Relationship between Water Quality and Abundance of Cyanophyta in Penjalin Reservoir

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Abstract—Cyanophyta (blue green algae) is one of the divisions of phytoplankton, microscopic aquatic organisms that some of them is harmful because secrete toxins and cause blooming so polluted waters. The purpose of this study was to determine the water quality in the Penjalin Reservoir in terms of physical and chemical parameters, determine abundance of Cyanophyta in Penjalin Reservoir, as well as determine the relationship between water quality with an abundance of Cyanophyta in order to control the blooming of Cyanophyta in Penjalin Reservoir. The method applied in this research is survey. The analytical method used to determine the water quality is descriptive method with table. Abundance of Cyanophyta were analyzed qualitatively and quantitatively. The relationship between physics and chemistry waters with an abundance of Cyanophyta were analyzed using correlation analysis. The results of the research in the waters of the Penjalin Reservoir obtained 25 species of Cyanophyta abundance ranged from 838.16 to 1322.77 ind.l-1, with the highest species abundance owned by Microcystis sp. Diversity index values ranged from 0.7 to 2.15 indicate that the diversity of Cyanophyta is classified, and the dominance index value of 0.009 to 0.29 indicates that no species dominates. Cyanophyta abundance in the waters of the Penjalin Reservoir 37,89% influenced by parameter TDS and Total P (r = 0,501) with equation Y = -701,5 + 33,4 (TDS) + 919,7 (Total P). Water quality in Penjalin Reservoir still within the range of good and decent for the life of organisms present in the reservoir. (Abstract)

Keywords—Cyanophyta, Water Quality, Structure of Community, Blooming, Penjalin Reservoir.

INTRODUCTION

Cyanophyta or blue-green algae is one of phytoplanktons division that are prokaryotic, the shape is single cells or colonies with filaments or sheets [1]. Most Cyanophyta cause an adverse impact to the environment. Some species like Microcystis, Anabaena, and Oscillatoria produce toxins that dissolved in the water like neurotoxin, hepatotoxin, sitotoxin, and endotoxin that can poisoning organisms that drink it. Cyanophytas that overflow in the water commonly referred as HABs (Harmful Algal Blooms), a condition where certain algae species produce toxins during blooming, causing the death of other organisms in the water. Therefore, research on the abundance of Cyanophyta important to maintain the profitable and minimize the adverse impacts of Cyanophyta [2].

Existence and abundance of phytoplankton in the ecosystem is very determined by its interaction with physical, chemical, and biological factors in the water. High abundance of phytoplankton in the waters due to the utilization of nutrients, solar radiation, temperature, and predation by zooplankton [3].

Nutrients are chemical elements or compounds that are essential for the growth of organisms, such as nitrogen and phosphate. Nitrogen (N) is necessary for the organism's metabolism. Nitrate is the main form of nitrogen in natural waters and is a major nutrient for algae and plant growth [4]. Phosphorus (P) at the water in the form of phosphoric compound, which consists of dissolved phosphate and particulate phosphate. Dissolved phosphate divided into organic and inorganic phosphate that consists of orthophosphate and polyphosphate [5]. Orthophosphate is an inorganic phosphate compound in dissolved form is essential for phytoplankton growth.

Based on the description above can be formulated issues to be examined in this study. First, how is the quality of water in the Penjalin Reservoir terms of physical parameters (light penetration, TSS, TDS) and chemical parameters (nitrate, orthophosphate, total N, total P, dissolved O_2, CO_2, and BOD). Second, how the abundance of Cyanophyta in Penjalin Reservoir. Third, how the relationship between water quality and abundance of Cyanophyta in Penjalin Reservoir.

Referring description of the problem, there are three objectives in this study:

1. Knowing the water quality of Penjalin Reservoir in terms of physical parameters (penetration of light, temperature, TSS, TDS) and chemical parameters (orthophosphate, nitrate, total N, total P, dissolved O_2, CO_2, and BOD),
2. Knowing the abundance of Cyanophyta in Penjalin Reservoir,
3. Knowing the relationship between water quality with an abundance of Cyanophyta in Penjalin Reservoir.

