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Research Article

Evaluation of the Conditions of Mamberamo River Water with Biomass and Phytoplankton Community Approach

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Abstract

Mamberamo River in Papua Province, that is a place of livelihood for the surrounding population, has a high biodiversity. This study aimed to provide information about the condition of the waters in the Mamberamo River by using biological and chemical parameters, namely community and phytoplankton biomass and chlorophyll-a content. The method used in determining the location was purposive random sampling based on differences in microhabitat that conducted in February, March, August, and October 2016. Phytoplankton observations were carried out through the method of sweeping Sediment Rafter (SR), and phytoplankton biomass obtained from chlorophyll-a. The results of this study showed three classes of phytoplankton were found, namely Bacillariophyceae, Chlorophyceae, and Cyanophyceae. The highest class of abundance was found in the river such as Bacillariophycea Chlorophyceae, and Cyanophyceae respectively. The chlorophyll-a concentration of phytoplankton biomass ranged from 2.01-548.73 mg/l and equation obtained from regression analysis between abundance and chlorophyll-a content was y = 1.2206 x – 0.7702 with a coefficient of determination r = 0.68. It could be concluded that the high phytoplankton biomass had a positive relationship with the chlorophyll-a content and the condition of the waters of the Mamberamo River is still categorized as good with good water fertility of the Mamberamo River is still classified as good category with good water fertility.

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1. Introduction

Mamberamo river is located at the south of Foja Mountain, Sarmi District, Papua Province. This river has an absorption area of 138,877 km² with depth range between 8 to 33 m (Chairunisa, 2013). The people of Mamberamo area were quite scarce with only 7,000 lives. In general, the people in this area are highly dependent on natural resources. The absorption area of about 90% in Mamberamo river is still forests inhabited by residence with small scale farming, hunting, and fishing activity (Boissiere, 2004).

According to Richards and Suryadi (2003), Mamberamo river has a really high biological diversity (flora and fauna) in which some of them are endemic species from New Guinea. However, the area around Mamberamo river currently suffers from threat of the decrease of biodiversity by its status of Special Autonomy according to the Constitution of the Republic of Indonesia No. 21 Year 2001 that was made by the People's Representative Council of the Republic of Indonesia (DPR RI).

The river banks environment includes abiotic and biotic components that interact with each other through current, energy, and nutrient. However, if this interaction is interrupted, there will be changes or disruption that cause imbalanced ecosystem (Soylu and Gönülol, 2003). According to Sugiarti *et al.* (2015), physical and chemical parameter measurements can only describe temporary environment quality, meanwhile biological parameters can continuously observe and can be served as an indicator to pollution.

Sastrawijaya (2000) stated that water pollution can decrease species diversity because each organism has inhabited the area for a considerable amount of duration or even have permanently inhabit it. The plankton or periphytons is usually used by organism group for observation of water quality changes or declines. The existence of planktons in waters may provide information regarding the waters' quality. Phytoplankton plays as the primary producer (Lacerda *et al*., 2004) and zooplankton as the consumer. The existence condition whether it's physical, chemical, or biological. Chlorophyll-a can be utilized as an indicator of phytoplankton abundance, and also the organic potency of a body of water (Arinardi *et al*., 1996). Meanwhile, phytoplankton abundance is related to natural cycle of nutrients, two of which are nitrate and phosphate input. Nitrate and phosphate are primary inorganic nutrients needed by phytoplankton to grow and develop, meanwhile other nutrients are needed in relatively small amounts because its effects on productivity are not as significant as nitrate and phosphate. Composition and abundance of the phytoplankton can be used as a productivity indicator of a body water (Ardiwijaya, 2002). The information regarding river waters condition around Papua area including Mamberamo river was quite scarce, therefore, this research aimed to find out the quality of Mamberamo river water based on community, biomass of phytoplankton, and its relation to nutrients

2. Materials and Methods

2.1 Data Collection Method

This research was carried out in February, May, August, and October 2016 at Mamberamo river, Papua province. The research locations were comprised of four stations namely Kali Merah, Kerumi, Telaga, and Sungai Putus (Figure 1). The location was decided through purposive sampling (Hadiwigeno, 1990) and this research had different habitat of each station (Table 1).

