Bioindicator for environmental water quality based on saprobic and diversity indices of planktonic microalgae: a study case at Rawapening lake, Semarang district, Central Java, Indonesia

Bioindicator for environmental water quality based on saprobic and diversity indices of planktonic microalgae: a study case at Rawapening lake, Semarang district, Central Java, Indonesia

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Abstract. Over the last twenty years, the aquatic environment of Rawapening Lake has been negatively impacted by increasing rates of sedimentation and rising levels of soluble organic materials. The uncontrolled growth rate of hyacinth and other aquatic plants, and the rapidly increased implementation of traditional fish cages are believed to be the main contributing factors, resulting in degraded water quality. Dynamic structure of phytoplankton can be used as a bioindicator. This study is aimed at understanding the phytoplankton community in Rawapening Lake and assessing the water quality based on saprobic and diversity indices. A purposive random sampling method was used to determine four sampling locations. The data were analyzed with the saprobic index, Shanon-Wiener diversity index, and domination index. The result of the study shows that a substantial amount of phytoplankton were dominated by the genus *Melosira* sp., *Aulacoseria granulosa, Oscillatoria* sp., and *Synedra* sp., with low to moderate diversity index values. The quality of the Rawapening Lake water environment based on the saprobic index value was categorized as β meso-Oligosaprobic, indicating very mild to light pollution.

1. Introduction

The primary concerns for the Rawapening Lake water environment are the high rates of sedimentation. These problems are triggered by human interference without consideration for the damaging impact on land and surface flow. Another factor is cropping patterns without concern for the preservation of the environment, and the rapidly increasing implementation of fish cages that are operated in the lake's water bodies and result in degradation of water quality. The high rate of sedimentation can affect the declining capacity and shorten the technical lifespan of the lake by erosion and increased growth of water hyacinth (Eichorniacrassipes).

Based on several studies, RawapeningLake is currently experiencing water fertility problems, or 'eutrophication.' Eutrophication is a process of nutrient enrichment or aquatic productivity due to the supply of organic matter derived from both humans as well as natural activity. This is characterized by a high concentration of total-P, and total-N, thus spurring the uncontrolled growth of aquatic plants (Scholten et al., 2005). Eutrophication in stagnant waters such as in a lake will lead to degraded water quality, and blooming of algae, vegetable plankton/microalgae, and water hyacinth. Additionally,

household and agricultural activities have contributed to dissolved harmful materials in river waters that end up in Rawapening Lake.

Microalgae in aquatic ecosystems have an important role as the primary producer of waters. According to Boney (1989), the microalgae also play an important role in photosynthesis. The process of photosynthesis carried out by microalgae is a major source of nutrition for other groups of water organisms that make up the food chain (Odum, 1993). Hariyati (2014) mentions that the change of water quality greatly affects the life of biota that lives in the water, microalgae being one of them. The microalgae are a biological parameter that can be used as an indicator to evaluate the quality and level of water fertility (bioindicator). One way to measure the quality of water is by knowing the value of the saprobic coefficient (Ravera, 1979). The saprobic coefficient is an index closely related to the level of pollution and can be determined after knowing the structure of microalgae community in the water.

The purpose of this research is to study the structure of the microalgae community in Rawapening Lake and to know the water quality of Rawapening Lake based on the saprobic index.

2. Materials and methods

The research locations are determined by Purposive Random Sampling with four main stations and three replications. The four stations include:

- Station 1: Galeh river inlet;
- Station 2: Bukit Cinta;
- Station 3: Karamba location;
- Station 4: Tuntang river outlet.

The sampling of microalgae uses plankton net size 25. Samples of filtered microalga are put into sample bottles and are administered formalin 4%. Afterward, the samples are analyzed and identified in the laboratory.

