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Phytoplankton Community Structure as Bioindicator of Water Quality in Floating Net Cage Area with Different Density at Cirata Reservoir

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Authors' contributions

This work was carried out in collaboration with all Authors. Author MRRNF designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ZH and IMA managed the analyses of the study. Author HH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Cirata Reservoir is built with water sources originating from the Citarum River. Cirata Reservoir mainly use as a hydroelectric power plant and fish cultivation area with a floating net cage system. The utilization of a reservoir for the cultivation of fish in the Cirata Reservoir had exceeded the specified capacity by the government. That matter had caused the water quality to change in waters of the Cirata Reservoir. Phytoplankton is the first organism that is affected because the degradation of water quality. The purpose of this research is to determine the structure community of phytoplankton in floating net cage areas with different density and water flow at Cirata Reservoir. This research was conducted on November 16 - December 8 of 2019 in the Cirata Reservoir with sampling station located at Jangari, Meleber, and Patokbeusi. The method that was used in this research was purposive sampling method. The result of physic-chemical parameter of this research showed that temperature at all station ranged between 31,9-34,5°C, transparency 53,5-76 cm, pH 6,87-7,67, CO_2 8,4-16,8 mg/L, BOD_5 1,1-20,5 mg/L, DO 5,83-9,72 mg/L, nitrate 0,169-

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0,241 mg/L, ammonia 0,001-0,241 mg/L, and phosphate 0,131-0,195 mg/L. The result of phytoplankton community structure indicated that composition of phytoplankton had 30 genera with Chlorophyceae class as the most dominant. The abundance of phytoplankton during research was ranged between 49.570-338.450 ind/L, diversity index 0,78-0,88, domination index 0,12-0,22, and saprobic index 1,04-1,59. Saprobic index indicated that water in each station was included in mild to moderate pollution category or in the β-Meso/ oligosaprobic phased which was showed by the large number of Gloeocystis and Glenodinium genera.

Keywords: Bioindicator; cirata reservoir; phytoplankton; saprobic index; water quality.

1. INTRODUCTION

Reservoirs are lakes or artificial water bodies that are formed due to containment of river flow and are one of the water resources [1]. Cirata Reservoir is built with water sources originating from the Citarum River and is a cascade reservoir located at the second position between the two other reservoirs, the Saguling (upstream) and Jatiluhur (downstream). Cirata Reservoir has the main function as a Hydroelectric Power Plant (HPP) [2]. Other functions are as an area for tourism, irrigation, water conservation, and fish farming. Fish cultivation activity that has been developed in Cirata Reservoir is using the floating net cage system.

The number of floating net cage in the Cirata Reservoir has increased from time to time. Based on the Decree of the West Java Governor No. 41 in the year 2002, the maximum number of floating net cage in the Cirata Reservoir is 12,000 plots. But in 2011 alone the number has reached 53,031 plots and continues to increase each year until 2018 reaching 98,397 plots [2]. The amount of excess from floating net cage causes a decrease in the quality of waters in the Cirata Reservoir due to the waste of fish farming feed residue and the results of fish metabolic waste that exceed the Cirata Reservoir capacity. This is in accordance with a research conducted at 2014 which stated that the Cirata Reservoir was in eutrophic condition with hypereutrophic tendencies in the floating net cage area [3].

Organisms that will be affected by the condition of degraded waters are phytoplankton. Phytoplankton as an autotrophic organism is the biota that first responds to changes in the physical and chemistry quality of waters [4]. That is because phytoplankton is the main autotrophic organisms that supply dissolved oxygen in water and act as primary producers who also determine the production of biota at other trophic levels [4]. Phytoplankton is also a biological parameter that can be used as an indicator to evaluate the quality and fertility of a waters or commonly referred to as bioindicator [5].

The decline in water quality in the Cirata Reservoir can have negative impacts on those who utilize the reservoir, especially the fish cultivators themselves. Therefore, research is needed on the phytoplankton community structure to determine waters quality in the floating net cage area of the Cirata Reservoir so that it can be used as a review to evaluate and monitor the feasibility of the floating net cage.

2. MATERIALS AND METHODS

This research was conducted at the transition of the dry season to the rainy season, which was on November 16 - December 8 of 2019. Sampling locations are in three floating net cage blocks in the Cirata Reservoir, West Java, Indonesia with due regard to the floating net cage density and water flow at each station, namely the station 1 in the Jangari block with a total number of 3,584 plots, station 2 in the Meleber block totaling 2,075 plots and station 3 in the Patokbeusi block totaling 2,268 plots [6]. The research method used in this research was purposive sampling method. Data was taken for 5 repetitions with a vulnerable time of 7 days. The location of the research location can be seen in Fig. 1.