Phytoplankton samples were taken from those tributaries with amount of 10L, each of 5 repetition at a depth of ± 1m by using plankton net number 25 with 60µm mesh size. Furthermore, the samples were put into 100 ml bottle and preserved with ± 1ml 1% lugol solution. The observation was carried out with the *Sedweight Rafter* (SR) method by using inverted microscope on 200 folds magnification. Phytoplankton samples were identified according to a guide by Mizuno (1979).

The nutrients analyzed in this research were ammonia (N-NH), nitrate (NO), nitrite (NO), and total phosphate of phytoplankton as a biological parameter to observe the quality (Table 2), and the fertility of a water body (Farichi *et al*., 2013; Indrayani *et al*., 2014; Wijaya and Hariyati, 2012; Prabandani, 2002), and also to find out the changes within the waters caused by the imbalance in ecosystem due to pollution (Ekwu and Sikoki, 2006: Oxborough and Baker, 1997).

2.2 Data Analysis

Phytoplankton abundance was calculated based on Lackey Drop Microtransect Counting method (APHA, 1995) with the following formula:

$$N = n \times A/B \times C/D \times 1 / E$$

Where:

N = phytoplankton abundance (cell/l)
n = average individual count on observation field
A = cover glass area (mm²)
B = one observation field area (mm²)
C = concentrated water volume (ml)
D = water drop volume (ml) under the cover glass
E = filtered water volume (l)

Table 1. Research station on Mamberamo river

Station Name	Coordinates	Description
Kali Merah	S 03°44,37,8' E 140°18,55,5'	Tributary area of Mamberamo river, river width of 30 m, red-blackish water.
Kerumi	S 03°44,389' E 140°17,882'	Mamberamo river tributary area, river width of 7m, depth less than 1.5 m, brownish water. Plenty of trees surrounding.
Telaga	S 03°43,984' E 140°18,192'	Water's type: dead river. Only on high tide it connects with the main river. Crystal clear and surrounded with trees, sunlight penetration at minimum.
Sungai Putus	S 03°42,861' E 140°16,799'	Mamberamo river tributary area, a dead river, connects with main river on high tide.