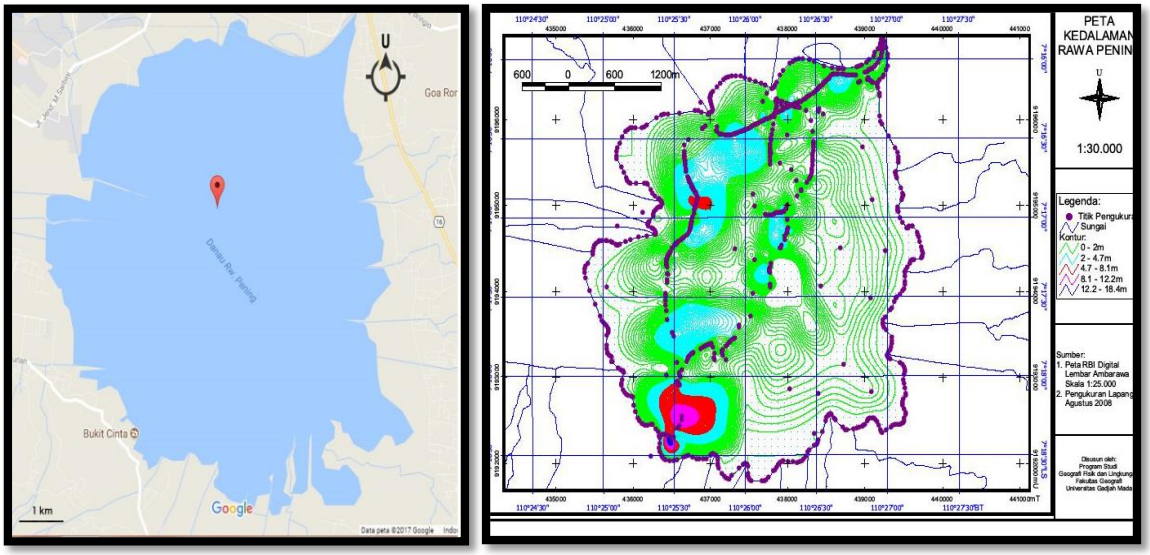


Figure 1. Research Location, Rawapening Lake

Besides microalgae sampling, water quality measurements are also conducted by use of an In Situ water checker. The data analysis in this study includes microalgae community structure analysis. The main component of microalgae community structure analysis exists of several biological indexes such as the diversity index (H'), uniformity (E), and dominance (C), which refer to Krebs (1989). The saprobic index values are only used to see the dominant group of organisms and are widely used to determine the level of pollution (Ravera, 1979 in Koesoebiono, 1987).

3. Results and discussion

The results of this study on the water of Rawapening Lake cover 28 genera in 4 divisions. These are Chrysophyta (14 genera), Chlorophyta (7 genera), Cyanophyta (4 genera), and Pyrrophyta/Dynoflagellata (3 genera). Chrysophyta is the most dominant division. The number of species obtained from each station ranges from 14 to 18 species with the total number of individuals being between 1,833 individuals per liter to 4,935 individuals per liter.

Of the species found, *Melosira* sp., *Aulacoseria granulata*, *Oscillatoria* sp., and *Synedra ulna* are the most dominant. The highest abundance is obtained from station two at Bukit Cinta location. The most dominant species of station 2 is *Aulacoseria granulata*, with a concentration of 1.034 individuals per liter.

