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Plankton Community Structure as Bioindicator Trophic Status of Jatigede Reservoir Waters

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Abstract Jatigede Reservoir in Sumedang Regency is a land mass planning designed as a multi-function reservoir. The main water source for this reservoir is from Cimanuk River, which flows through Garut Regency, and has many industrial activities around the river flow. This research was conducted to assess the trophic status of water pollution in Jatigede Reservoir by utilizing plankton as a bioindicator agent. Samples were collected from 9 observation stations from November 2018 until January 2019. The results showed that 26 species of phytoplankton from 7 divisions including *Dinophyta, Cyanophyta, Chlorophyta, Chrysophyta, Euglenophyta, Bacillariophyta*, and *Charophyta* was found in Jatigede Reservoir at about 461 ind/m^3. Zooplankton abundance of 6 species from 2 divisions of *Rotifera* and *Copepoda* at 2 ind/m^3. The average phytoplankton diversity index was 0.93 and zooplankton diversity index was 0.23. The average phytoplankton evenness index was 0.44 and zooplankton evenness index was 0.24. The average dominance of phytoplankton was 0.58 and dominance of zooplankton was 0.25. Based on the plankton community structure, the trophic status of Jatigede Reservoir was classified to moderate polluted (*eutroph*) to heavily pollutants (*hypereutroph*). The dominant species was *Perinidium* sp from Dinophyta division.

Introduction

Jatigede Reservoir is a public land area located in Sumedang Regency, West Java Province. This reservoir project was inaugurated in August 2015 and fully operated in 2017. The main function of this reservoir is as a flood controller, irrigation and hydroelectric power plants.

Jatigede Reservoir is very potential for fisheries activities. However, fish farming in Floating Net Cages (FNC) is not recommended by the local government. Allowed activities is general aquaculture (*restocking*), fishing, and ecotourism. However, many communities around the inundation area are doing fish farming in FNC, even though it is illegal.

As a general plot land, natural conditions and some utilization activities by the community, Jatigede Reservoir is quite vulnerable to pollution. The amount of nutrient load which entered by the water flow and finally trapped in the reservoir have an opportunity for the eutrophication process. Increasing nutrient in waters can cause from both outside and inside the ecosystem as well as organic matter decomposition, nutrients regeneration by zooplankton, and entered waste by the water flow (Garno, 2019; Agustini and Madyowati, 2014). Therefore, Andani *et al.* (2017) explained that the quality of Jatigede Reservoir water is needed to be monitored.

Eutrophication is a process of nutrient enrichment especially nitrogen and

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phosphorus which can directly or indirectly affect plankton and other aquatic biota that contaminated by eutrophic reservoirs (Serafim *et al*., 2010). The presence of plankton in reservoir water is affected by trophic conditions of the water. So that plankton can be used as an indicator of the eutrophication process in water (Astirin and Setyawan, 2000; Thakur *et al.*, 2013). The step in monitoring water nowadays are developed by utilizing the presence of aquatic biota, namely *biomonitoring* or *bioindicator (Sidi et al*., 2018; García *et al*., 2018; Setyono, 2008). One of the most widely used aquatic biotas as a bio indicator is plankton. The phytoplankton community can be used as an indicator of the ecological conditions of the water (Effendi *et al*., 2016).

Plankton is a water organism that was firstly introduced by Victor Hensen in 1887, which was later refund by Haeckel in 1890, plankton can function as a medium in determining the condition of a processing environment. The abundance and diversity of plankton can be used as an indicator of water fertility (Chankaew *et al.,* 2015; Perbiche-Neves *et al*., 2016; Gabilondo *et al*., 2018). Plankton also plays an important role in the energy supply of the food chain cycle in one ecosystem due to the function of phytoplankton as the primary producers in food chain networks in aquatic ecosystems.