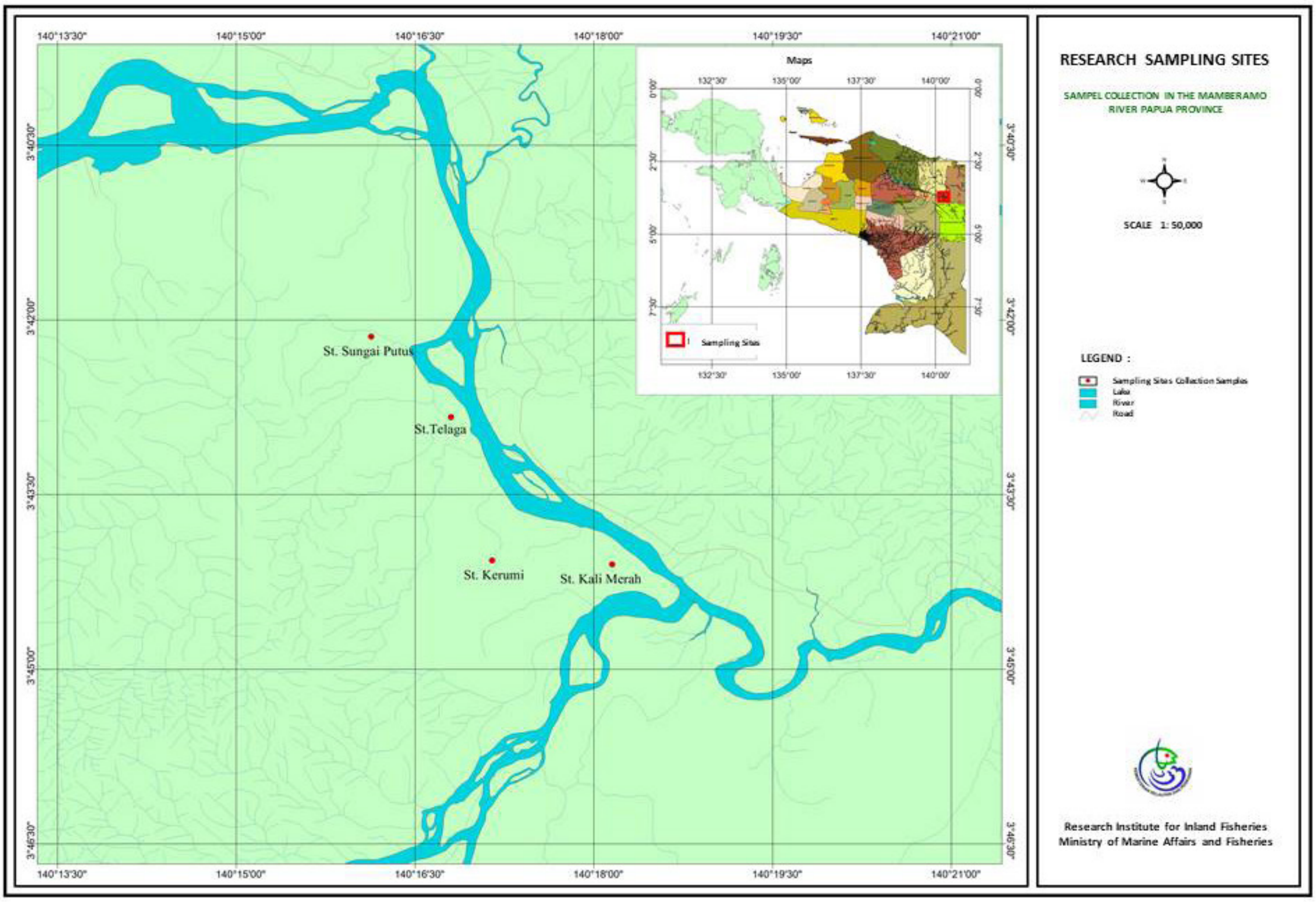

Figure 1. Research location map, Mamberamo river, Papua province

A total of 1L water samples for each nutrient analysis and chlorophyll-a taken from the surface of the water was put into the bottle, wrapped into an aluminum foil for chlorophyll-a only, then stored in a cooler box. Furthermore, the samples were carried out and analyzed at the laboratory of Research Institute for General Aquatic Fisheries, and Fisheries Extension in Palembang.

Table 2. Nutrient anlayzed at Mamberamo river

Nutrient	Analysis method
Ammonia (N-NH_3)	Fenate
Nitrate (NO_3)	Brusinsulphanylate
Nitrite (NO_2)	Sulphanylamide
Total phosphate (TP)	Ascorbic acid

Chlorophyll-a content was measured with spectrophotometer, and calculated with the following equation by APHA (1995):

Ca = 11.85 (OD664) – 1.54 (OD647) –0.08 (OD630)

$$\text{Chlorophyll-a} = \frac{(\text{Ca x Extract volume})}{(\text{Sample volume})}$$

Where:

- Ca : chlorophyill-a concentration in extract (mg/m^3)
- Extract volume: extract sample volume after dissolved in acetone (ml)
- Sample volume: filtered water volume(l
- OD664,OD647,OD630: absorbance value on 664, 647, and 630 nm wave length after sub extraction by absorbance value on 750 nm wave length.

Phytoplankton biomass determination was done through the chlorophyll-a approach.This is because chlorophyll-a is the primary photosynthesis pigment on all plants. (Asriana and Yuliana, 2012). Phytoplankton biomass calculation was done using chlorophyll-a based on its empirical relation with phytoplankton abundance (Rahman *et al*.,2016). Marker *et al*. (1980) stated that phytoplankton biomass is obtained from chlorophyll-a content conversion according to the following formula:

B = 67 x Ca

Where:

B = phytoplankton biomass (mg/m^3)

Ca = chlorophyll-a content (mg/m^3)

Nutrient impacts on phytoplankton biomass was calculated through regression analaysis with the statistic software, “8”.

3. Results and Discussion

3.1 Phytoplankton Composition

There were three classes of phytoplankton that had been found, namely Chlorophyceae (12 genera), Bacillariophyceae (18 genera), and Cyanophyceae (4 genera) (Table 3). The composition is in the Cyanophycaee class (Figure 2).

The result showed that the highest abundance of Phytoplankton was in August at Kerumi station with 608 cell/l, meanwhile the lowest abundance was at Telaga station with 420 cells/l (Figure 3).