The benefits of this research are as a baseline for monitoring the waters of the reservoir and for the information of the authorized agency in the management of the waters of the Penjalin Reservoir.

METHODS

a. Research Location

The Research located in Penjalin Reservoir, Winduaji Village, Paguyangan District, Brebes, Central Java at coordinate 6°44'56" SL - 7°20'51,48" SL and 108°41'37" EL - 109°11'29" EL.

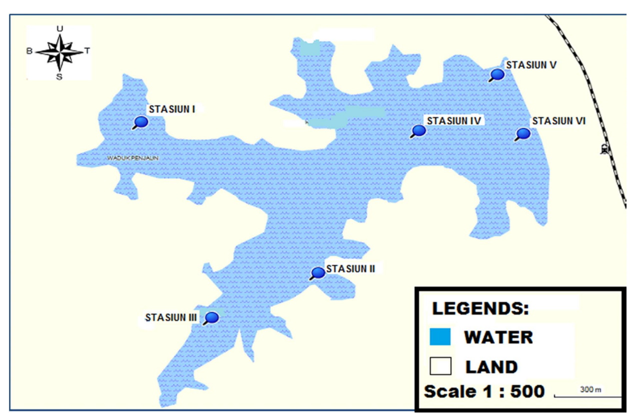

Figure 3.1. Research Sites
Station 1: Center of the reservoir
Station 2: Inlet from Garung River
Station 3: Inlet from Penjalin River
Station 4: Inlet from Soka River
Station 5: Outlet
Station 6: Dock Area

Measurement of physical and chemical parameters of waters is take place in the research location, in the Laboratory of Environmental and Aquatic Laboratory, Faculty of Biology, Jenderal Soedirman University. The research was conducted in June 2015 – February 2016.

The method used was survey with variables observed dependent variable and independent variables. The dependent variable is the abundance of Cyanophyta and the independent variables are the concentration factor of physics and chemistry in the waters of the reservoir. Physical factors observed including Total Suspended Solid (TSS) and Total Dissolved Solid (TDS), chemical factors including nitrate, orthophosphate, total P, total N, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), O_2 and CO_2. Supporting parameters were light penetration, temperature, pH and depth.

b. Measurements of Cyanophyta Samples

Cyanophyta Sampling was done by filtering 100 liters of water reservoirs using a plankton-net No. 25, and then transferred into the sample bottles that had been labeled, then add 3-4 drops of lugol and formalin concentration from 40% to 4%. Formalin can also be obtained by using the following formula:

$$C1.\ V1 = C2.\ V2$$

Explanation :
C_1 = Desired concentration of formalin
C_2 = Available concentration of formalin
V_1 = Volume of water in the bottle
V_2 = Volume of formalin needed

Cyanophyta were found then identified using a book of [6] and [7], as well as its abundance is calculated by a modified method Lackey Drop Microtransect Counting Chamber [7]:

$$F = \frac{Q1}{Q2} x \frac{V1}{V2} x \frac{1}{P} x \frac{1}{W}$$

The abundance formulas (ind.l^{-1}) = F × N
Explanation :
F = Total individu per liter
Q_1 = Cover glass wide
Q_2 = Field of views wide
V_1 = Water volume in the bottle
V_2 = Water volume in cover glass
P = Total Field of views
W = Volume of strained water
N = Total of plankton that counted from all field of views

c. Measurements of Physical and Chemical Parameters

Measurements of physical and chemical parameters that shown in Table 1.