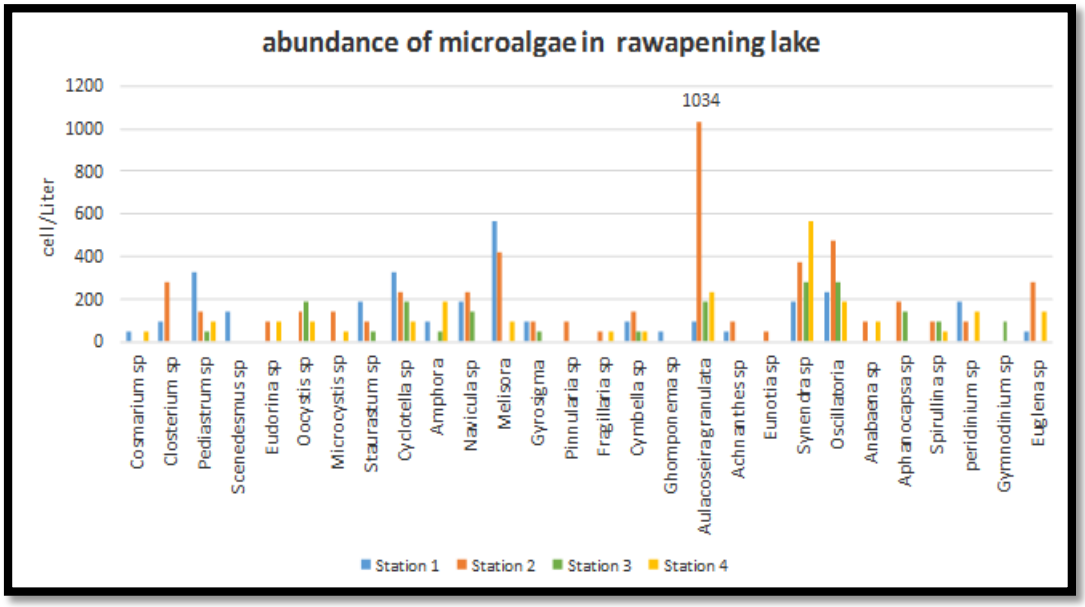


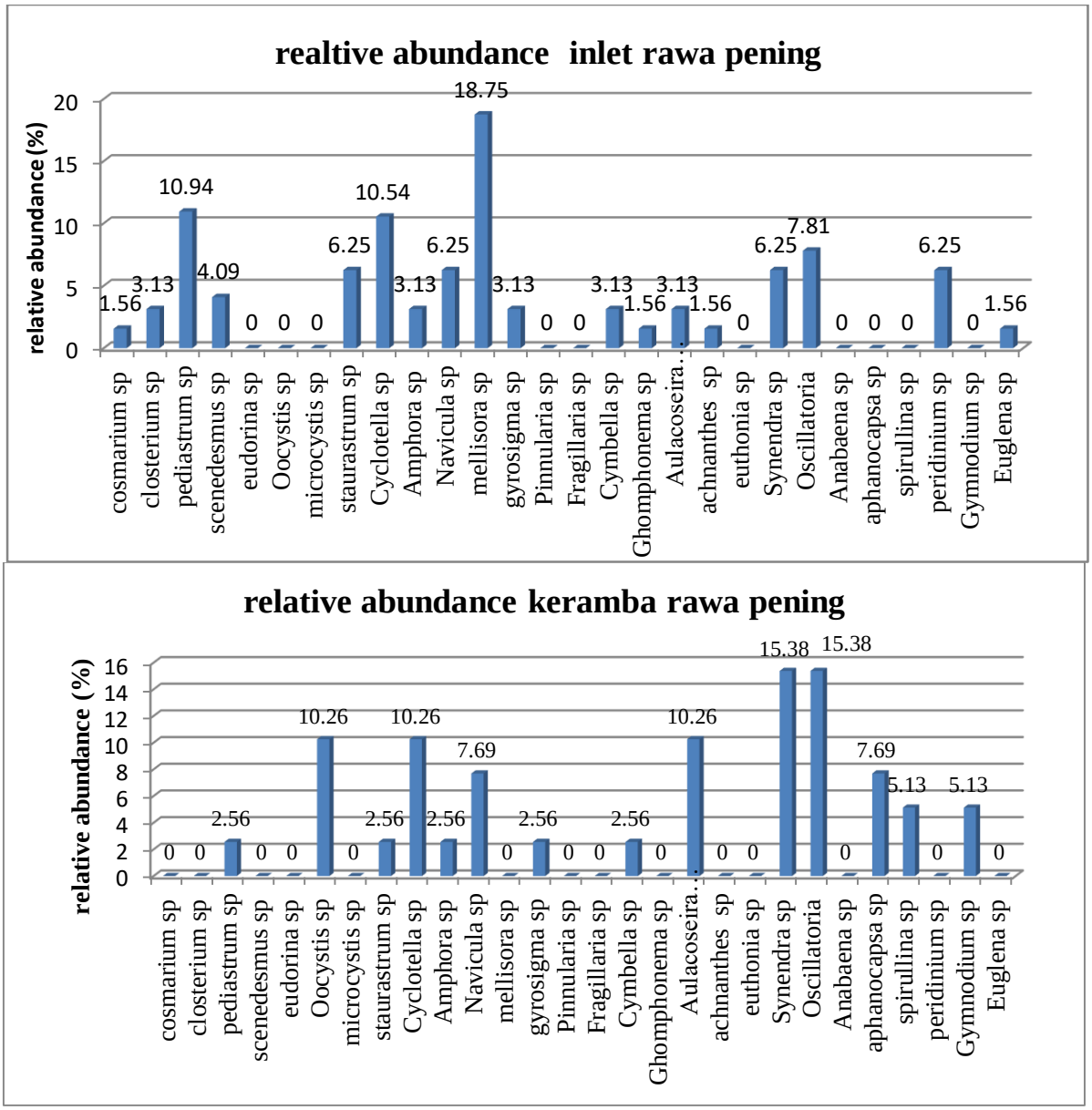
Figure 2.Abundance of Microalgae in Rawapening Lake