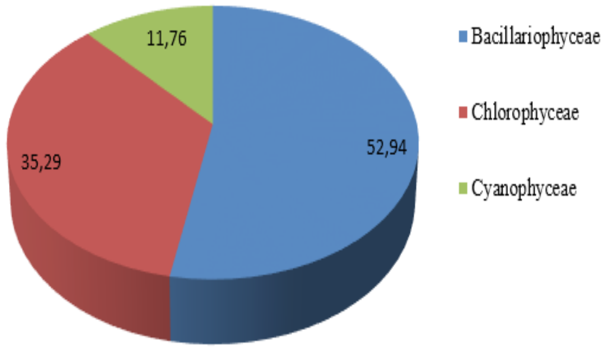

Figure 2. Phytoplankton class percentage in Mamberamo river

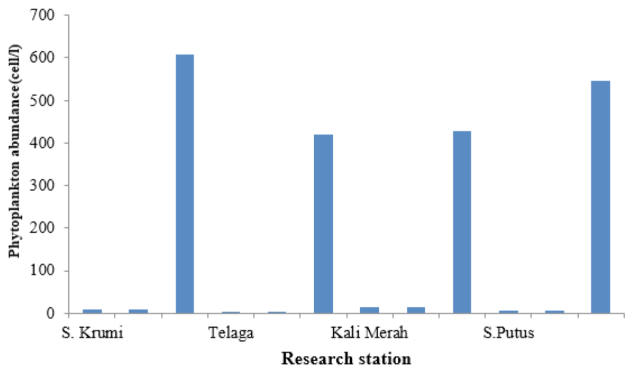

Figure 3. Phytoplankton abundance in Mamberamo river

According to the observation and calculation result, the highest phytoplankton biomass value was recorded in February and the lowest was in August (Figure 4).

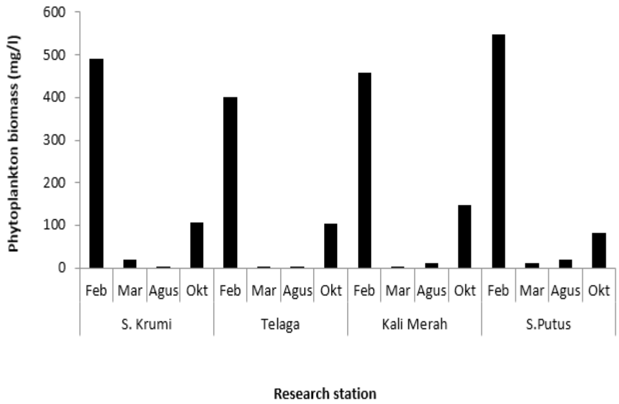

Figure 4. Phytoplankton abundance and biomass in Mamberamo river

According to the result, chlorophyll-a in February was not higher compared to other months (Table 4).

3.2 Water Quality Parameter

The observed water quality parameters were none other than NH_3, NO_2, NO_3, and TP which all contained

N and P element.

3.3 Relation between Abundance and Water Quality Parameters

Parameters Nitrate (NO_3) is one of the most important nutrients for the growth of phytoplankton and algae, this is because the content of nitrate and phosphate has a good effect on the growth of phytoplankton or algae (Fried *et al.,* 2003, Niu *et al*., 2015). These elements are very easy to dissolve in water and have stable properties, this is resulted from the oxidation process of nitrogen compounds in the water; while the phosphate content will decrease in dark conditions. Wetzel (2001) stated that optimal phytoplankton growth occurs where high phosphate and nitrite content are nitrogen sources for growth. According to research by Daniel *et al.* (2009), an aquatic ecosystem contains a lot of nutrients and can show that the N and P boundaries can change seasonally or spatially. Based on the observations, the highest abundance was Kerumi station and lowest was Telaga station with Element N and Elemental values which were still in the good category for phytoplankton life (Figure 6)

3.4 Relation between Chlorophyll-a and Phytoplankton Abundance

Phytoplankton, one of the organisms that exists in water, plays a role as a converter of inorganic substances into organic substances through the process of photosynthesis. The photosynthesis process requires chlorophyll and the content of chlorophyll-a can be used as an indicator of the high and low productivity of a water (Roshisati, 2002). The content in photosynthetic pigments in the sample water will describe the phytoplankton biomass in a water area. Chlorophyll is a pigment in phytoplankton and autotrophic organisms and is a pigment that is directly involved in the process of photosynthesis. Arifin (2009) stated that the composition of the type of phytoplankton affects the chlorophyll content in waters. Thus, the concentration value or content of chlorophyll-a in phytoplankton is influenced by other aquatic physio-chemical and biological factors. The relation between Chlorophyll-a and Phytoplankton abundance provides linear regression correlation (Figure 7). Thus, the value of phytoplankton is directly proportional to its chlorophyll content.