Table 1. Measurements of physical and chemical parameters

No.	Parameters	Methods
1.	Light Penetration	Secchi [8]
2.	Air and Water Temperature	Expansion [9]
3.	Depth	Depth Sounder
4.	Acidity (pH)	Universal pH Indicator [9]
5.	Dissolved Oxygen (DO)	Winkler [10]
6	Total Suspended Solid (TSS) and Total Dissolved Solid (TDS)	Gravimetric [10]
7.	Biochemical Oxygen Demand (BOD)	Colorimetric [10]
8.	Ortophosphate	Spectrophotometric [10]
9.	Nitrate	UV Spectrofotometric [9]
10	Total N	Mikrokjeldahl [9]
11	Total P	Spectrophotometric [9]

d. Analysis Methods

1. Water quality (physical and chemical parameters) tested with descriptive method using the table to see the differences in the concentration of each station. Results of water quality measurements obtained is matched by the PP numb 82 of 2001 about Management of Water Quality and Water Pollution Control.
2. Cyanophyta abundance analyzed qualitatively and quantitatively. Qualitative analysis by describing the number of species and individual numbers of Cyanophyta obtained using tables. Quantitative analysis using index of diversity and index of dominance.
3. The correlation between the abundance of Cyanophyta with physical and chemical factors were analyzed with correlation analysis and multiple linear regression aided software SPSS and Microsoft Excel. Testing the hypothesis in multiple linear regression analysis was done by determining the value of the correlation coefficient (r).

RESULTS

a. Water Quality in Penjalin Reservoir

Cyanophyta abundance is supported by the quality of waters which includes physical and chemical factors. The results of measurements of physical parameters (temperature, light penetration, depth, TSS, TDS) and chemical (pH, DO, CO2, BOD, COD, nitrate, orthophosphate) Penjalin Reservoir waters are presented in Table 2.

Table 2. Measurements results of physical and chemical parameters in penjalin reservoir

Parameters	Unit	Station						Water Quality Standard Class III
		I	II	III	IV	V	VI	
pH		6	6	6	6	6	6	06-09
Water Temperature	°C	26,6	26	25,83	27	26,3	26	23-29
Air Temperature	°C	24,3	25	24,6	25,3	24,6	25,3	4
Light Penetration	m	1,53	1,41	1,29	1,5	1,29	1,28	-
Depth	m	8,86	4,1	3,26	2,9	5,6	4,43	-
DO	mg/l^{-1}	6,96	5,86	5,76	7,1	6,93	7,03	>4
CO_2	mg/l^{-1}	3,29	3,19	1,57	2,23	2,67	3,15	-
COD	mg/l^{-1}	18,5	14,8	21	17,06	14,2	18,2	<50
BOD	mg/l^{-1}	1,75	2,35	1,78	1,08	3,09	3,87	<6
TSS	mg/l^{-1}	3,36	3,34	3,3	2,98	3,69	3,31	<50
TDS	mg/l^{-1}	49,6	51,3	51,6	52,3	51,3	51,6	<1000
Nitrate	mg/l^{-1}	0,4144	0,3668	0,3477	0,4595	0,568	0,5057	<20
Orthophosphate	mg/l^{-1}	0,0065	0,0062	0,0403	0,038	0,0118	0,0748	-

Penjalin reservoirs have good condition and suitable for the life of aquatic organisms due to the temperature and pH of the water is still in the tolerance limits. PH measurement results obtained from the sixth station is 6. Cyanophyta commonly found in freshwater environments with a pH neutral [1].

Penjalin reservoir has a temperature range that is suitable for Cyanophyta. The temperature range for normal growth of phytoplankton is 25-30^{0}C [8]. Penetration of light is in the range of 1.28 to 1.53 m. Dissolved oxygen (DO) in Reservoir Penjalin ranges 5,76 - 7,03 mg.l^{-1} and complies with the minimum requirements of aquatic organisms. Living organisms in the water can survive if there is a minimum dissolved oxygen as much as 5 mg.l^{-1}.