2.1 Research Procedure

2.1.1 Measurement of physical and chemistry variables

Water sample from floating net cage area was taken as much as 1 L and put into a sample bottle. Measurement of water physical variables including temperature and transparency and also chemical variables including DO, CO^2 and pH was carried out directly at the study site. While the measurement of chemical variables including BOD_5, nitrate, ammonia, and phosphate was conducted at the Water Resources Laboratory, Faculty of Fisheries and Marine Science, Padjadjaran University.

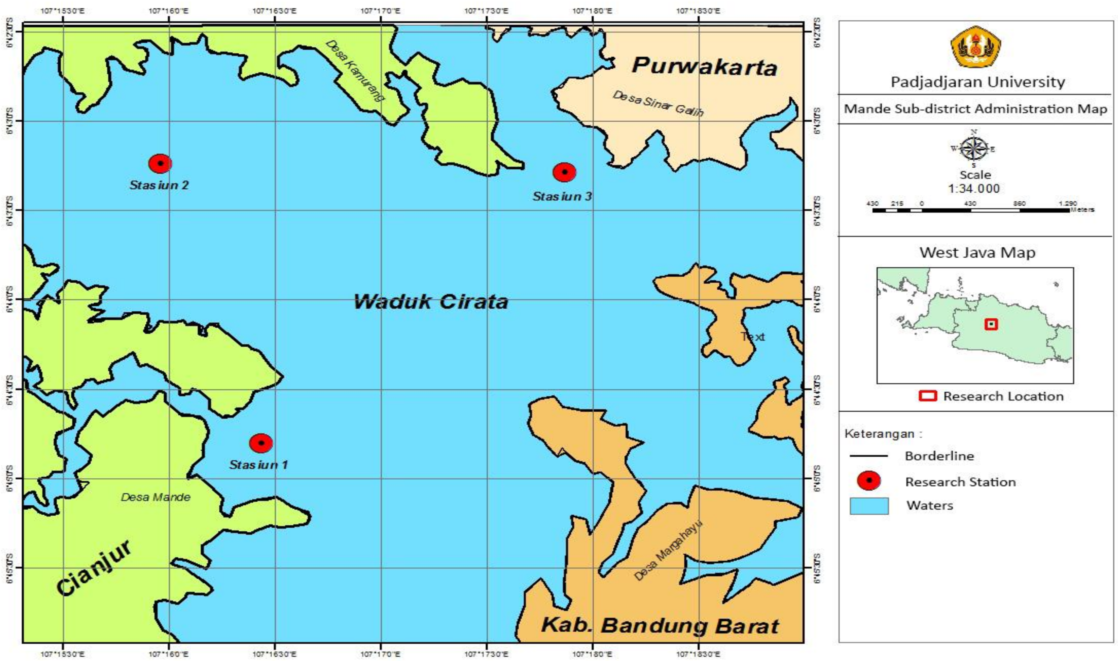

Fig. 1. Research location map

2.1.2 Sampling of phytoplankton

Phytoplankton sampling stage consists of phytoplankton samples taken from the floating net cage area by filtering as much as 2 L of water using a plankton net with mesh size of 20 µm and preserved using 0.5% Lugol solution as much as 10-20 drops until the colour becomes brown. Phytoplankton were identified based on their genera using a binocular microscope with a magnification of 10 x 10. Phytoplankton were identified using Sachlan (1982) and Davis (1955) identification books.

2.2 Data Analysis

Observation data are explained descriptively by explicating water quality data that includes physical and chemical variables comparable to the water quality standards described in Government Regulations of the Rebuplic of Indonesia (GR RI) No. 82 year 2001 to determine the feasibility of water quality in the floating net cage area. The phytoplankton community structure data, which includes composition, abundance, diversity, dominance and saprobic index is discussed qualitatively. Furthermore, phytoplankton data are linked to physical and chemical variables through correspondent correlation analysis (CCA) method.

2.3 Phytoplankton Abundance

Phytoplankton abundance was measured using the modified Sachlan formula (1982) [7].

$$N = n\,x\,\frac{Vr}{Vo}\,x\,\frac{1}{Vs}$$

Information:

N = plankton abundance (individual / liter)
n = number of plankton identified
Vo = calculated plankton volume (mL)
Vs = the volume of filtered water (L)
Vr = volume of concentrated water (mL)

2.4 Phytoplankton Diversity

Phytoplankton diversity was measured using the Simpsons diversity index as follows [8].

$$H' = 1 - \sum\left(\frac{ni}{N}\right)^2$$

Information:

H '= Index of Simpsons diversity
ni = Number of individual types-i
N = The total number of individuals of all types

2.5 Phytoplankton Dominance

Phytoplankton dominance was measured using the Simpsons diversity index as follows [9].