The presence of plankton is greatly determine the reservoir ecosystem. Plankton abundance provides the opportunity for the growth and development of fish biota in aquatic habitats. Moreover, the presence of plankton is also influenced by the water quality and the level of water pollution. Thus, regarding the important benefit of plankton as a bioindicator and biomonitoring, this study was aimed to determine the level of water pollution of Jatigede Reservoir based on the plankton community structure analysis, including the abundance, diversity index, evenness index, and dominance index. The results obtained are expected to provide an overview of the water condition as the approach materials to optimize and manage the sustainable reservoir ecosystem.

Materials and Methods

The study was conducted in Jatigede Reservoir, Sumedang Regency on November 2018 until January 2019 by survey method. Samples were collected from nine observation stations based on purposive sampling following the supply flow of water (Figure 1).

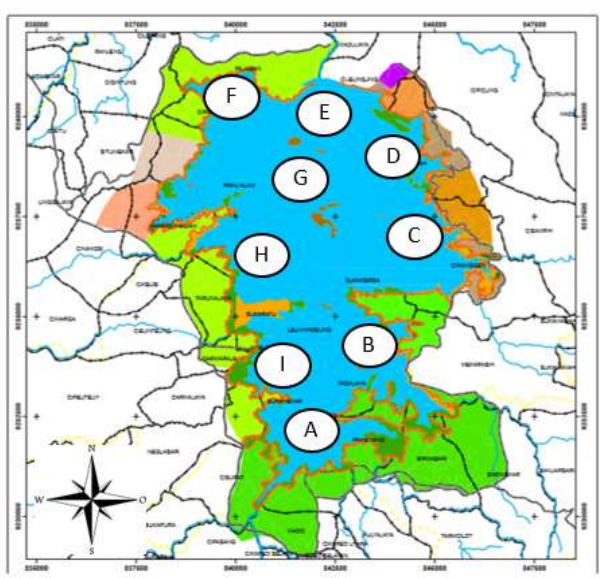

Figure 1. Observation station in Jatigede Reservoir

A Station : 6°55’32,9”S,108°5’46,8”T, Cimanuk River estuary area (*inlet).*

B Station : 6°54’57,5”S,108°6’23,5”T, the body area of Jatigede Reservoir which crossed by the Cacaban River.

C Station : 6°53’56”S,108°7’16,2”T, the body area of Jatigede Reservoir which crossed by the Cinambo River.

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D Station	:	6°52'11,8"S,108°6'47,1"T, the body area of Jatigede Reservoir which crossed by the Cijeunjing River.
E Station	:	6°51'47,4"S,108°5'47,7"T, the *outlet* area *t* of Jatigede Reservoir.
F Station	:	6°51'47,4"S,108°5'47,7"T, the body area of Jatigede Reservoir which crossed by the Pajagan River.
G Station	:	6°51"33,1"S,108°4'12,2"T, the middle area of Jatigede Reservoir.
H Station	:	6°53'47,8"S,108°4'44,2"T, the body area of Jatigede Reservoir which crossed by the Pajagan Cipaku River.
I Station	:	6°54'57,5"S,108°5'44,1"T, the body area of Jatigede Reservoir which crossed by the Pajagan Cibogo River.

Procedures

20 liters of total water samples were taken using plastic buckets from ± 5-50 cm depth then filtered using plankton nets (50 µm mesh). 10 ml of filtered water sample was put into a labelled sample bottle. The sample then preserved using 4% formalin solution (Suhenda, 2009) and tightly closed. The sample bottles were temporarily stored in the cool box during the trip. The water analysis was carried out in the Water Quality Laboratory of Water Resource Management, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Bandung.

Plankton abundance (N) was analyzed using *Sedwich Rafter Counting Cell* method (Novia *et al*, 2016). Plankton abundance was calculated based on the formula:

$$N = (Oi/Op \times Vr/Vo \times I/Vs \times n/p)$$

where: N = Number of plankton, Oi = Area of glass cover preparation (mm^2), Op = Area of one field of view (mm^2), Vr = Volume of filtered water (ml), Vo = Volume of water observed (ml), Vs = Volume of filtered water (l), n = Number of plankton in the entire field of view, and p = Number of fields of view observed.