Environmental conditions in the reservoir Penjalin based organic matter content is in the range of tolerance limits. This is indicated by BOD values ranging from 1,08-3,87 mg.l^{-1}. Waters with BOD values 10-20 mg.l^{-1} indicates the high level of contamination by organic matter [11]. The higher the BOD of a water body indicates that the worse the condition of the waters, because the amount of oxygen more required to decompose organic compounds. Measurements of TSS in Penjalin Reservoir ranging from 2,98-3,69 mg.l^{-1}. Water quality including very good level, if value of TSS < 4 mg.l^{-1}; good, if about 4-10 mg.l^{-1}; moderate, if about 10-15 mg.l^{-1}; weak, if about 15-20 mg.l^{-1}; and bad if about 20-35 mg.l^{-1}. This means that the measurement of TSS Reservoir Penjalin including very good.

Cyanophyta require dissolved nutrients such as nitrate and orthophosphate to continue photosynthesis. Nitrate concentration of research in Reservoir Penjalin is 0,34-0,56 mg.l^{-1}. The measurement results showed that nitrate concentrations in reservoir Penjalin still within the normal range and still comply with the Water Quality standard class III that is not more than 10 mg.l^{-1}. The concentration of orthophosphate in Reservoir Penjalin relatively low compared to the concentrations needed without causing blooming phytoplankton [18], is about 0,0062-0,074 mg.l^{-1}. Concentrations of orthophosphate in Reservoir Penjalin still in natural range (< 1 mg.l^{-1}).

b. Structure of Community and Abundance of Cyanophyta in Penjalin Reservoir

Cyanophyta obtained in Reservoir Penjalin as much as three orders of 15 genera and 25 species, with the number of species in each research station ranges from 1 to 8 species (Table 3).

Table 3. Abundance of cyanophyta in penjalin reservoir

No	Species of Fitoplankton	Station I	II	III	IV	V	VI	Σ	RA (%)
Class Cyanophyceae									
Ordo Chroococcales									
1	*Aphanocapsa sp.*	-	21,48	-	-	-	-	21,48	0,285
2	*Aphanocapsa delicatissima*	64,47	32,23	-	-	21,48	42,98	161,16	2,142
3	*Aphanocapsa elachista*	10,74	85,97	150,44	64,47	53,98	118,55	484,15	**6,436**
4	*Chroococcus dispersus*	-	53,73	-	-	-	-	53,73	0,714
5	*Chroococcus giganteus*	-	-	214,91	-	-	128,95	343,87	4,571
6	*Chroococcus turgidus*	-	32,23	-	128,95	-	-	161,18	2,142
7	*Coelosphaerium dubium*	-	-	21,48	-	-	-	21,48	0,285
8	*Coelosphaerium naegelianum*	-	-	-	42,98	-	-	42,98	0,571
9	*Gloeocapsa sp.*	-	-	-	21,49	-	-	21,49	0,285
10	*Gomphosphaeria aponina*	-	-	-	21,49	-	-	21,49	0,285
11	*Lyngbya bergii*	-	32,23	-	21,49	-	-	53,72	0,714
12	*Merismopedia elegans*	-	-	64,47	-	-	-	64,47	0,857
13	*Merismopedia minuta*	-	64,47	-	-	21,48	-	85,96	1,142
14	*Microcrosis geminata*	32,23	10,74	85,96	225,66	139,69	75,21	569,49	7,57
15	*Microcystis sp.*	376,11	419,02	569,94	257,9	343,87	495,01	2461,85	**32,726**
16	*Microcystis aeruginosa*	193,42	300,88	290,13	-	342,08	365,36	1491,87	**19,832**
17	*Microcystis flos-aquae*	-	10,74	75,21	42,98	21,48	-	150,41	1,999
Ordo Nostocales									
18	*Anabaena solitaria*	-	-	236,4	-	-	-	236,4	3,142
19	*Aphanizomenon ovalisporum*	21,48	-	-	-	-	-	21,48	0,285
20	*Cylindrospermopsis sp.*	53,72	85,96	182,68	-	-	21,48	343,84	4,571
21	*Cylindrospermum sp.*	107,46	151,14	-	-	32,23	64,47	355,3	4,723
Ordo Oscillatoriales									
22	*Oscillatoria sp*	-	-	214,91	-	-	-	214,91	2,856
23	*Oscillatoria limosa*	-	-	-	-	-	10,74	10,74	0,142
24	*Oscillatoria spledida*	-	-	10,74	-	-	-	10,74	0,142
25	*Trichodesmium erythreum*	107,41	-	-	10,74	-	-	118,15	1,57
Total of Individual Per Station		967,04	**1300,82**	**2117,33**	838,16	976,31	**1322,77**	7522,45	100
Total of Species Per Station		9	13	12	10	8	9		
Community Structure									
Abundance		967,04	1300,82	2117,33	838,16	976,31	1322,77	7522,43	
Diversity		1,758	1,995	2,15	1,828	1,532	0,7	9,963	
Dominance		0,2106	0,18182	0,13702	0,1999	0,2923	0,00905	7532,393	