$$C = \sum_{i=1}^{n} \left(\frac{ni}{N}\right)^2$$

Information:

C = simpson dominance index
Ni = Number of individuals of type-i
N = total number of individuals

2.6 Saprobic Index

Saprobic index can be calculated using the following formula [10]:

$$X = \frac{(C + 3D - B - 3A)}{(A + B + C + D)}$$

Information:

A= Ciliata group shows Polysaprobitas
B= Euglenophyta group shows α Mesosaprobitas
C= Chlorococcales + Diatomae,group shows β-Mesosaprobitas
D= Peridinael/ Chrysophyceae/ Conjugatae group shows Oligosaprobitas

2.7 Canonical Correspondence Analysis (CCA)

Canonical Correspondence Analysis (CCA) is a multivariate method for explaining the relationship between biological parameters and their environment. This method is designed to extract gradients from synthetic environments from ecological data sets. Gradients are the basis for describing concisely and visualizing differential habitat preferences from a taxavia diagram [11]. The CCA graph in this study was created using the PAST 4.0 application.

3. RESULTS AND DISCUSSION

3.1 Physycal and Chemical Parameter of Water

Waters quality, in general, was still capable for fish farming activities, but within a number of physical and chemical parameters, did not support phytoplankton's growth. The results of water quality measurements can be seen in Table 1.

The result of temperature measurement showed that the temperature at the three stations ranged from 31.9°C to 34.5°C. Temperature measurement carried out during the day which made the intensity of the light entering the body of water was also high. High light intensity will produce heat which will further increase the temperature and vice versa [12]. Temperature at station 1, station 2 and station 3 had exceeded the favorable temperature range for phytoplankton and fish growth. This was due to the optimum temperature for phytoplankton growth and fish life in the tropic region is ranging from 25.0-31.0°C [13].

The result of transparency measurement at station 1, station 2 and station 3 ranged from 53.5 to 76 cm. This transparency was affected by the murky waters caused by the large number of solids suspended due to aquaculture, domestic, and waste carried from the Citarum River. Transparency could be influenced by human activities that produce waste, causing high levels of dissolved particles and suspended particles [14]. Station 2 had average transparency of 68,6 cm, which meant it was the best region for phytoplankton growth because the higher the transparency is the higher the growth of phytoplankton as well because phytoplankton are more active in carrying out photosynthesis [15].

The result of pH measurement at each station ranged from 6.87-7.67. When compared with GR RI No. 82 of 2001, the average pH values at station 1, station 2 and station 3 were included in the class II and III categories, which are favourable water categories for fish farming activities. The pH value at each station was also good for phytoplankton growth because it was still in the range of 6.0-9.0 [16].

The result of CO^2 measurement at each station ranged from 8.4-16.8 mg/L. High and low concentrations of CO^2 could be influenced by the process of decomposition of organic material derived from waste fisheries, domestic activities, and waste carried by the Citarum River and also affected by the respiration process. CO^2 concentration is influenced by the decomposition and oxidation of organic compounds by microorganisms contained in polluted water. CO^2 concentrations were also influenced by atmospheric diffusion, rainwater, water that passes through organic soil, and the respiration of plants and animals, as well as aerobic and anaerobic bacteria [17]. The concentration of CO^2 at each station was still decent for fish farming. This was due to the maximum of good free carbon dioxide concentration for fisheries activities is 15 mg / L [18].

Table 1. Water quality at study station

Parameter	Station	Repetition					Average
		1	2	3	4	5	
Temperature (°C)	1	32,3	32,6	32,4	34,5	32,0	32,76
	2	32,8	33,0	33,0	33,0	33,0	32,96
	3	31,7	32,3	34,0	34,5	32,0	32,90
Transparancy (cm)	1	60	62	65	66	62	63,00
	2	70	68	76	66	63	68,60
	3	65	66	65	53,5	67	63,30
pH	1	7,47	6,98	6,90	7,25	6,89	7,10
	2	7,57	6,97	7,10	7,11	6,87	7,12
	3	7,67	6,97	7,10	7,40	6,95	7,22
CO_2 (mg/L)	1	12,4	12,6	8,4	8,4	8,4	10,02
	2	12,4	12,6	12,6	12,6	12,6	12,54
	3	20,7	16,8	12,6	12,6	12,6	15,03
BOD_5 (mg/L)	1	0,4	1,3	2,2	2,6	0,9	1,48
	2	0,3	1,2	2,2	1,1	2,2	1,40
	3	0,5	2,1	1,1	1,5	0,5	1,14
DO (mg/L)	1	8,43	9,72	9,72	8,40	9,72	9,20
	2	8,43	7,45	9,72	9,72	9,72	9,01
	3	8,76	8,10	5,83	9,07	9,07	8,17
Nitrate (mg/L)	1	0,175	0,226	0,192	0,225	0,198	0,203
	2	0,241	0,185	0,202	0,223	0,219	0,214
	3	0,169	0,181	0,19	0,217	0,208	0,193
Ammonia (mg/L)	1	0,002	0,002	0,004	0,005	0,003	0,003
	2	0,003	0,001	0,005	0,003	0,003	0,003
	3	0,003	0,002	0,004	0,005	0,005	0,004
Phosphate (mg/L)	1	0,168	0,185	0,158	0,154	0,186	0,170
	2	0,154	0,159	0,131	0,168	0,181	0,159
	3	0,155	0,163	0,152	0,153	0,195	0,164