Table 1. Microalgae community structure and Saprobic value of Rawa Pening waters of Semarang.

Parameter of Values	***Sampling Sites***			
	Inlet	**Bukitcinta**	**Net Cage**	**Outlet**
Number of species(n)	18	23	14	17
Total number of individuals (N)	3008	4935	1833	2256
Diversity Index(H')	1.53	0.92	0.81	0.87
Uniformity Index	0.53	0.29	0.31	0.31
Saprobic Value	1.140			

From all of the research sites, the least number of species were obtained from the Karamba sites. The relative abundance for each station indicates the quantity of the different species. At the inlet location (Galeh River), the highest relative abundance is 18.75 and the most abundant species are *Melosira* sp., *Pediastrum* sp., and *Cyclotella* sp., sharing a relative abundance of 10.94%.

The relative abundance at Bukit Cinta station is 20.95%. At the Karamba site, the highest relative abundance is 15.38%, dominated by species of *Synedra ulna* and *Oscillatoria* sp. Meanwhile, at the outlet station (Tuntang river), the relative abundance is 25% with *Synedra* sp., being the most abundant species.


realtive abundance inlet rawa pening
relative abundance (%)
0
5
10
15
20
1.56
3.13
10.94
4.09
0
0
0
6.25
10.54
3.13
6.25
18.75
3.13
0
0
3.13
1.56
3.13
1.56
0
6.25
7.81
0
0
0
6.25
0
1.56
cosmarium sp
closterium sp
pediastrum sp
scenedesmus sp
eudorina sp
Oocystis sp
microcystis sp
staurastrum sp
Cyclotella sp
Amphora sp
Navicula sp
mellisora sp
gyrosigma sp
Pinnularia sp
Fragillaria sp
Cymbella sp
Ghomphonema sp
Aulacoseira...
achnanthes sp
euthonia sp
Synendra sp
Oscillatoria
Anabaena sp
aphanocapsa sp
spirullina sp
peridinium sp
Gymnodium sp
Euglena sp

relative abundance keramba rawa pening
relative abundance (%)
0
2
4
6
8
10
12
14
16
0
0
2.56
0
0
10.26
0
2.56
10.26
2.56
7.69
0
2.56
0
0
2.56
0
10.26
0
0
15.38
15.38
0
7.69
5.13
0
5.13
0
cosmarium sp
closterium sp
pediastrum sp
scenedesmus sp
eudorina sp
Oocystis sp
microcystis sp
staurastrum sp
Cyclotella sp
Amphora sp
Navicula sp
mellisora sp
gyrosigma sp
Pinnularia sp
Fragillaria sp
Cymbella sp
Ghomphonema sp
Aulacoseira...
achnanthes sp
euthonia sp
Synendra sp
Oscillatoria
Anabaena sp
aphanocapsa sp
spirullina sp
peridinium sp
Gymnodium sp
Euglena sp

