

COMMUNITY STRUCTURE AND DIVERSITY OF PHYTOPLANKTON IN LEMUKUTAN ISLAND WATERS, WEST KALIMANTAN

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ABSTRACT

Phytoplankton plays an important role in marine ecosystems as primary producer, as the basis of food chains and the food web, and are widely used as bioindicators to monitor water condition. The study of phytoplankton is the primary interest to explore aquatic resources for blue biotechnology applications in conditions as a live feed, antibacterial, antiviral, antioxidant, pharmaceutical, cosmetics, possibly food and health industry. The study aims to assess the composition, abundance and diversity of phytoplankton community in Lemukutan Island waters of West Kalimantan. The present study found 31 genera of phytoplankton, consisted of *Bacillariophyceae* (28 genera) and *Dinophyceae* (3 genera). In term of contribution, *Bacillariophyceae* were found to be dominant (93.035%) than *dinophyceae* (6.965%). The abundance of phytoplankton varied between 636.91 to 2034.48 cell.L⁻¹. The diversity index (H'), the evenness (E) index, and the dominance (C) index ranged from 1.959–2.579, 0.582–0.868, 0.094–0.283, respectively. The result showed that the diversity index was moderate, the evenness index was high, and the dominance index was low

Keywords: community structure; diversity; phytoplankton; Lemukutan Island Waters.

INTRODUCTION

Phytoplankton plays an important role in marine ecosystems as a primary producers, entrap solar energy by the photosynthesis process and produce organic matters. They are the basis of food chains and food webs which directly provide food for zooplankton, fishes and other aquatic organisms.

Furthermore, phytoplankton are widely used as bioindicators to monitor water conditions, pollution, and eutrophication (Round, 1984; Richardson, 2008). The study of phytoplankton is the primary interest to explore aquatic resources for blue biotechnology applications in aquaculture as a live feed, antibacterial against *Vibrio* sp. and antiviral (Gastineau *et al.*, 2012). Moreover, they are also widely used for the pharmaceutical, cosmetics, possibly food and health industry. Diatoms and dinoflagellates are also known to produce Harmful Algal Blooms (HABs) by releasing toxins into the water. HABs cause both health and economic concerns due to toxins accumulating in fish and shellfish that humans then consume. The occurrence of algal blooms in the waters of Indonesia have been reported. Blooms of *Pyrodinium bahamense* var. *compressum* caused red tide phenomenon in marine environments. Blooms of *Noctiluca scintillans* turns water into green slush off the coast of Jakarta Bay (Nontji, 2006).

The waters of Lemukutan Island has a potential marine resource to explore the phytoplankton abundance. Furthermore, the study of aquatic biological index could be conducted generally from the analysis of the phytoplankton community. A Study about the diversity of epiphytic

microalgae has been done by Herlina *et al.* (2018) in this area. The species composition, abundance, and distribution of phytoplankton in Lemukutan Island waters then must be studied. Thus, the environmental conditions are also an important parameter to be utilized in the growth of phytoplankton. The study aims to assess the composition, abundance and diversity of phytoplankton community, and to evaluate the physico-chemical parameters.

RESEARCH METHODS

Study Area

This study was conducted in Lemukutan Island waters, Bengkayang Regency, West Kalimantan in May 2016. The sample collection was carried out at five stations (Figure. 1) with Station I zone is close to the pier, Station II zone is close to settlements, Station III zone is far from settlements, Station IV is fishery zone and Station V is seaweed cultivation zone.

Sampling of Phytoplankton

Phytoplankton samples were collected using plankton nets with diameter of net mouth 30 cm, mesh size of 30 μ m, and net length 100 cm long (Aquino *et al.*, 2010; Mulyani *et al.*, 2012). One hundred liters of surface water were filtered through a ring type (Brraich and Kaur, 2015)). The concentrated of phytoplankton samples were put into a clean specimen vial bottles of 30 mL, then fixed and preserved with formalin (4%) solution (Edler and Elbrachter, 2010) on the site. The sampling was conducted in three replicates each station. All samples were stored in a cool box and protected from direct light beam (Aryawati *et al.*, 2017) in order to avoid the damage of samples.