.**Table 3.** Class and genera of phytoplanktons in Mamberamo river

Class	Genera		
Chlorophyceae	*Ankistrodesmus*	*Mougeotia*	*Pleurotaenium*
	Cladophora	*Oedogonium*	*Spondylosium*
	Closterium	*Oscillatoria*	*Staurastrum*
	Cosmarium	*Pediastrum*	*Ulothrix*
Bacillariophyceae	*Biddulphia*	*Diploneis*	*Nitzschia*
	Coconeis	*Epithemia*	*Pinularia*
	Coscinodiscus	*Eunotia*	*Pleurosigma*
	Cyclotella	*Fragilaria*	*Surirella*
	Cymbella	*Gyrosigma*	*Synedra*
	Diatoma	*Navicula*	*Tabellaria*
Cyanophyceae	*Aphanizomenon*	*Microcystis*	*Spirulina*
	Gomphossphaeria		

Table 4. Chlorophyll-a value (mg/l) in each observation station in Mamberamo river in 2016

Location	February	May	August	October
Kerumi	7.31	0.28	0.03	1.6
Telaga	5.98	0.06	0.06	1.23
Kali Merah	6.84	0.03	0.18	2.19
Sungai Putus	8.19	0.18	0.28	1.57

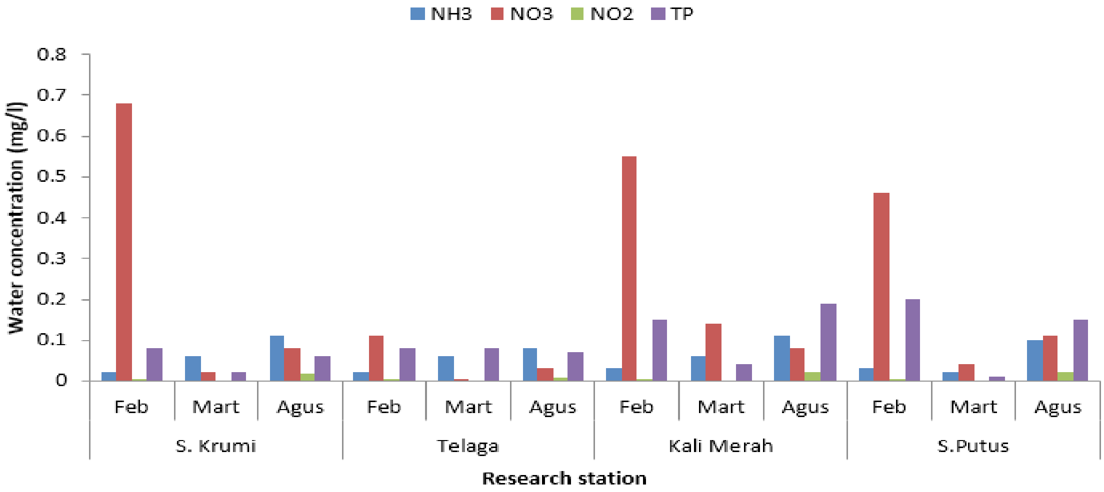

Figure 5. Concentration value for NH3, NO2, NO3 and TP parameters for each month of observation on Mamberamo river.