Plankton diversity index (H') is calculated using the *Shannon-Wiener Index* based on (Fedor dan Spellerberg, 2013) with the formula:

$$H' = -\sum_{i=1}^{n} Pi \ Ln \ Pi$$

where: H'= species diversity index; Pi= relative abundance species, n= the number of species.

The evenness index is determined by the following formula:

$$E = \frac{H'}{Hmax}$$

where E= evenness index, H'= species diversity index, Hmax= Ln S (S= total number of species).

The Dominance Index (D) is determined by the following formula:

$$D = \sum_{i=1}^{n} (Pi)^2$$

where: D= species dominance Index, Pi= relative abundance of species. Dominance index values range from 0–1 (Novia *et al.*, 2016), if D is close to 1 (one), that means there is a dominant species, whereas if D close to 0 (zero), that means no dominant species.

Results and Discussion

Plankton Composition and Abundance

The results of the identification sample from nine observation stations obtained the abundance of phytoplankton and zooplankton as described in (Table 1). Jatigede Reservoir

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had 26 types of phytoplankton species from 7 divisions i.e. *Dinophyta*, *Cyanophyta*, *Chlorophyta*, *Chrysophyta*, *Euglenophyta*, *Bacillariophyta*, and *Charophyta* and 6 zooplankton species from 2 divisions, i.e. *Rotifera* and *Copepoda*.

Table 1. Plankton Abundance in Jatigede Reservoir

Species (individual/m³)	Observation Station								
	A	B	C	D	E	F	G	H	I
Phytoplankton									
Dinophyta									
Peridinium sp	1,410	307	347	242	58	55	40	149	604
Ceratium sp						26		1	
Cyanophyta									
Merismopodia sp	4	3				3			2
Oscillatoria sp					21	4	2	1	
Nodularia sp					3	1		6	3
Mycrosytis sp	1				8			2	
Phormidium sp		1			6	4	1	1	
Lyngbia sp		1	2	1	3				
Coelosphaerium sp		3	3	1	4				
Chlorophyta									
Staurastrum sp		2	9	16	20	7	8	8	13
Coelastrum sp			1				56		
Chamaesiphoncofervicolus sp	2	1					1	1	
Tetraedronlobatusvar sp								1	3
Gonatozygon sp	1	2							
Cosmarium sp		1			3				
Chrysophyta									
Tribonema sp	16		1					6	5
Gyrosigma sp	3	3				1	2	1	
Euglenophyta									
Euglena sp	1		3			5	6	2	13
Bacillariophyta									
Synendra sp		3	17	9	17	6	58	59	13
Nitzschia sp	5	41	2	1	6	3	8	21	
Amphora sp	1			2					
Fragilaria sp	4					3			
Navicula sp	5	107	61	25	80	7	11	17	25
Mastogloia sp		1			3				
Charophyta									
Closterium sp					1	1	2		
Arthrodesmus sp					3				
Total abundance	**1,453**	**476**	**446**	**297**	**236**	**126**	**195**	**276**	**681**
Zooplankton									
Rotifera									
Keratella sp	2	1						2	
Brachionus sp	4	1	1					1	
Filinia sp	1							2	1
Polyarthra sp	1								2
Copepoda									
Cyclops sp								1	
Naupli sp								1	
Total abundance	**8**	**2**	**1**	**0**	**0**	**0**	**0**	**7**	**3**

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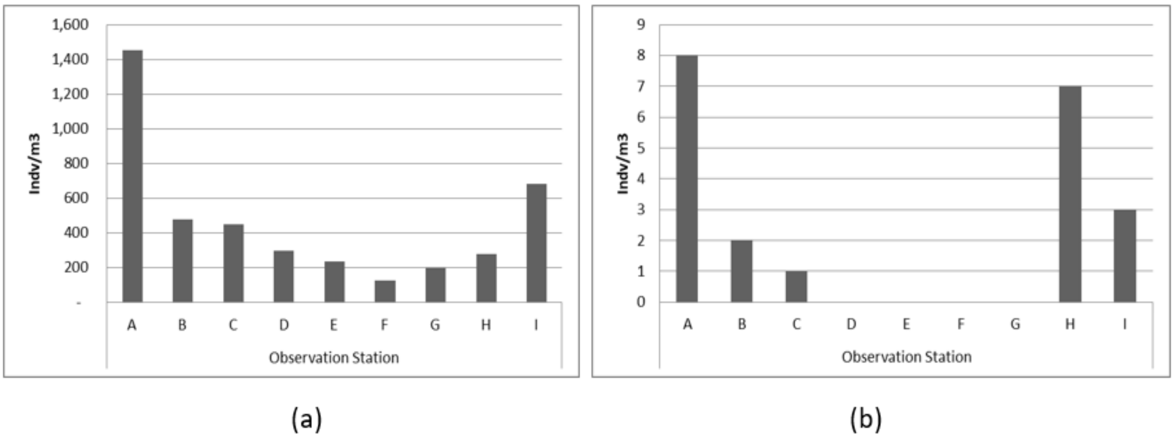