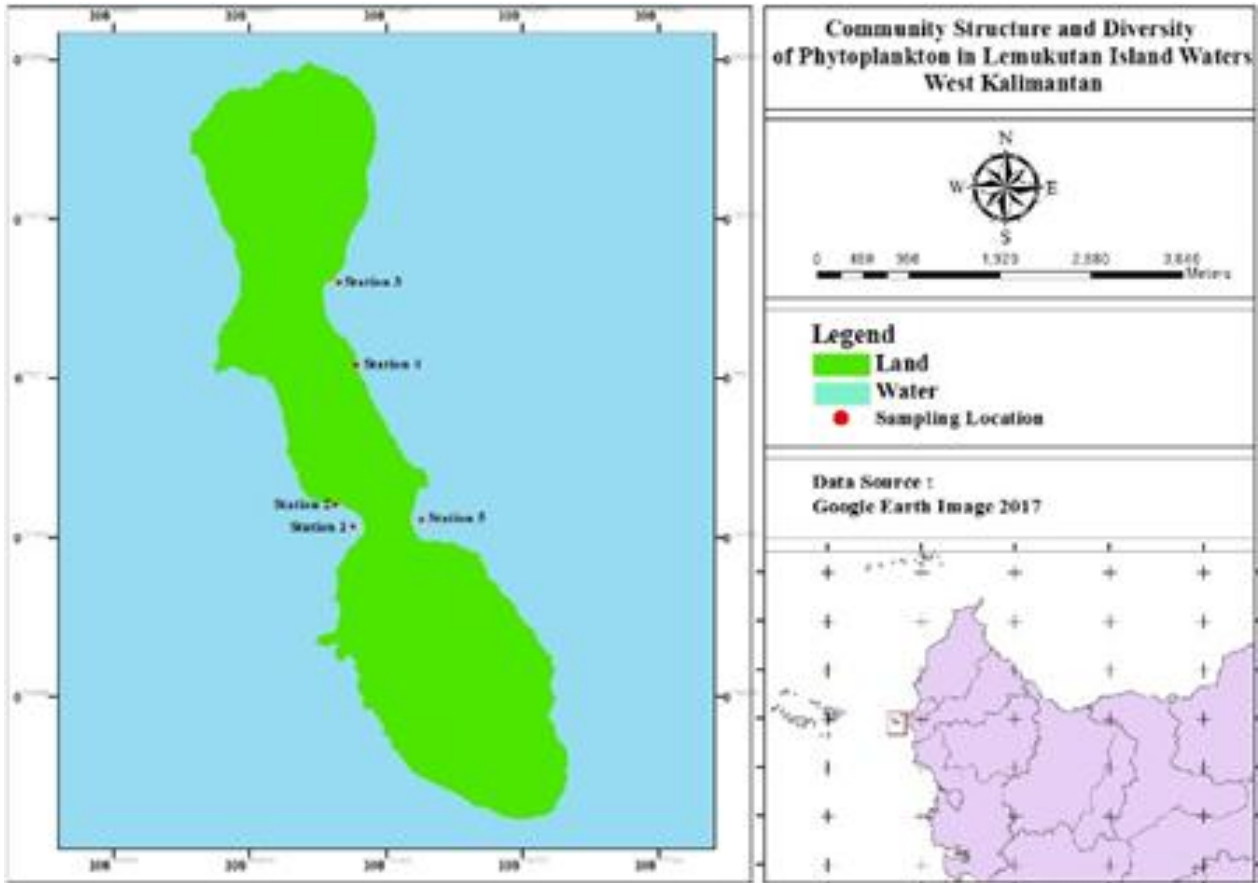


Figure 1. Map of Study Sites in Lemukutan Island waters of West Kalimantan.

Phytoplankton Samples Analysis

The preserved samples were collected and identified in the laboratory. Quantitative analysis of phytoplankton was done by putting one drop of a fixed sample (0.02 mL) on the glass slide (Ganai and Parveen, 2014) and the numerical phytoplankton was carried out with the help of a binocular light microscope. Analysis of their abundance was enumerated using Sedgwick Rafter Counting Chamber and calculated using standard methods (APHA, 2005). The results were expressed in cell.L⁻¹. Samples were identified up to genus level by using the identification textbook of Newell and Newell (1977), Yamaji (1984), Tomas (1996), Tomas (1997), dan Omura *et al.* (2012).

Phytoplankton species diversity index (H') was determined following Shannons-Wiener's formula (Shannon and Wiener, 1969):

$$H' = - \sum pi \ln pi \dots\dots\dots (1)$$

Where, pi = proportional abundance of each species, is given pi = ni/N; ni = number of individuals species i; and N = total abundance of individuals species in a community.