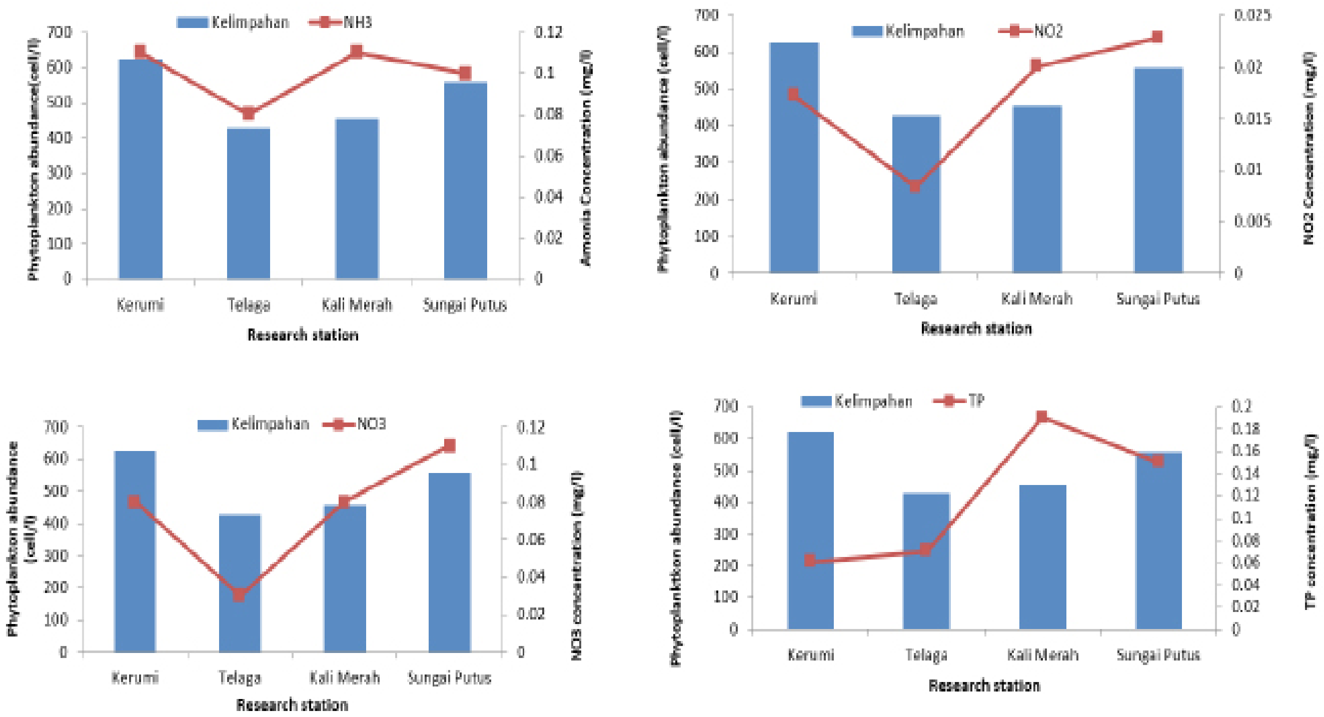

Figure 6. Relation between abundance and nutrients in Mamberamo river.

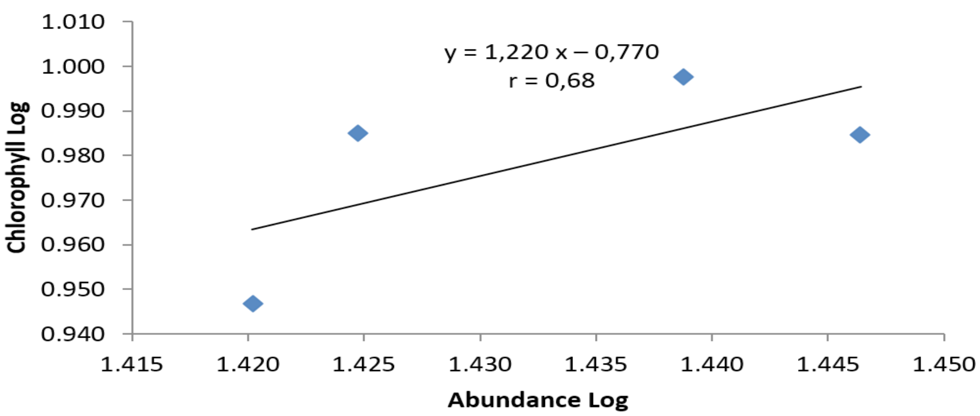

Figure 7. Relation between chlorophyll-a content and phytoplankton abundance in Mamberamo river