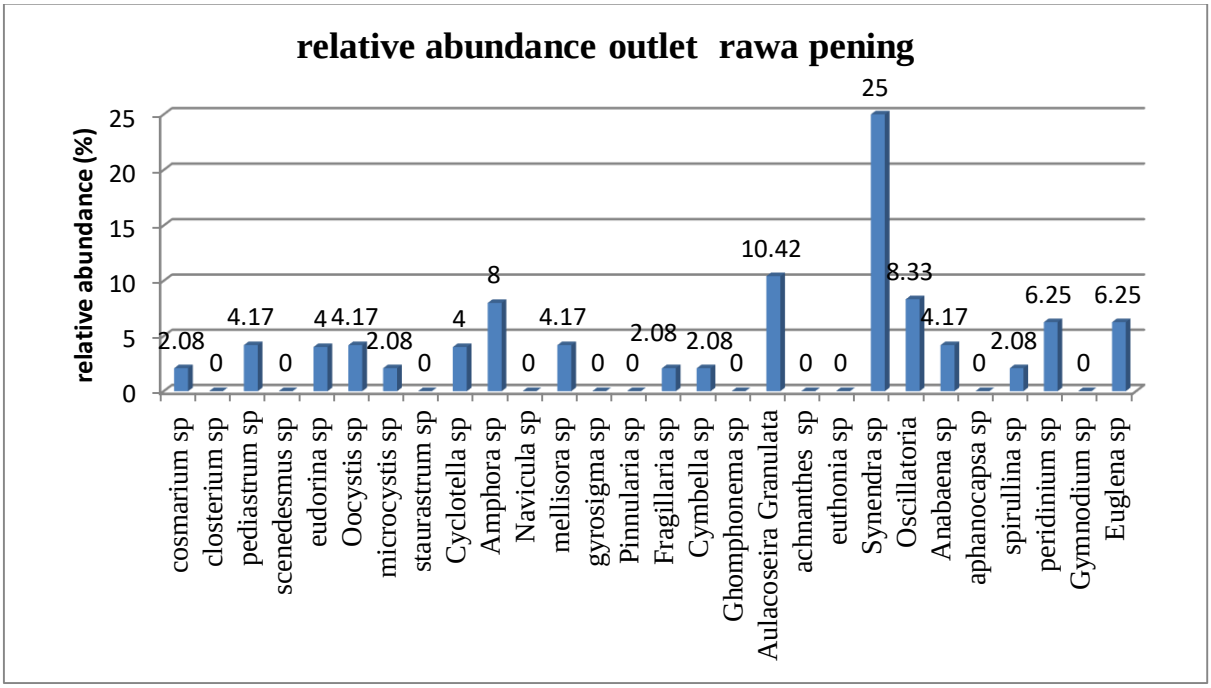


Figure 3. Relative abundance graphs of each station

Generally, the research sites in RawapeningLake are primarily dominated by the Chrysophyta or Bacillariophyta groups. This is due to their relatively high growth and regenerative ability. The presence of the Bacillariophyceae class that dominates water is a common occurrence, as proposed by Nybakken (1992) stating that the microalgae composition in the water is dominated by the Bacillariophyceae group. In addition, in the Rawapening Lake water, there are high levels of organic material allowing the Chrysophyta group to dominate. This is in accordance with Sachlan's (1982) opinion, in which the high Chryshophyta abundance corresponds with the availability of organic matter.