Cyanophyta obtained with relatively high abundance in the research included in the order Chroococcales: *Microcystis* sp (32,72%) and *Microcystis aeruginosa* (19,83%) (Table 4.2). Based on these data, the species that found to have high abundance is largely a species of Microcystis. Differences in the two species *Microcystis* sp. and *Microcystis aeruginosa* are the cells in *Microcystis* sp. compactus in regular colonies, whereas the cells on *Microcystis aeruginosa* arranged in an irregular colonies [12]. The cause rapid growth of Microcystis is a high temperature and high concentration of nutrients, especially nitrates. Microcystis generally dominate the freshwater in the temperature range 25^0 C. In addition, predation on Microcystis tend to be low because it has a slime, making it less favored by aquatic organisms [13].

Cyanophyta division consists of only one class that is Cyanophyceae and divided into four orders: Nostocales, Chroococcales, Chamaesiphonales, and Oscillatoriales [14]. Chroococcales is the order of the most commonly found in the waters of the reservoir Penjalin, which consists of 13 species of 28 species were found. In addition, four species are included in the order Nostocales, 8 orders are included in orders Oscillatoriales, and not found a species of the order Chamaesiphonales (Table 4.2) Order Chroococcales have a cell morphology in the form of non-filament, sometimes forming a pseudofilamenteus, unicellular or colonial, cell size of 1,5-3 µm, sometimes motile cells. Members of the order Chroococcales tends to overflow than the other orders. In contrast to the order Chrooccales, members of the order Nostocales shaped filament of a series of cells with the potential to develop into heterokis at the terminal or intercalary. As Nostocales orders, orders Oscillatoriales shaped filaments and make heterokist when nitrogen is limited [15].

Cyanophyta abundance in Penjalin Reservoirs ranged from 967,04-1322,77 ind.l^{-1} (Table 4.2). Cyanophyta obtained abundant because it is cosmopolitan. Cyanophyta can be found in the clean or polluted waters, salt or fresh water, tapering or lotik waters, waters of lakes, ponds, and reservoirs. Inorganic nutrient needs at Cyanophyta much lower than other divisions thus enabling more and more species of this division that can take advantage of the nutrients and result in high abundance [2]. Many of the species Cyanophyta can grow well in Indonesia, including the tropical country for warm climates throughout the year [12].

c. Relationship between Abundance of Cyanophyta and Water Quality in Penjalin Reservoir

The abundance of phytoplankton will change on many levels as a response to changes in environmental conditions that include biology, physics and chemistry [16]. In this study the alleged abundance of Cyanophyta in Reservoir Penjalin have a relationship with the water chemistry physical parameters which include pH, light penetration, depth, temperature, TSS, TDS, DO, BOD, nitrate, orthophosphate, Total N and Total P. The magnitude relationship between the abundance of Cyanophyta with each of these parameters were then analyzed using the correlation analysis (Table 4).