Research found three classes of phytoplanktons namely, Chlorophyceae (12 genera), Bacillariophyceae (18 genera), and Cyanophyceae (4 genera, Table 3). Setiawan *et al.* (2018) with their research on phytoplankton habitat in Lenggang river, East Belitung, had found six classes, namely Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, and Xantophyceae. The highest composition was Bacillariophyceae class with 52.94% and lowest was Cyanophyceae of 11.76% (Figure 2). According to Nybakken (1992), Bacillariophyceae is able to grow rapidly despite of minimum illumination and nutrients. This was supported by researches stating that the highest composition of phytoplankton was Bacillariophyceae class (Setiawan *et al.*, 2018; Adani *et al.*, 2013; Irawati, 2013; Usman *et al.*, 2013). This is due to their great adaptabilities to reproduce in higher number compared to other phytoplankton. Phytoplankton of the Bacillariophyceae class was found in abundance due to uniqueness in all parts of a water body (A'Ayun, 2015).

The observation carried out in February, May, and August showed highest abundance of the Bacillariophyceae class, followed by Chlorophyceae and Cyanophyceae (Figure 2). Dwirastina and Makri (2014) stated that Bacillariophyceae is a phytoplankton class with rapid growth rate and high environmental tolerance. Other than that, according to Adjie *et al.* (2003), Bacillariophyceae is a pervasive algae group in rivers, either in quality or quantity and whether as a plankton or periphyton.

The highest abundance was in August at the Kerumi station with 608 cell/l, meanwhile lowest abundance was at Telaga station, with 420 cell/l (Figure 3). The highest abundance on February and May was at Kali Merah station with 14 cell/l, meanwhile the lowest was at Telaga station with only 4 cell/l. This was because the months of February and May were a rainy season that sped up the river current, meanwhile it was dry in August. High nutrient content of water in February was maybe due to run offs from land carrying nutrients into waters. Lihan *et al.* (2008) stated that the factor affecting organic matter supply into waters is the season. Phytoplankton growth is dependent on nutrient fluctuation, and waters hydrodynamics (Rokhim *et al.*, 2009). Other than that, Ayuningsih (2014) stated that the condition of water affects phytoplankton distribution pattern either vertically or horizontally and also affects the abundance. The abundance value of phytoplankton was low due to rapid currents river and rocky substrate.

According to Aryawati and Thoha (2011), phytoplankton community abundance in waters is tightly related with nutrient content such as phosphate, nitrate, silicate, and other nutrients. Nutrient content may affect abundance as well as the other way around where abundant phytoplankton will make the waters unfertilized (Adani *et al.*, 2013).

Phytoplankton biomass in Mamberamo river was averaged from 2.01–548.73 mg/l (Figure 4). According to the observation on all four stations, the highest phytoplankton biomass was in February, however, the decline was observed in May and August, and it re-increased in October. According to chlorophyll-a data obtained from each station, February had the highest chlorophyll-a value, followed by October, but declined in May and August (Table 4). The fluctuation content of chlorophyll-a might be due to its close relationship with nutrient supplies from the land through river current heading towards its waters. This research was supported by Zulhaniarta *et al.* (2015) and Sihombing *et al.* (2013) which stated that chlorophyll-a produced from breech zone averaged around 5.10-6.32 mg/m^3 and it was more commonly found near the land.