Figure 2. The mean value of phytoplankton abundance (a) and zooplankton abundance (b) in each observation station

The highest abundance of phytoplankton was found in A station at 1,453 individuals/m^3, while the lowest abundance was in F station at 126 individuals/m^3. Phytoplankton abundance in A station was higher than others (Figure 2). A Station is the inlet area (estuary) of Cimanuk River which is the main water supplier of Jatigede Reservoir.

Zooplankton abundance ranged from 0–8 individuals/m^3. The highest abundance was found in A station, and the lowest was in D, E, F, and G station (Figure 2). The species of zooplankton during observation are composed of *Karatella* sp, *Branchionus* sp, *Filinia* sp, and *Polyarthra* sp involved in Rotifera divisions, as well *Cyclops* sp and Naupli sp involved in Copepoda divisions (Table 1).

Diversity Index

Plankton diversity index (H') in each station showed a low value (Table 2). The average diversity index of phytoplankton was ranged from 0.53–1.62, while the zooplankton diversity index was 0–0.76. The highest phytoplankton diversity index value was in E station, while the lowest was in I station. The highest zooplankton diversity index value was in A station, while the lowest was in B, C, and I stations.

Based on Diversity index (Figure 3), water characteristics in Jatigede Reservoir had low plankton diversity. Categorization level of diversity was referring to Augusta and Evi (2014), if the index value of H'<1 is categorized in low diversity, 1<H'<3 is categorized in moderate diversity, and H'>3 is categorized in high diversity. The level of plankton diversity shows the level of water pollution. If H'>2 indicates that the pollutant has not been polluted, H' of 1.6–2.0 indicates the level of mild pollution, H' of 1.0–1.5 indicates the level of moderate pollution, and H'<1 indicates the level of heavy pollution (Astirin and Setyawan, 2000). Based on the plankton diversity index, the water type of Jatigede Reservoir was categorized in moderate level of pollution (*eutroph*) to heavily pollution (*hypereutroph*ic).

Table 2. Mean Value of Phytoplankton and Zooplankton Diversity Index in Jatigede Reservoir

Mean	Observation Station								
	A	B	C	D	E	F	G	H	I
Phytoplankton Diversity Index	0.90	0.55	0.58	0.62	1.60	1.27	1.25	1.09	0.53
Zooplankton Diversity Index	0.76	0.32	0.00	-	-	-	-	0.73	0.28

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Table 3. Mean Value of Phytoplankton and Zooplankton Evenness Index in Jatigede Reservoir

Mean	Observation Station								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Phytoplankton evenness Index	0.41	0.25	0.31	0.39	0.71	0.55	0.61	0.48	0.27
Zooplankton evenness Index	0.82	0.46	0.00	-	-	-	-	0.46	0.41

Evenness Index

Data showed that the phytoplankton evenness index value E<1 (Table 3). The mean value of phytoplankton evenness index in each station was A (0.41), B (0.25), C (0.31), D (0.39), E (0.71), F (0.55), G (0.61), H (0.48), and I (0.27). The highest phytoplankton evenness index was in E station, and the lowest was in B station (Table 3). The highest zooplankton evenness index was found in A station (0.82), and the lowest index at B, C, H, and I stations.