Diversity index illustrate the communities structure and explains the number of species in a coloum waters. The Evenness index (E) was used to determine the pattern of

organisms distribution. This index was calculated following the formula:

$$E = H'/H_{max} \dots\dots\dots (2)$$

Where, H' = species diversity index; H_{max} = maximum possible value of species diversity, is expressed H_{max} = ln S; and S = total number of species of a community. The value of H' could be more than 2, and the increase of H' indicates the greater diversity in a communities.

Odum (1998) proposed that H' < 1 indicates low diversity, 1 < H' < 3 is moderate diversity, and H' > 3 is high diversity. The Shannon-Wiener diversity index proposed that H' > 3 indicates clean water, 1 < H' < 3 is mildly polluted, and H' < 1 is characterized as heavily polluted water (Begon *et al.*, 1986)

The uniformity index ranges from 0 to 1, where the smaller value (near zero) explains the weak of population uniformity, indicating that the spread of each individual from each genus is not the same and there is a tendency of a genus to dominate the population. Otherwise, if the value is closed to 1, the population shows uniformity, indicating that the individual's number of each genus is not much different or could be mentioned the same and there is no a tendency of a genus to dominate the population (Odum, 1998).

The dominance index (C) was calculated by the formula from Odum (1998):

$$C = \sum (ni/N)^2 \dots\dots\dots (1)$$

Where, ni = number of individual species and N = total number of individuals species in the community

Dominance index was used to determine the existence of a certain species dominance in the column waters. The value of this index ranges between 0 to 1, where the value near zero shows that there is no genus that dominates, whereas, the greater value closes to 1 indicates the dominancy of a certain genus in the waters (Odum, 1998).

Physico-Chemical Analysis

Surface water samples were collected from the same site and during the same time of sampling of phytoplankton. The water temperature, pH, salinity were recorded in situ with the help of thermometer, gun (pen) of the pH meter, and refractometer, respectively. The Dissolved Oxygen was fixed and measured on the spot using Winkler’s method (Strickland and Parsons, 1972). The samples were conducted in three replicates. Current velocity was measured by current kite method.

RESULT AND DISCUSSION

Composition and Abundance of Phytoplankton

In a community, a species composition illustrates the diversity of species. During the study period, a total of 31 phytoplankton genera were recorded belonging to two classes, Bacillariophyceae (28 genera) and Dinophyceae (3 genera). The number of total identified genera was varied among the five stations (Table 1).

In Lemukutan Island waters, Bacillariophyceae were found to be dominant and contributed higher of percent contribution (93.035%) than Dinophyceae (6.965%) of the total genera (Fig. 2). Herlina *et al.* (2018) has also recorded the domination of Bacillariophyceae as epiphytic microalgae on the leaves of *Thalassia hemprichii* than other groups in Lemukutan Island. Bacillariophyceae dominate the composition of the phytoplankton in the sea (Nybakken, 1988; Widianingsih *et al.*, 2007; de Wit *et al.*, 2012). Shallow water conditions, high brightness and the presence of nutrient inputs from the surrounding environment provide opportunities for Bacillariophyceae (Purnawan *et al.*, 2016). In addition to environmental factors, household activities also contribute to waste to waters which contain a lot of inorganic compounds nitrogen (N), phosphate (P), ammonia (NH3), nitrate (NO3), and silica (SiO2), where all these inorganic compounds are sources of energy. nutrition for microalgae. Several research results state that the high abundance of the Bacillariophyceae class can be related to the fertility level of a waters (Ayuningsih *et al.*, 2014)

In addition, the number of pennate diatoms was 42.86% and centric diatoms was 57.14%. There was no huge different percentage of these two types of phytoplankton.

Bacillariophyceae (diatoms) are a major group of algae and usually the most common type of phytoplankton in marine water communities. Several studies have observed that diatom

remains dominant and occurs in the highest percentage than other groups (Al. Hassany *et al.*, 2012; Badsy *et al.*, 2012; Ganai and Parveen, 2014; Aryawati *et al.*, 2017). It is well known that the domination of diatom also as a phenomenon in Indonesian waters and it was recorded by several studies (Haumahu, 2004; Haumahu, 2005; Soedibjo, 2006; Fathi and Al-Kahtani, 2009; Rokhim *et al.*, 2009; Amelia *et al.*, 2012; Ismunarti, 2013; Riniatsih *et al.*, 2013; Thoha and Aryawati, 2014; Setiabudi *et al.*, 2016; Sahami *et al.*, 2017; Herlina *et al.*, 2018).