Table 4. Abundance of cyanophyta in penjalin reservoir

Parameters	Correlation Coefficient (r)	Level of Relationship	Equation
DO	-0,216	Low	Abundance = 1719 - 95 DO
CO_2	-0,211	Low	Abundance = 1335 - 84,6 CO2
BOD	-0,172	Very Low	Abundance = 1223 - 60,9 BOD
COD	0,217	Low	Abundance = 759 + 19,5 COD
TSS	0,181	Very Low	Abundance = 467 + 193 TSS
TDS	**0,455**	**Moderate**	**Abundance = -995 + 41,7 TDS**
Nitrate	-0,024	Very Low	Abundance = 1143 - 81 Nitrate
Orthophosphate	0,046	Very Low	Abundance = 1093 + 819 Orthophosphate
Total N	-0,026	Very Low	Abundance = 1148 - 7,8 Total N
Total P	**0,501**	**Moderate**	**Abundance = 966 + 1087 Total P**

The value of the relationship between the abundance of Cyanophyta with each parameter of chemical physics quality in Penjalin Reservoir with a level of 95% (Table 4.3.) indicates that no parameters are a powerful influence on the abundance of Cyanophyta. Total P and TDS have a fairly moderate level of relationship with the abundance of Cyanophyta (r = 0,40 – 0,70). The DO, CO2 and COD have a fairly low level of relationship with the abundance of Cyanophyta (r = 0.20 to 0.40), while the BOD, TSS, nitrate, orthophosphate, and total N has a very low level of relationship with the abundance of Cyanophyta, with correlation coefficient values <0.20, so it can be interpreted that the changing levels of BOD, TSS, nitrate, orthophosphate and total N give a weak influence on the abundance Cyanophyta.

The relationship between the abundance of Cyanophyta with TDS in Penjalin Reservoir indicated by the value of the correlation coefficient (r) of 0.455, meaning that the relationship obtained from the TDS with an abundance of Cyanophyta fairly moderate and have a positive relationship, which means any increase in the levels of DO will be followed by the increasing abundance of Cyanophyta. The relationship between the abundance of Cyanophyta with Total P indicated by the value of the correlation coefficient (r) of 0.501, meaning that the relationship Total P with an abundance of Cyanophyta fairly moderate and have a positive relationship means that any increase in the levels of total P will be followed by the increasing abundance of Cyanophyta.

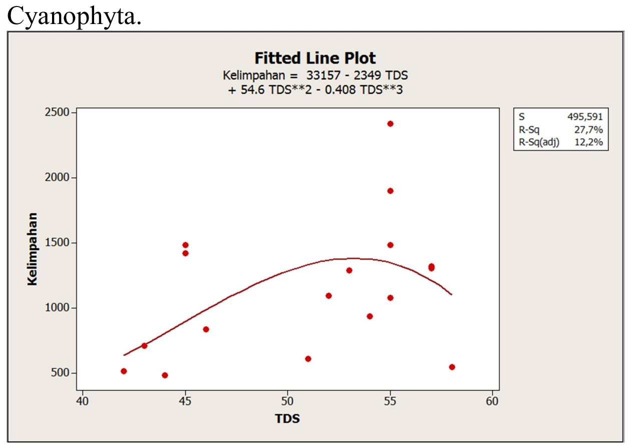

Diagram 1. Relationship between TDS and Abundance of Cyanophyta

Based on statistical test to the regression model showed that the best model to show the relationship between TDS with an abundance of Cyanophyta is the cubic regression model, with the following equation:
Abundance = 33157 – 2349 TDS + 54,6 TDS^2 – 0,408 TDS^3, R^2 = 20,67%

R^2 values of 20.67% means that the abundance of Cyanophyta influenced by the levels of TDS with a significance level of 20.67%, while as much as 79.33% influenced by other factors. This mean that the concentration of TDS will affect aquatic organisms, in particular the levels of nutrients contained in TDS such as nitrate and orthophosphate [3]. Based on the plot, the abundance of Cyanophyta will increase on the TDS levels ranged from 42 to 53, after which it will decline to TDS levels that more than 53.