The zooplankton evenness index at D, E, F, and G stations are 0 (zero). This is because during the research at the station there were no zooplankton species found. This condition indicates that influenced by water flow factors and the water in C, D, F, E, and G stations were highly polluted. So there were not able to provide the good carrying capacity for zooplankton growth and breeding.

Based on the observations in each station, the water characteristic of the Jatigede Reservoir has diverse plankton evenness index. Low phytoplankton evenness categories are found in B, C, D, and I stations, the medium phytoplankton evenness at A, F, and H stations, while phytoplankton evenness is high at E and G stations. Low categories zooplankton evenness index is found at C station, medium categories at B, H, and I stations, and high categories at A station. According to opinion Augusta and Evi (2014), if the evenness index 0–0.4 was categorized in low category, evenness 0.4–0.6 is medium category, and value 0.6–1.0 is high evenness category. If the evenness index value is low, most likely in the waters, there was indicates a dominant species (Sulawesty and Suryono, 2017).

Dominance Index

The dominance index of plankton in Jatigede Reservoir was ranged between 0–0.77 (Table 4). Phytoplankton dominance index in stations A (0.62), B (0.74), C (0.72), D (0.67), E (0.27), F (0.49), G (0.42), H (0.51), and I (0.77). The highest phytoplankton dominance index was found in I station at 0.77 and the lowest was in E station at about 0.27. The highest zooplankton dominance index was in C station at about 0.50 and the lowest was in H and I station at about 0.07 and 0.09.

The dominance index value (D) at about 0–1. If D value is close to 1 (one), it indicates a dominant species, whereas if it close to 0 (zero), it indicates no dominant species (Novia *et al.*, 2016; Fachrul *et al*., 2016). The mean of phytoplankton dominance index (Figure 3) in A, B, C, D, H, and I stations were close to 1 (one). This was indicated by the dominant presence of *Perinidium* sp in the water. The dominance of a plankton species illustrated that the water condition was unstable, and it can cause negative impact on the water quality (Utomo *et al*., 2011).

Table 4. Mean value of Phytoplankton and Zooplankton dominance index in Jatigede Reservoir

Mean	Observation Station								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Phytoplankton Dominance Index	0.62	0.74	0.72	0.67	0.27	0.49	0.42	0.51	0.77
Zooplankton Dominance Index	0.44	0.39	0.50	-	-	-	-	0.07	0.09

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Peridinium sp has the highest abundance in almost all observation stations. The highest abundance of *Peridinium* sp was found in A station at 1.410 individuals/m^3, while the lowest abundance was in G station at 40 individuals/m^3. The abundance of *Perinidium* sp was obtained on January, this was assumed because of the rainy season. The high nutrient load that entered from Cimanuk River during the rainy season provides high nutrients for *Perinidium* sp growth in Jatigede Reservoir.

Peridinium sp is a Dinophyta division phytoplankton organism, it well known as Dinoflagellate (Samudra *et al*., 2013). *Peridinium* is one of phytoplankton which is frequently found and predominantly grew in tropical lake water (Rengefors and Legrand, 2001). *Peridinium* can be toxic and harmful to other organisms and able to inhibit the growth of other plankton. So that, it can cause the blooming *Perinidium* species in the water.

The presence of *Peridinium* in Jatigede Reservoir must be controlled. Data showed that this organism could grow and develop in all observation stations. This condition can be indicated that all areas of Jatigede Reservoir are potential for the growth and development of *Peridinium* sp. The dominance of *Peridinium* was assumed to be one of the inhibiting factors for the growth and development of other types. Therefore, the density of other phytoplankton was low and not evenly distributed. The dominance condition of *Perinidium* was explained as an indicator that Jatigede Reservoir water is unstable. This was in line with Djoko *et al.* (2011), the dominance of one species indicates that the water is less stable less stable waters. If a species bloom occurs, it will cause negative impact on the water quality.

Synendra sp and *Navicula* sp are another major species which found in Jatigede Reservoir waters. Members of *Euglenophyta* and *Bacillariophyta* division was evenly distributed in almost every observation station. The density of *Synendra* and *Navicula* were 20 and 37 individual/m^3, respectively. *Synendra* and *Navicula* were highly adapted in Jatigede Reservoir water.