The result of BOD_5 measurement of the three stations ranged from 1.1-20.5 mg/L. According to GR RI No. 82 of 2001, BOD_5 concentrations at each station had passed the quality standards in class II and class III, which are 3 mg/L and 6 mg/L. It meant the waters were not well for fisheries activities. High and low concentrations of BOD_5 were caused by the influence of the organic waste availability from fish farming activities, domestic waste, and industrial waste carried by the Citarum River. Suparjo (2009) states that organic materials naturally originate from the waters themselves through the processes of decomposition of weathering or decomposition of landfill wastes such as domestic, industrial, agricultural and livestock waste or food scraps in the presence of bacteria decomposing into nutrients [19].

The result of DO measurement at station 1, station 2, and station 3 ranged between 5.83-9.72 mg/L. DO concentration was influenced by the process of oxygen diffusion found in the atmosphere and photosynthetic activity by aquatic plants and phytoplankton [13]. According to GR RI No. 82 of 2001, the DO concentration in each station was included in class II and III because it exceeded the minimum concentration of 4 mg / L and 3 mg/L. Furthermore, DO concentrations at station 1, station 2, and station 3 still supported the growth of phytoplankton. Phytoplankton generally lived well because oxygen concentrations at each station were more than 3 mg/L [20].

The result of nitrate measurement at each station ranged from 0.169 to 0.241 mg/L. Nitrate concentration was influenced by water entering the reservoir, fish farming waste, and the availability of nutrients in the reservoir itself (internal loading) [21]. Based on GR RI No. 82 of 2001 nitrate concentrations at each station belonged to class II because the maximum concentration standard for class II is 10 mg/L which meant it was still favorable for fishing activities. However, nitrate concentrations at all stations were less supportive for phytoplankton growth. That is because the optimal growth of phytoplankton requires nitrate content in the range between 0.9-3.5 mg/L. Nonetheless, if the nitrate concentration level is more than 0.1 mg/L it can still be used for phytoplankton growth [22].

Ammonia measurement results at each station ranged from 0.001 to 0.005 mg/L. Ammonia concentration was influenced by the process of decomposition of organic matter through the ammonification process [19]. When compared with GR RI No. 82 of 2001, the ammonia concentrations of station 1, station 2 and station 3 were belonged to classes II and III. Ammonia concentrations at all stations were less supportive for phytoplankton growth because the lowest limit of favorable ammonia concentration for phytoplankton growth is 0.017 mg/L [23].

The result of phosphate measurement during the study ranged from 0.131 to 0.195 mg/L. The wastes that most affected the phosphate concentration at the three research stations were fish farming activities such as feces or leftover feed, domestic wastes such as detergents, and wastes brought from the Citarum River. Phosphate concentration in waters was influenced by the process of decomposition of organic waste, industrial waste, fertilizer, or domestic waste [24] and can also be influenced by fisheries activities [25]. As stated by GR RI No. 82 of 2001, the average phosphate concentration at each station was included in class II with a maximum concentration standard is 0.2 mg/L. Phosphate concentration at all stations was less supportive for phytoplankton growth. This is due to the optimal phosphate content for phytoplankton growth is in the range of 0.27-5.51 ppm [26].

According to a research conducted at 2017, physical and chemical parameters of Cirata Reservoir which included temperature, transparency, pH, dissolved oxygen (DO), phospate, nitrate, and ammonia showed different results with the same physical and chemical parameters in this study. Research conducted at 2017 showed that average temperature of Cirata Reservoir ranged from 29.3 to 30.6°C, transparency ranged from 110 to 124 cm, pH ranged from 6.8 to 7.6, DO ranged from 6.8 to 7.6 mg/L, phosphate ranged from 0.061 to 0.068 mg/L, nitrate ranged from 1.171 to 1.257 mg/L, and ammonia ranged from 0.153 to 0.221 mg/L [1].