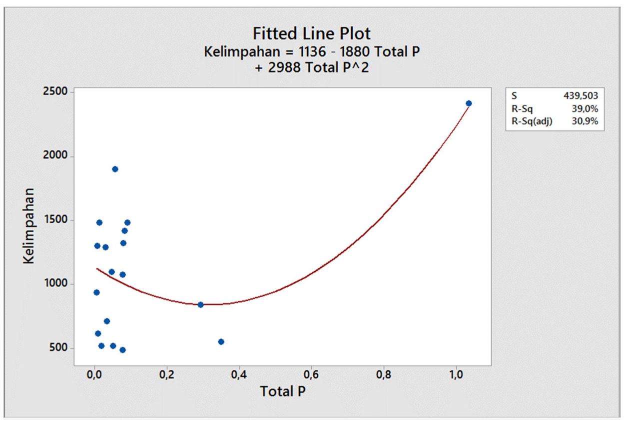

Diagram 2. Relationship between Total P and Abundance of Cyanophyta

The best model to show the relationship between Total P with an abundance of Cyanophyta is the quadratic regression model, with the following equation: Abundance = 1136 – 1880 Total P + 2988 Total P^2, R^2 = 25,15%

R^2 values of 25.15% means that the abundance of Cyanophyta is influenced by the level of Total P with a significance level of 25.15%, while as much as 74.85% influenced by other factors. Based on the plot, Cyanophyta abundance will descend on the level of Total P ranged from 0 to 0.3, after which it will increase the level of Total P more than 0.3.

Based on Table. 4 it can be concluded that the parameters that are considered to have an influence on the abundance of Cyanophyta is TDS and Total P, so we need a multiple regression analysis to determine how much influence the TDS and Total P to the abundance of Cyanophyta.

Table 5. Abundance of cyanophyta in penjalin reservoir

r	R^2	Adjusted R^2	Standard Error
0,61	37,89%	0,296	443,632

Model	*Coefficients*	*Standard Error*
Abundance	-701,541	957,915
TDS	33,448	19,067
Total P	919,706	450,938

The results of the correlation analysis between the levels of TDS and Total P with an abundance of Cyanophyta is moderate with a correlation coefficient (r) 0.61. The reliability of the data indicated by the coefficient of determination (R^2) 37.89%. It means that both parameters affect the abundance of Cyanophyta amounted to 37.89% and the remaining 62.11% influenced by other factors.

Based on Table 5., the results of the regression analysis is shared between TDS and Total P with an abundance of Cyanophyta presented in a multiple linear equation: Y = -701,5 + 33,4 (TDS) + 919,7 (Total P)

The positive direction of the relationship between these two variables can be defined if the concentration of each parameter in the waters of growing will be followed by the increase in the abundance of Cyanophyta. If that happened was a negative relationship, then the opposite is true and abundance decreases with increased levels of negative parameters [17]. The equation obtained explained that the increase of 1 unit of TDS and Total P will raise Cyanophyta abundance of
251.6ind.l^{-1}(-701,5+33,4+919,7= 251,6).

CONCLUSION AND SUGGESTION

a. Conclusions

Based on the results and discussion we concluded :

1. The quality of water in Penjalin Reservoirs is still in good range and worth it for the life of organisms present in the reservoir under PP 82 of 2001.
2. Abundance of Cyanophyta in Penjalin is about 967,04-1322,77 ind.l-1. Value of Diversity Index is about 0,7-2,15 shows that diversity of Cyanophyta is moderate, and the dominance index value of 0.009-0,29 shows that none of species that dominate.
3. The abundance of Cyanophyta in Penjalin Reservoir influenced by the parameters of the TDS with a correlation coefficient of 0.45 and Total P with a correlation coefficient of 0.50, presented in a multiple linear equation: Y = -701,5 + 33,4 (TDS) + 919,7 (Total P). These two parameters together affect the abundance of Cyanophyta amounted to 37.89% and the remaining 62.11% influenced by other factors.