The finding of *Microcystis* sp is an indication that the water need to be controlled. The member of Cyanophyta division is one of the species which categorized as toxic plankton (Utomo *et al*., 2011; Krismono *et al*., 2009). Although the mean density was only 1 individual/m^3, but this toxic type can cause nerve paralysis (Lindon and Heiskary, 2009). Thus, the presence of *Microcystis* needs serious attention.

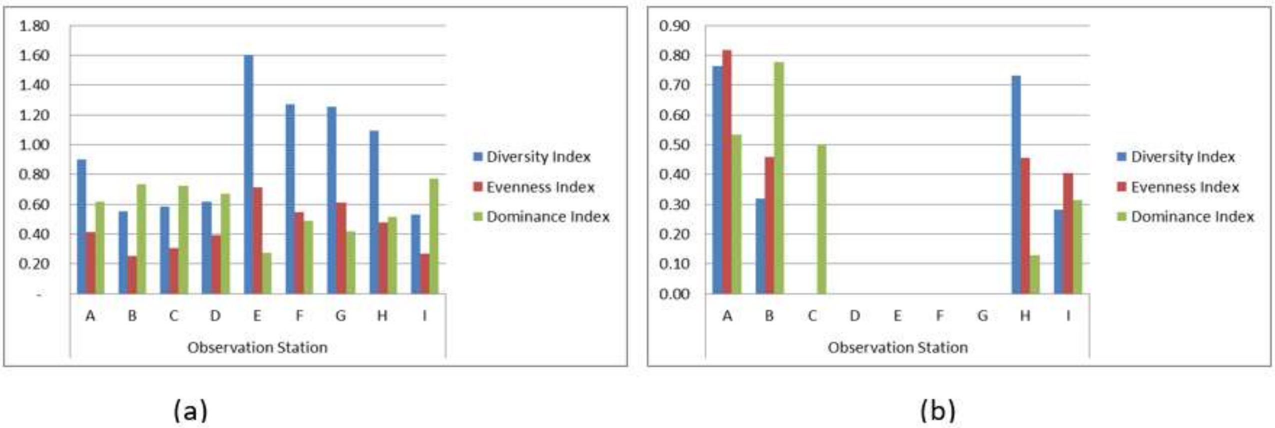

Figure 3. Diversity index, evenness index, and dominance index of phytoplankton (a), diversity index, evenness index, and dominance index of zooplankton (b)

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The distribution of zooplankton abundance in the Jatigede Reservoir is not evenly distributed. This can be seen by the unpresented of zooplankton species in D, E, F, and G stations. The highest zooplankton distribution was found in A station at 7 individuals/m^3, composed of *Keratella* sp, *Brachionus* sp, *Filinia* sp, and *Polyarthra* sp species. The lowest distribution was found in C station with 1 species i.e. *Brachionus* sp. *Cyclops* sp and *Naupli* sp were the lowest zooplankton species distribution, at only 1 individual/m^3 which found in H station.

Brachionus sp was the most found organism of zooplankton community. This indicated that *Brachionus* sp was highly adapted than other types of zooplankton. The presence of *Brachionus* is one of the great eutrophic indicators in the water (Sousa *et al.*, 2008). In line with opinion Saksena (1987) which explained that the types of *Branchionus* and *Caratella* from Rotifers are the indicators that indicates the quite fresh water (*mesotrophy*). Based on the distribution of zooplankton which showed low abundance with uneven distribution indicated that the water in Jatigede Reservoir was in unstable condition. The Water with low plankton abundance is categorized as oligotrophic water (Rizky *et al*., 2018).

Physical-Chemical Quality of Water

Water is medium for the growth and development of plankton and another aquatic biota in the reservoir water ecosystem. Plankton, can properly grow and develop and it requires the optimum physical and chemical characteristics of water. The unoptimum condition of water quality both physics and chemical can cause fish and other aquatic biota living under pressure, migrating, and even experiencing death (Makmur, 1884).