This difference can be caused by the reduction of waste entering the water bodies from industries along Citarum River and from the reduction of floating net cage. Government of Indonesia through Citarum Harum Program that had been regulated by the presidential regulation number 15 year 2018 concerning the acceleration of pollution and damage control in the Citarum River basin which was signed on march 14 of 2018 has determined to make Citrarum River drinkable within 7 years. This program mainly focus on revitization of Cirata River by encourage indsutries to use wastewater treatment plant properly and to markdown the number of floating net cage at each reservoir.

3.2 Structure Community of Phytoplankton

The types of phytoplankton found during the study were generally from the Chlorophyceae class with a percentage of 54.77% - 58.51% of all classes that had been identified. Chlorophyceae are a class that is commonly found in abundance in freshwater [27]. Phytoplankton composition can be seen in Fig. 2. While the results of the calculation of the structure of the phytoplankton community can be seen in Fig. 3.

The composition of the phytoplankton genera found at all three stations during the study was as many as 30 genera. The genera belong to several classes, namely Chlorophyceae with 14 genera, 7 genera Cyanophyceae, 4 genera Bacillariophyceae, 2 genera Dyanophyceae, 2 genera Zygnemophyceae, and 2 genera Euglenophyceae. The types of genera in each class identified can be seen in Table 2.

Based on Table 2 the genera of Gloeocystis was the most dominant among other genera. The high amount of Gloeocystis is due to the influence of nutrients and favorable environmental conditions for the growth of the genera. In addition, Gloeocystis also has a concentric layer of mucus with a high capacity to expel a lot of mucus [28]. This mucus serves as a protector so that phytoplankton is able to survive better [29]. In addition to protection, the mucus also functions as an adaptation tool to the current of either strong current or slow current by sticking to the substrate [30].

The results of the phytoplankton abundance calculation at the three stations ranged from 49,579-338,340 ind/L. Phytoplankton abundance at station 1, station 2 and station 3 were included in the high abundance because the number of phytoplankton in each station was above 40,000 ind / L. Soegianto (1994) states that abundance with values <1,000 ind/L is classified as low, abundance between 1,000-40,000 ind/L is classified as moderate, and abundance> 40,000 ind/L is classified as high [31]. The high abundance of phytoplankton due to the influence of organic materials available in the waters. A high abundance of phytoplankton in waters occurs when the availability of organic material is also high [8]. The high availability of organic material came from fish farming activities, domestic waste, rainwater-borne waste and waste that enters through the Citarum River.