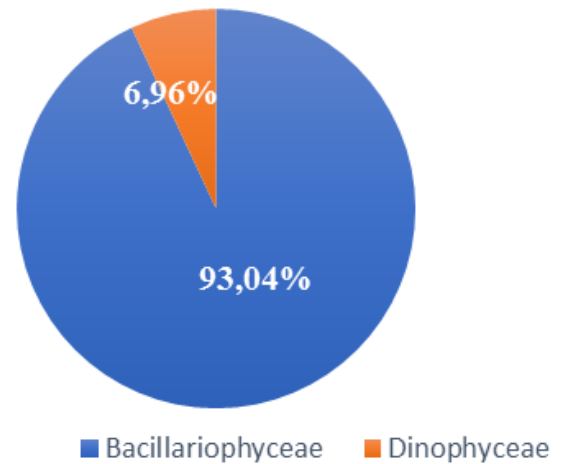


Figure 2. Percentage Contribution of Two Groups of Phytoplankton in The Waters of Lemukutan Island

Diatoms have a crucial role and comprise a major component of primary producers and food web in aquatic ecosystems (Zalewski *et al.*, 1997; Baghela, 2006), high adaptability and tolerance, are able to adapt a wide range of environmental parameters and to be cosmopolite (Arinardi *et al.*, 1997; Rajasegar *et al.*, 2002; Basmi, 2010). Furthermore, this dominance is due to their ability to grow and reproduce in widely changing of salinity, temperature, light intensity, availability of nutrients (N and P) (Lagus *et al.*, 2004; Kasim and Mukai, 2006; Ganai *et al.*, 2010; Ganai and Parveen, 2014). The abundance of phytoplankton was associated with the increased nutrients in the coastal waters (Pednekar *et al.*, 2012).

The abundance of phytoplankton was recorded in the range between 636.91 cells.L⁻¹ (station III) to 2034.48 cells.L⁻¹ (Station II). Seven genera represented by the greater number of abundance than other groups in all stations, such as *Asterionella*, *Biddulphia*, *Chaetoceros*, *Navicula*, *Odontella*, *Thalassionema*, and *Thalassiothrix*. Otherwise, in term of the appearance during the study period, the rare species include *Asterolampra*, *Bacillaria*, *Centronella*, *Dytilum*, *Thalassiosira*, and *Dinophysis* (Fig. 3). The genus *Navicula* (Badsy *et al.*, 2012; Tyokumbur and Okorie, 2013; Ganai and Parveen, 2014) and *Chaetoceros* (Soedibjo, 2006; Thoha, 2013; Aryawati *et al.*, 2017) were common and has been found in a large quantities in most water communities. The temperature and salinity levels were linked to the domination of these groups (Soedibjo, 2007). Moreover, the proliferation of *Chaetoceros* was due to the ability to survive and grow in extreme conditions (Aryawati *et al.*, 2017)

Table 1. Phytoplankton Composition in Lemukutan Island Waters

	Station I	Station II	Station III	Station IV	Station V
Bacillariophyceae					
<i>Amphora</i>	*	-	-	*	-
<i>Asterionella</i>	*	*	*	*	*
<i>Asterolampra</i>	*	-	-	-	-
<i>Bacillaria</i>	*	*	*	*	*
<i>Bacteriastrium</i>	*	*	*	*	*
<i>Biddulphia</i>	*	*	*	*	*
<i>Centronella</i>	*	*	*	-	-
<i>Chaetaceros</i>	*	*	*	*	*
<i>Coscinodiscus</i>	*	*	*	*	*
<i>Dactyliosolen</i>	*	-	*	-	*
<i>Diatoma</i>	*	-	*	*	*
<i>Ditylum</i>	*	*	-	-	-
<i>Guinardia</i>	*	*	*	-	*
<i>Hemiaulus</i>	-	-	-	*	-
<i>Hemidiscus</i>	*	*	-	-	-
<i>Lauderia</i>	*	*	-	*	-
<i>Navicula</i>	*	*	*	*	*
<i>Nitzschia</i>	-	*	*	*	*
<i>Odontella</i>	*	*	*	*	*
<i>Pinnularia</i>	*	*	-	-	*
<i>Pleurosigma</i>	*	*	-	*	-
<i>Pseudo-nitzschia</i>	*	*	*	*	*
<i>Rhizosolenia</i>	*	*	*	*	*
<i>Skeletonema</i>	*	*	-	*	*
<i>Thalassionema</i>	*	*	-	*	*
<i>Thalassiosira</i>	*	-	-	-	-
<i>Thalassiothrix</i>	*	*	*	*	*
<i>Triceratium</i>	*	-	-	-	-
Dinophyceae					
<i>Ceratium</i>	*	*	*	*	*
<i>Dinophysis</i>	*	-	-	-	*
<i>Pyrocystis</i>	*	-	*	*	*
total	29	22	17	20	20