b. Suggestion

Suggestion can be given to people who were around Penjalin Reservoir and reservoir managers is the need to control the activity around the reservoir and reducing waste disposal into reservoirs to prevent rising levels of TDS and Total P as a determinant of Cyanophyta abundance. Suggestions for the researchers is the need for further study of the TDS and Total P in order to secure the reservoir Penjalin of Cyanophyta blooming.

REFERENCES

[1] Graham, L.E. & Wilcox. 2000. *Algae.* New Jersey: Prentice Hall Inc

[2] Kumar, H.D. & Singh. 1979. A Textbook of Algae. New Delhi: Affiliated East-West Press PVT Ltd.

[3] Basmi, J., 1988. Planktonologi : Chrysophyta– Diatom. Bogor : Fakultas Perikanan dan Ilmu Kelautan Institut Pertanian Bogor

[4] Effendi, H., 2003. Telaah Kualitas Air Bagi Pengolahan Sumberdaya Hayati Lingkungan Perairan. Yogyakarta : Kanisius

[5] Rumhayati, B. 2010. Studi Senyawa Fosfat dalam Sedimen dan Air Menggunakan Teknik Diffusive Gradien in Thin Films. Jurnal Ilmu Dasar, 11 (2) :160-166.

[6] Sachlan, M. 1972. Planktonologi. Jakarta: Correspondence Course Centre, Direktorat Jenderal Perikanan, Departemen Pertanian

[7] Davis, L.H., 1955. The Marine and Freshwater Plankton (Terjemahan). Semarang : Badan Penerbit Universitas Diponegoro.

[8] Wetzel, R.G. & Likens, G.E., 1995. Limnology Analyses. New York : Springer Verlag.

[9] APHA, 1992. Standard Methods For The Examination of Water and Waste Water. 16th ed. Washington DC : AWWA.

ISBN: 978-602-60569-5-5

[10] Standar Nasional Indonesia (SNI), 1991a. Air dan Air Limbah : Metode Pengujian Kadar Silika dalam Air dengan Alat Spektrofotometer secara Molibdatsilikat. Jakarta : Badan Standardisasi Nasional.

[11] Brower, J.E. & Zar, J.H., 1977. Field and Laboratory Methods for General Ecology. New York : W.M.C. Brown Comp. Publising Co. Inc.

[12] Prihantini, N.B., Wardhana, W. Hendrayanti, D. 2008. Biodiversitas Cyanobacteria dari Beberapa Situ/Danau di Kawasan Jakarta-Depok-Bogor, Indonesia. Makara, Seri Sains, 12 (1): 44-54.

[13] Ramirez, J. & Bicudo, C.E.M. 2005. Diurnal and Spatial Dynamics of Nutrients in Four Sampling Days in Tropical Shallow Reservoir and Their Relationship with the Phytoplankton Community. Braz. J. Biol, 65 (1): 41-57.

[14] Vashishta, B. 1999. Algae Part 1. New Delhi: Chand Company.

[15] John, D.M. & Whitton, B.A. 2002. The Freshwater Algal Flora of The British Isles: An Identification Guide to Freshwater and Terrestrial Algae. United Kingdom: Cambridge University Press.

[16] Reynold, C.S. 1993. The Ecology of Freshwater Phytoplankton. Cambridge: Cambridge University Press.

[17] Hasani, Q. & Enan, M.A. 2012. The Relationship between The Harmful Algal Blooms Phenomenon with Nutrients at Shrimp Farms and Fish Cage Culture Sites in Pesawaran District Lampung Bay. Jurnal Makara Sains, 16 (3), pp 183-191.