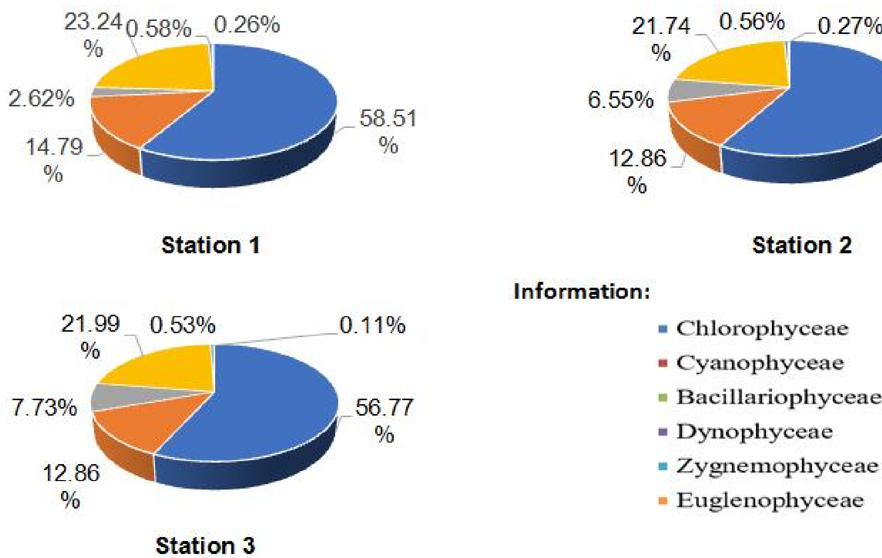

Fig. 2. Phytoplankton composition based on class

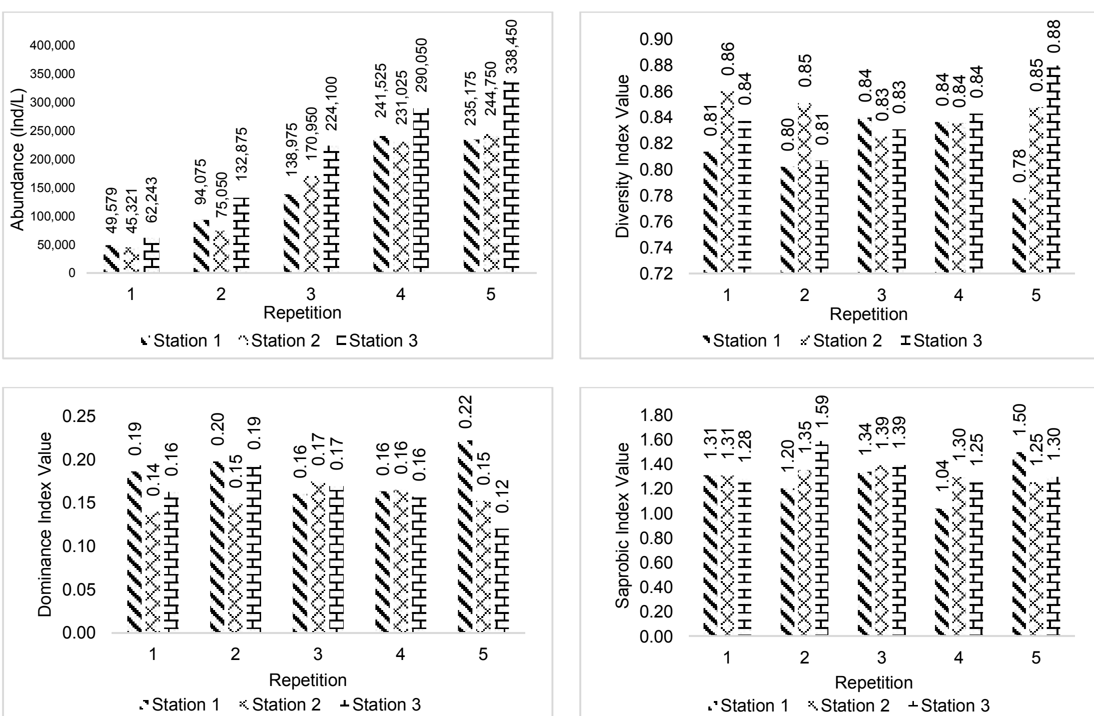

Fig. 3. Results of phytoplankton structrure community calculation

Table 2. The amount of phytoplankton found during study (individuals/liter)

No.	Class	Genera	St 1	St	St 3	Amount
1	Chlorophyceae	Gleocystis	11374	10217	13610	35201
2		Pediastrum	1666	2395	3402	7463
3		Scenedesmus	2358	2558	3095	8011
4		Cosmarium	435	376	502	1313
5		Chlorococcum	1640	1245	1753	4638
6		Closterium	834	1315	2317	4466
7		Chlorella	393	350	439	1182
8		Selenestrum	339	406	555	1300
9		Antikistrodesmus	153	274	220	647
10		Staurastrum	473	455	537	1465
11		Coelastrum	296	267	362	925
12		Tetraedron	98	81	53	232
13		Crucigenia	386	218	195	799
14		Actinastrum	226	275	287	788
15	Cyanophyceae	Microcystis	163	131	194	488
16		Anabaena	133	197	187	517
17		Merismopedia	1415	1197	2718	5330
18		Oscilatoria	34	102	62	198
19		Lyngbya	106	115	75	296
20		Spirulina	183	191	218	592
21		Phormodium	3191	2596	2738	8525
22	Bacillariophyceae	Nitzschia	280	204	354	838
23		Navicula	232	424	369	1025
24		Synedra	111	182	232	525
25		Melosira	304	1496	2768	4568
26	Dynophiceae	Peridinium	75	185	640	900
27		Glenodinium	8137	7472	9944	25553
28	Zygnemophyceae	Hyalotheca	165	127	158	450
29		Euastrum	39	71	97	207
30	Euglenophyceae	Euglena	92	94	52	238

The results of the phytoplankton diversity index at each station ranged from 0.78 to 0.88. The diversity index value indicated that the phytoplankton community in each station was included in the medium-high diversity category. Score index approaching 1 means the distribution of individuals is high, and ecosystem stability is said to be good if it has a diversity value between 0.6-0.8 [9].

The results of the calculation of the phytoplankton dominance index during the study ranged from 0.12 to 0.22. The dominance index value indicated that the phytoplankton community at each station was belonged to the category of no genera dominates. Dominance index values ranging from 0-0.5 indicate that no genera dominates and if it ranges from 0.5-1 indicates that there is a dominant genera [9].

The result of saprobic index calculation in three stations ranged from 1.04-1.59. The saprobic index value indicated that the pollution level of each station was fell into the category of mild to moderate pollution. This was because the saprobic index values at stations 1, station 2, and station 3 were in the range of +1 to +1.5 which meant the pollution level of the waters was mild to moderate or in the β-Meso/ oligosaprobic phased [10].

