that the McIntosh Index was suitable to describe phytoplankton condition at Garden House ornamental lake.

Diversity index with high discriminant capacity value could describe the difference of diversity index among stations with a relatively similar environmental condition or water quality vice versa [4,12].

In this study, the value of McIntosh Index of plankton community was close to 0, which indicated that organisms in the community were not homogenized distributed. When the value of McIntosh Index close to 1, it is indicated that organisms in the community are homogenized distributed both temporally and spatially [17]. The values of the diversity index fluctuated at both approaches.

Biplot of PCA shows that in Group 1. Cyanophyceae and Cryptophyceae were in high density and laid in the same radian with a high value of nitrate, pH, salinity and nitrite. Group 2 was characterized by high density of Bacillariophyceae. Furthermore. Group 3 was characterized by the high density of Euglenophyceae and high concentration of TSS, total ammonia, and phosphate.

As a whole, the density of phytoplankton was influenced by nutrients, pH, and salinity. Based on the correlation test, the phytoplankton density was highly correlated with nutrient, pH, salinity, and TSS. Nutrients have a role as limiting factors (nitrogen and phosphor) for the phytoplankton community [18]. The pH could influence the life of phytoplankton, which the low value of pH will decrease water quality that will also influence the living inside [19].

The correlation value between Cyanophyceae and pH, salinity and nitrite was relatively high ($r > 0.75$). A high pH and magnified nutrients (nitrate and nitrite) were suitable for Cyanophyceae. Besides the Cyanophyceae was also correlated to salinity [15]. Salinity is one of controlling factor for nitrogen fixation of Cyanobacteria [20]. Furthermore, Cryptophyceae was highly correlated to nitrate and nitrite. Nitrogen in the sort of nitrate, nitrite, and ammonium has a role in protein synthesis of phytoplankton [21].

The relationship between Euglenophyceae and nutrients (orthophosphate and ammonium) was relatively high ($r > 0.75$). Orthophosphate was used to and influence the process and the development of phytoplankton. Phosphor transforms energy for phytoplankton [21]. Euglenophyceae was also highly

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correlated to TSS and temperature. TSS will influence light Transparency that used by phytoplankton in the photosynthesis process.

Garden House ornamental lake was assumed to receive a high organic material load that was indicated by the high density of Cyanophyceae. The McIntosh diversity index is the most suitable index for describing the condition of phytoplankton community structure, based on the high value of the discriminant capacity both temporal and spatially.

The less homogenous distribution of species density leads the low value of McIntosh index. The difference of species density distribution was assumed to be correlated to several characterized parameter that influences the density of phytoplankton. Furthermore, based on correlation test the density of phytoplankton was highly correlated to water quality such as pH, salinity, nitrate, nitrite, and orthophosphate. Those environmental parameters influence the biological process in phytoplankton community.

5. Conclusion

The most suitable diversity index to describe the phytoplankton Community structure in Garden House coastal ornamental lake. Pantai Indah Kapuk. Jakarta is McIntosh Index (McI). The phytoplankton community was highly correlated with salinity, pH, nitrite, nitrate and orthophosphate.

References

[1] Ismael A A and Dorgham M M 2003 Ecological indices as a tool for assessing pollution in El-Dekhaila Harbour (Alexandria. Egypt) *Oceanologia* **45**(1) 21–131

[2] Morris E K. Caruso T. Buscot F. Fischer M. Hancock C. Maier T S. Meiners T. Muller C. Obermaier E and Prati D 2014 Choosing and using diversity indices: insights for ecological applications from the German Biodiversity Exploratories *Ecology and Evolution* **4**(18) 3514-3524

[3] Maguran E A 1983 *Ecological Diversity and Its Measurement* (London: Cambridge University Press)

[4] Lexerød N L and Eid T 2006 An evaluation of different diameter diversity indices based on criteria related to forest management planning *Forest Ecology and Management* **222** 17-28

[5] Peet R K 1974 The measurement of species diversity *Annual Review of Ecology and Systematics* **5** 285-307

[6] [APHA] American Public Health Association 2012 *Standard Methods for Examination of Water and Wastewater.* 22nd ed (Washington: [APHA] American Public Health Association. [AWWA] American Water Works Association. [WEF] Water Environment Federation)

[7] Prescott G W 1970 *The Freshwater Algae* (Dubuque Lowa: Brown Company Publishers)

[8] Mizuno T 1979 *Illustrations of The Freshwater Plankton of Japan*. revised ed (Osaka: Hoikusha Publishing Co.. LTD)

[9] Yamaji I E 1979 *Illustration of The Marine Plankton of Japan* (Osaka: Hoikusha Publishing Co.. LTD)

[10] Krebs C J 1999 *Ecological Methodology* (California: Benjamin/Cummings Imprint)

[11] Walpole R E 1993 *Pengantar Statistika Edisi 3* Bambang Soemantri. penerjemah (Jakarta: PT Gramedia)

[12] Ravera O 2001 A comparison between diversity. similarity. and biotic indices applied to the macroinvertebrate community of a small stream: The Ravella River (Como Province. Northern Italy) *Aquatic Ecology* **35** 97-107

[13] Nandan S N and Aher N H 2005 The algal community used for assessment of water quality of Haranbaree Dam and Mosam River of Maharashtra *Journal of Environmental Biology* **26**(2) 223-227

[14] Wang X. Wang Y. Liu L. Shu J. Zhu Y and Zhou J 2013 Phytoplankton and eutrophication degree assessment of Baiyangdian Lake Wetland. China *The Scientific World Journal* 1-8

[15] Ganai A H and Saltanat P 2014 Effect of physicochemical conditions on the structure and composition of the phytoplankton community in Wular Lake at Lankrishipora. Kashmir *Biodiversity and Conservation* **6** 71-84

[16] Zargar S and Ghosh T K 2006 Influence of cooling water discharges from kaiga nuclear power plant on selected indices applied to plankton population of Kadra Reservoir *Environmental Biology* **27**(2) 191-198
[17] Harazika L P 2013 Diversity indices of macro invertebrates in the Satajan Wetland of Lakhimpur District. Assam *Annals of Biological Research* **4**(8) 68-72
[18] Dzialowskai A R. Wang S H. Lim N C. Spotts M W and Huggins D G 2005 Nutrient limitation of phytoplankton growth in central plains reservoirs. USA *Plankton Research* **27** 587-595
[19] Susana T 2009 Tingkat keasaman (pH) dan oksigen terlarut sebagai indikator kualitas perairan sekitar Muara Sungai Cisadane *Teknologi Lingkungan* **5**(2) 33-39
[20] Moisander P H. McClinton E and Paerl H W 2002 Salinity effect on growth. photosynthetic parameters. and nitrogenase activity in estuarine planktonic cyanobacteria *Microb Ecology* **43** 432-442
[21] Reynold C S 2006 The Ecology of Phytoplankton (Cambridge: Cambridge University Press)