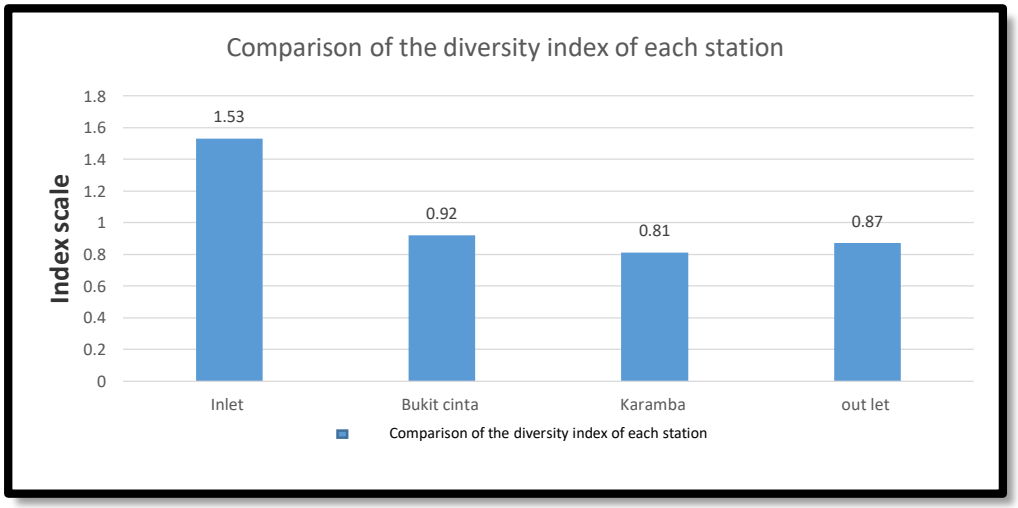


Figure 4. Graph index of the diversity of each station

The average diversity index ranges from 0.81 to1.53.According to Odum (1998), if the average value of diversity is less than 1, it is categorized as *low* (H '<1). Diversity ranging between 1 and 2 belongs to the *moderate* category. The diversity index is closely related to the dominance index. If the dominance index is high, the diversity index will below or vice versa (Odum, 1998). A lower

dominance index score indicates an absence of dominant species, whereas a higher dominance index indicates the opposite.

The uniformity index results range from 0.29 to 0.53. This is a relatively small range. A higher uniformity index value of aquatic organisms indicates that the relative abundance of each species prevails between stations. Whereas a lower value tends to indicate an unstable community. A lower value may occur when environmental conditions do not support the life of the biota inside. Based on the uniformity index value obtained from Rawapening Lake, (in particular from the water surrounding the research stations), the lake can still support the growth and development of all species of microalgae involved in this study. This is also bound with the utilization of nutrients between stations and observations that are relatively similar. Based on the environmental criteria, the microalgae community conditions in this water are in unstable conditions until stable conditions, but more likely in unstable conditions. This is confirmed by the different species of microalgae found during the study.

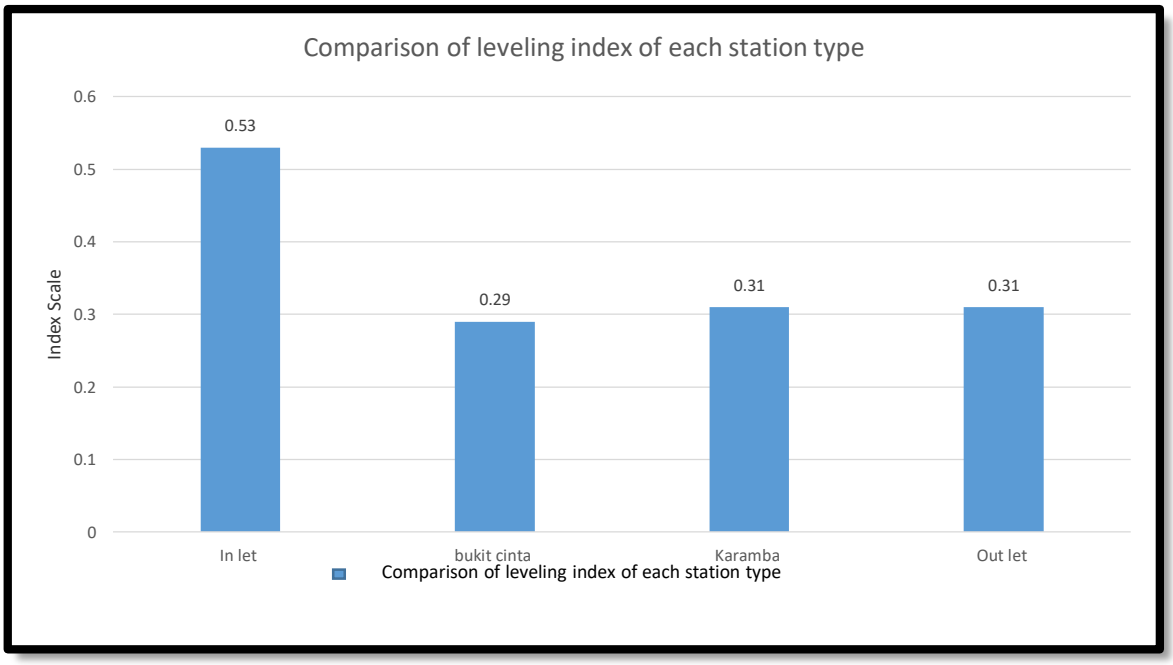


Figure 5. Graph of leveling index of each station

The value of Rawapening Lake's leveling index is included in the low category, indicating an uneven spread among the species. The types of microalgae that have a uniform distribution are Pediastrum sp., Cyclotella sp., Aulacoseira granulata, Synendra sp., and Oscillatoria sp. These species are spread evenly across all research stations.