During the study it was found that the most dominant saprobe group was group C (Chlorococcales and Diatomae groups) which showed β-Mesosaprobe and group D (group Pyrrophyta, Chrysophyceae, and Conjugatae) which showed Oligosaprobe. Saprobe organism that has the most number in group C is Gloeocystis. Whereas in group D was Glenodinium. The dominance of these two groups can influence the calculation of the saprobic index.

3.3 Phytoplankton Community Structure and Its Relationship with Water Quality

Physical and chemical parameters analyzed to determine its relationship with phytoplankton are temperature, transparency, pH, carbon dioxide, DO, nitrate, ammonia and phosphate. BOD_5 parameters are not included in the graph because they are not directly related to phytoplankton growth. The analysis result are presented in graphical form which can be seen in Fig. 4. The graph shows the relationship between the identified phytoplankton genera and the physical-chemical parameters of the waters.

The result of correlation analysis in the growth of each phytoplankton genera indicated that there was a difference in the relationship between each phytoplankton genera with physical-chemical parameters of the waters. This is indicated by the presence of an intersection between a physical and chemical parameter line of the waters with the point of ecological objects (phytoplankton genera).

DO and nitrate parameters had a strong correlation with 8 genera namely Antichrististrodesmus, Euglena, Lyngbya, Tetraedron, Glenodinium, Chlorella, Spriulina, and Scenedesmus. Based on its abundance, the genera Glenodinium was greatly affected by this parameter. Glenodinium has a high total abundance composition compared to other genera in the same segment, which is 22.35%. DO concentrations at station 1, station 2 and station 3 were 5.83-9,72 mg/L which was good for phytoplankton growth because it was above the minimum range of favorable dissolved oxygen concentration. On the other hand, nitrate concentrations were fell into the suboptimal category for phytoplankton growth, ranging from 0.169 to 0.241 mg/L. This situation showed that the Glenodinium genera was able to adapt better than other genera in utilizing nitrate concentrations that were less supportive. Nitrate is one of the main nutrients in the growth of phytoplankton.

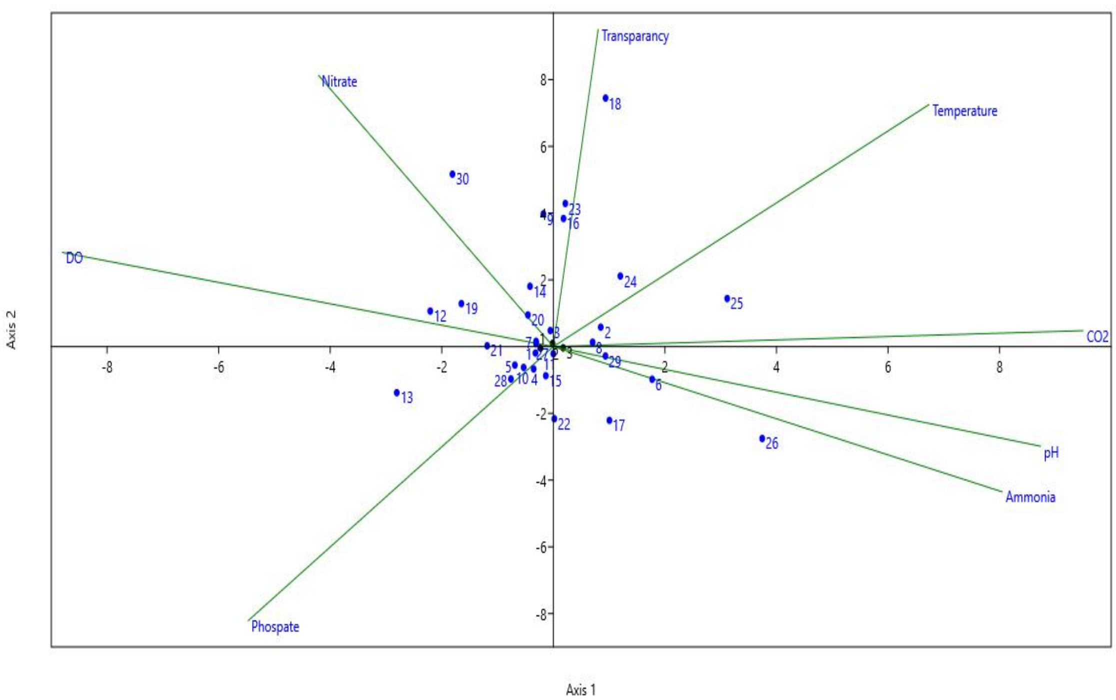

Fig. 4. Graph of canonical correspondence analysis (CCA)