Aryawati *et al.* (2014) stated that chlorophyll-a content in certain waters is highly dependent on nutrient availability and sunlight intensity. If the nutrient and sunlight intensity is high, chlorophyll-a concentration will be higher as well, vice versa. The presence of photosynthetic pigment, namely chlorophyll-a, in water sample illustrates phytoplankton biomass in waters. Chlorophyll-a content in each phytoplankton depends on its type, therefore phytoplankton type composition determines the chlorophyll-a content in the water. Research by Aryawati and Thoha (2011) stated that phytoplankton abundance affects chlorophyll-a content. According to a research in Bangka strait water, the chlorophyll-a content was classified low (0.00315-0.15753 mg/m^3) compared to research by Prianto *et al.* (2013) where it ranged from 0.786-12.274 mg/m^3. Meanwhile, Sihombing *et al.* (2013) stated that phytoplankton chlorophyll-a content is about 5.10-6.32 mg/m^3 and the research in Natuna had chlorophyll-a estimate of around 0.92-5.39 mg/m^3 (Fitriya *et al.*, 2011). Furthermore, chlorophyll-a research in Beraru, East Borneo ranged from 0.19-4.24 mg/m^3 (Aryawati and Thoha, 2011). These varied values are due to a season difference at the time of sampling and its water's characteristics. Low chlorophyll-a content on research site was due to the plankton's cell itself (Adani *et al.*, 2013). This research is supported by Tambaru (2008) at Tallo river estuary where it was recorded average chlorophyll-a content of 0.2 mg/l on dry season or low tide. Furthermore, Barus (2004) argued that difference in chlorophyll-a content on terrestrial waters was due to upwelling and characteristics of each waters. Hatta (2002) stated that in general, high chlorophyll content in coastal waters was due to high nutrient supply from land through rivers. On the contrary, chlorophyll-a content on high seas tended to be lower because there is no supply of nutrient from the land. Although, in some area far from land, there still seems to be those with high chlorophyll content. According to Kunarso (2011), the increase of nutrient will also increase the primary productivity that resulted higher chlorophyll-a content.

Presence of nutrients in waters are vital to the growth of phytoplankton (Reynolds, 1990). According to Welch and Lindell (1992), nutrients like N and P usually serve as the limiting factor in phytoplankton growth in natural waters and can also induce blooming if there is more than needed. Relation between abundance, biomass, and nutrients in Mamberamo river had the same pattern throughout February, May, and August in 2016 (Figure 5). Ammonia concentration in Mamberamo river ranged from 0.02–0.11 mg/l. The highest NH_3 concentration was found in August and relatively low in other months.

Free ammonia concentration value in Mamberamo river ranged 0.005–0.08 mg/l. According to Government Regulation number 20 year of 1990, concerning water pollution, concentration of free ammonia in waters is not allowed to exceed 0.02 mg/l. Free ammonia concentration in Mamberamo river is safe for aquatic organism life (Atminarso *et al*., 2016). Nitrate concentration in Mamberamo river ranged 0.02-0.68 mg/l. Nitrate concentration in February (rainy season) had higher value than in May and August (dry season). This was supported by Sutanto and Iryani (2011) who stated that the increase of nitrate in rain water was caused by high NO_2 concentration in air. Nitrate concentration exceeding 0.2 mg/l might cause eutrophication in waters and boosts algae and aquatic plant growth (Effendi, 2003). Effendi (2003) stated that nitrate concentration value can be used to classify waters fertility level. Therefore, nitrate concentration in Mamberamo river showed good fertility. Average concentration of total phosphate in Mamberamo river exceeds to 0.05 mg/l. This means the fertility level was high. The presence of phosphate in water affects water ecosystem greatly. Kusumangtyas (2017) stated that if phosphate concentration in water is low (<0,01 mg/l), algae growth will be stunted, this condition is called oligotrophic. On the contrary, if phosphate in water was high, algae and aquatic plant growth will not be limited (eutrophic), which reduces dissolved oxygen in water. This can threat aquatic ecosystem sustainability.

According to the result, the highest phytoplankton biomass was in Putus river. High biomass in an area related positively with phytoplankton abundance in its area. This went accordingly with correlation analysis result between phytoplankton biomass and phytoplankton (Figure 6). Linear regression analysis of the dependent variable, chlorophyll-a log, independent variable, and abundance log produced linear regression equation where $y = 1.2206x - 0.7702$ with determination coefficient of r=0.68.

4. Conclusions

According to the research, it was found that there are three classes of phytoplankton, namely Bacillariophycea, Chlorophyceae, and Cyanophyceae. Produced phytoplankton biomass ranged was 2.01-548.73 mg/l. Regression analysis on relation between phytoplankton and chlorophyll-a yielded positive result. Water quality of Mamberamo river was classified as good where the nutrients were sufficient for aquatic life.

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Author Contribution

All authors have contributed to the final manuscript. Contributions of each author are as follows, Mirna D; collected the data, compiled the manuscripts and designed drawings, compiled main conceptual ideas, and revised the article. Dwi Atminarso; helped to revise the map design and was in charge of the activity.

Conflict of interest

The authors state that the research was conducted in the absence of a commercial or financial relationship which could be construed as a potential conflict of interest.

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