Table 2. Water qualityRawapening Lake

Environmental Parameters	***Inlet***	***Bukit Cinta***	***Area Keramba***	***Outlet***
Dissolved Oxygen (DO) ppm	4,03	5	4,21	5,5
Temperature (^{0}C)	27,5	27,5	27,4	27,7
Turbidity (NTU)	23	31	30	27
Light intensity (cm)	65	85	55	70
Conductivity	93	89	95	92

The data analysis of the saprobic coefficient in Rawapening Lake resulted in a value of 1.14. This indicates that the water is in the β-meso/Oligosaprobic phase, which means that the water is lightly

contaminated. This is likely due to the contaminants of organic and inorganic materials in the form of household waste and fish feed remnants.

Results from water quality measurements show dissolved oxygen concentrations ranging from 4.03 to 5.5 ppm, which are sustainable for aquatic life. Temperature is a physical factor that greatly affects the overall viability for an aquatic organism to flourish. Temperatures at the study sites averaged 27.5°C. The water temperature conditions are relatively homogeneous and are within the normal range that is tolerated by microalgae. According to Nybakken (1992), the optimal temperatures for microalgae growth generally range from 20 °C to 30 °C.

The pH values measured range from 7.3 to 7.5. The pH values in all stations are optimum normal because they range from 7 to 8. The pH value describes the acidity and basicity of the water. If the water has a pH value lower than 7, it can result in decreased plankton diversity (Hariyati, 2014). Turbidity in the lake ranges from 23 ppt to31 ppt. The main effect of higher turbidity is a significant decrease in light penetration of the water resulting in decreased activity of microalgae photosynthesis. Rawapening Lake water currently has a level of turbidity good enough for the life of aquatic organisms.

4. Conclusion

From the results of this study, it can be concluded that Rawapening Lake contains 18 species of vegetable plankton/microalgae consisting of divisions Chlorophyta, Chrysophyta, Cyanophyta and Pyrrophyta/Dinoflagellata. The number of individuals ranges between 1,833 individuals/liter and 4,935 individuals/liter. The abundance of vegetable plankton is dominated by the genus *Melosira* sp, *Aulacoseria granulose* sp, *Oscillatoria* sp and *Synedra* sp with low to moderate diversity index values. The quality of the raw water environment based on the saprobic index value is classified as β meso-oligosaprobic. The overall water quality is still good enough to sustain the life of aquatic organisms.

References

[1] A reference APHA (American and Public Health Association). 2005. Standard Methods For The Examination of Water and Wastewater. 17th d. APHA, AWWA(American Waste Water Association) and WPCF (Water PollutionControl Federation). Poet City Press. Ballymore. Maryland : xxxviii +1112 page.

[2] Boney, A. D. 1989. New Studies in Biology Phytoplankton. Edward Arnold Pub. Ltd. London.

[3] Hariyati, R., 2014. *Bioma*. **16**

[4] Koesoebiono, 1987. Methods and Techniques for Measuring Water Biology. Amdal Course Force V. Bogor

[5] Krebs, C.J. 1989. Ecological Methodology. New York, Harper & Row Inc.Publisher

[6] Nybakken, J.W. 1992. Marine biology: an ecological approach. Print to 2. Translated: H.M. Eidman, Koesoebiono, D.G. Bengen M. Hutomo & S. Sukoharjo. PT. Gramedia Pustaka Utama. Jakarta. Indonesia : xv+495 page.

[7] Odum, EP. 1998. Fundamentals of Ecology. Tjahjono Samingan Translation,1993.Edisi Ketiga.Yogyakarta : Universitas Gadjahmada.

[8] Schlan, M. 1982. Planktonology. Semarang: Faculty of Fisheries and Marine University of Diponegoro

[9] Scholten, M.C.Th. 2005. Eutrophication management and ecotoxicology. Springer.122p