Genera description: 1 = Gloeocystis. 2 = Pediastrum, 3 = Scenedesmus, 4 = Cosmarium, 5 = Chlorococcum, 6 = Closterium, 7 = Chlorella, 8 = Selenestrum, 9 = Antikistrodesmus, 10 = Staurastrum, 11 = Coelastrum, 12 = Tetraedron, 13 = Crucigenia, 14 = Actinastrum, 15 = Microcystis, 16 = Anabaena, 17 = Merismopedia, 18 = Oscillatoria, 19 = Lyngbya, 20 = Spirulina, 21 = Phormodium, 22 = Nitzschia, 23 = Navicula, 24 = Synedra, 25 = Melosira, 26 = Peridinium, 27 = Glenodinium, 28 = Hyalotheca, 29 = Euastrum, 30 = Euglena

The parameters of transparency, temperature, and CO^2 have a strong correlation with 7 genera, namely Oscillatoria, Navicula, Anabaena, Synedra, Melosira, Pediastrum and Selenestrum. This parameter greatly contributed to the growth of Melosira and Pediastrum which were characterized by a high composition of total abundance compared to other genera in the same segment with a percentage of about 3.97% and 6.05% in each genera. This showed that temperature and transparency were the limiting factors for phytoplankton growth in this segment, especially for Melosira and Pediastrum. Carbon dioxide is also used directly by phytoplankton for photosynthesis [32].

The parameters of pH and Ammonia had a strong correlation with 4 genera namely Euastrum, Closterium, Peridinium, and Merismopedia. In order, the total abundance composition of each genera in this segment was 0.16%, 3.95%, 0.85% and 4.37%. Based on the composition, it indicated that pH and Ammonia parameters were very influential on the growth of the Closterium and Merismopedia genera. Ammonia measured in this study was free ammonia (NH3-N) which cannot be utilized directly by phytoplankton because it cannot be ionized. However, free ammonia can take the form of gas due to the influence of temperature, pH and surface water pressure, causing the ammonia in the form of gas to balance the process with ammonium ions (NH3-H) [33]. At pH 7 or less, the majority of ammonia will undergo ionization [17]. This ammonium ion can be used directly by phytoplankton for its growth.

The parameters of pH, Ammonia, and phosphate had a strong correlation with 2 genera specifically Coelastrum and Nitzschia. Based on the composition of phytoplankton abundance, the two genera had low composition which was 0.53% and 0.64%. The low total abundance was caused by suboptimal concentrations of ammonia and phosphate for phytoplankton growth.

Phosphate parameters had a strong correlation with 8 genera namely Gloeocystis, Cosmarium, Chlorococcum, Straustrum, Microcystis, Actinastrum, Crucigenia, and Hyalotheca. This parameter greatly contributed to the growth of the Gloeocystis genera which was characterized by high composition, which was equal to 29.05% of total abundance compared to other genera in the same segment. Furthermore, Gloeocystis could also be found in large numbers with each repetition. Phosphate concentrations at each station were less than optimal for phytoplankton growth, ranging from 0.131 to 0.195 mg/L. This condition showed that Gloeocystis was able to maximize the low phosphate concentration to be used in its growth. Gloeocystis had the advantages discussed in section 3.2, namely that the genera have high capacity mucus so that they can adapt better to poor environmental conditions than other genera.

Phosphate, DO, and nitrate parameters had a strong correlation with the phormodium genera with total abundance composition of 8.08%. DO was needed for the oxidation of organic and inorganic materials in the aerobic process [34]. DO concentrations were high which caused a nitrification process that led to produce nitrate compounds [33]. Nitrate in the water column can be utilized directly by phytoplankton for growth [35]. Although during the study, concentrations of nitrate and phosphate were less supportive for phytoplankton growth. Phormodium was able to make maximum use of those two nutrients indicated by high composition of total abundance. In addition, nitrate and phosphate are the two main nutrients used for phytoplankton growth.

4. CONCLUSION

Physical and chemical parameters at station 1, station 2 and station 3 generally categorize into class II and III of GR RI No. 82 in the year 2001. Phytoplankton composition is divided into 30 genera with Chlorophyceae as the most dominant class with a percentage between 54.77 - 58.51%. Phytoplankton abundance is in the high abundance category ranging from 49,579 ind/L to 338,450 ind/L. Diversity index value is included in the medium-high diversity category with a range of 0.78 to 0.88. The dominance index value falls into the category of no dominant genera in the range of 0.12-0.22. Saprobic index calculation result indicates that each station falls into the category of mild to moderate pollution or in the -Meso / oligosaprobic phase. This is indicated by the large amount of phytoplankton from Gloeocystis and Glenodinium genera. The result of the correlation analysis shows that there are differences between the relationship of 8 physical-chemical parameters to the growth of each identified phytoplankton.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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