The physical and chemical characteristics of Jatigede Reservoir water during the research have been identified. Water temperature ranges from 27–31°C, acidity (pH) 8.0–9.0, brightness 25–85 cm, dissolved oxygen (DO) 6.3–8.2 mg/liter, ammonia 0.01–0.88 mg/liter, Nitrite 0–0.08 mg/liter, Nitrate 0.1–1.6 mg/liter, Phosphate 0.1–0.2 mg/liter, and Biological Oxygen Demand (BOD) 5.0–14.6 mg/liter. The water temperature slightly exceeds the maximum threshold, but it still considered feasible for plankton growth. This is in accordance with Effendi (2003) which explains that the optimum temperature range for phytoplankton growth is 20–30°C. Acidity pH of water exceeds the maximum threshold.

Based on the brightness value, the water of Jatigede Reservoir was categorized in hypereutrophic water. Data showed that the brightness value was over the maximum threshold range. The brightness value during the study is in line with the low abundance and diversity of plankton in Jatigede Reservoir. The brightness plays an important role in determining the characteristics of fish habitat and phytoplankton (Augusta and Evi, 2014). Thus, the brightness value of the result observation which reach 85 cm shows that the condition can not optimally support the plankton life. According to KemenLH (2009), the default brightness values of reservoir waters at ≥10 meter is belonging to oligotrophic water.

The value of oxygen solubility in the water shows that Jatigede Reservoir was not polluted. This is in accordance with Astirin & Setyawan (2000), suggest that the water is categorized as not polluted which has the DO values at >6.5 ppm. The minimum limit of the oxygen in water is 6 mg/liter including the category of first-class (Anonymous, 2001). Based on DO values, Jatigede Reservoir is classified as non-polluted water type (*oligotrophic*).

Based on an established criteria (Anonymous, 2001), free NH_3 value for fishing activities with sensitive fish species is ≤0.02 mg/liter. The minimum standard value for

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first-class waters is 0.5 mg/liter. The data of ammonia in Jatigede Reservoir is ranged from 0.1 to 0.8 mg/liter, this shows that the range was in the category of first-class water or classified as clean water type. Unlike Astirin and Setyawan (2000) which explain the range of NH_3 value at 0.1–0.8 mg/liter is classified in lightly polluted water.

Phosphorus (phosphate) and nitrogen (nitrate) elements are the main inorganic substances which needed as a food chain for growth and development of fiphytoplankton (Simanjuntak, 2009; Sagala, 2009). Low phosphate and nitrate content in water supported by low plankton abundance, it indicates that the water is in infertile conditions (Sagala, 2012). Referring to the Republic of Indonesia Government Regulation Number 82 of 2001, the phosphate value in Jatigede Reservoir is close to the first and second-grade water quality, and the BOD value show that the water is close to the third class quality standard. First class water quality category is a type of water that can be used for drinking water raw materials, while second and third class water quality is a type of water that can be used for recreational (tourism), fish farming, livestock and irrigation facilities (Anonymous, 2001). Based on the physical and chemical parameters, the water of Jatigede Reservoir is classified as non-polluted (*oligotrophic*) to mild (*mesotrophic*) water.

Conclusions and Suggestion

Jatigede Reservoir water have 26 types of phytoplankton species from 7 divisions i.e. *Dinophyta*, *Cyanophyta*, *Chlorophyta*, *Chrysophyta*, *Euglenophyta*, *Bacillariophyta*, and *Charophyta* with the abundance value at 461 individuals/m^3. The abundance of zooplankton is low at 2 individuals/m^3 which consist of 6 species from 2 divisions i.e. *Rotifers* and *Copepods*. The mean of phytoplankton diversity index is 0.93, while the zooplankton diversity index is 0.23. The mean of phytoplankton evenness index is 0.44, while the zooplankton index is 0.24. The mean of phytoplankton dominance index is 0.58 and zooplankton dominance index is 0.25. Based on the plankton community structure of Jatigede Reservoir, the water is classified in *eutrophic* category to *hypereutrophic* with *Perinidium* sp as the dominant plankton species.

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