Note: the sign (*) means that the phytoplankton genus is present; the sign (-) means absent

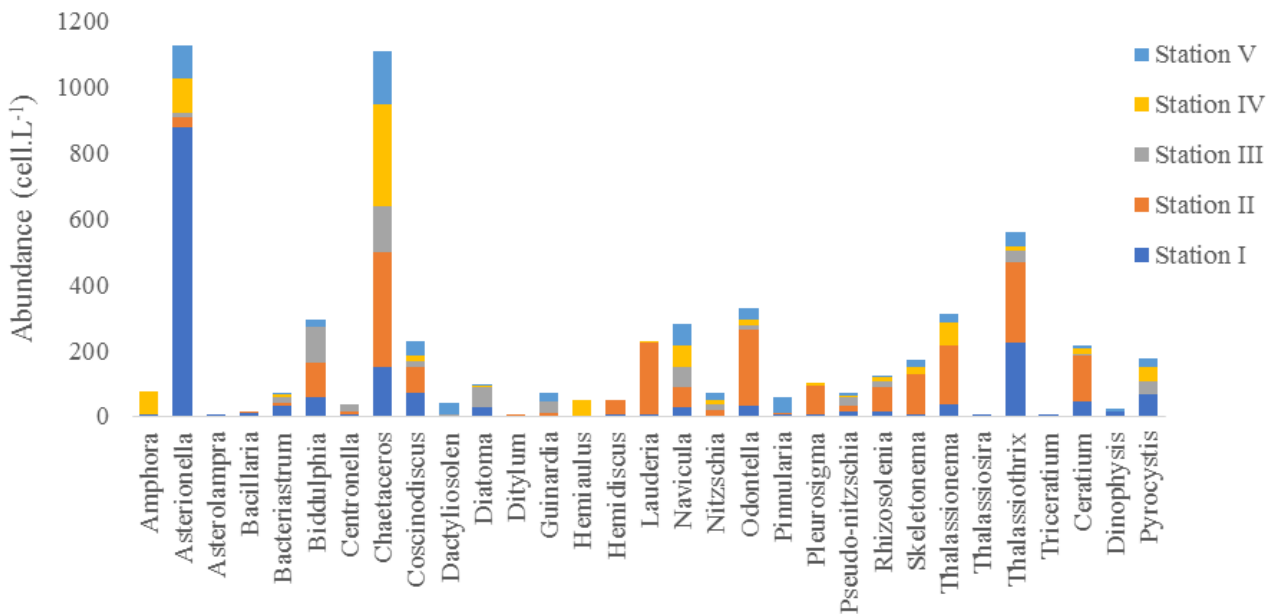


Figure 3. The Abundance (cell.L⁻¹) of Phytoplankton in The Waters of Lemukutan Island

Phytoplankton Diversity Indices

In an aquatic ecosystem, the quantitative abundance of diatoms is a major indicator of water quality and environmental conditions. The diversity indices were utilized in phytoplankton studies to measure biological diversity and determine the pollution status of a water body.

Moreover, the diversity index could be linked to the water conditions. In the present study, the value of H' was higher than 2 (2.245–2.579) in station II, III, IV, and V, although at station I was less than 2 (**Table 2**). Hence, it indicates that Lemukutan Island waters have the more species diversity of phytoplankton with moderate pollution. In addition to settlements, fisheries and seaweed cultivation, Lemukutan Island is also a popular marine tourism destination in West Kalimantan. The source of pollution was suspected from human anthropogenic activities and vessel traffic. Thus, this condition could affect the phytoplankton abundance, thereby affecting potentially the community structure of phytoplankton.

The existence of human anthropogenic loadings (Sellner *et al.*, 2003), domestic sewage, and urban run off (Sen *et al.*, 2013) are the main causative agent that contributed to the rise of nutrient content, which could alter the nutrient supply ratios (Anderson *et al.*, 2002) in coastal waters. An increase of the nutrient concentration - particularly N and P elements - caused the rise of chlorophyll concentration significantly in the water ecosystem (Setiabudi *et al.*, 2016). N and P as an ecological factors that influences the spatial distribution of phytoplankton (Ismunarti, 2013). These two major nutrients are essential for the growth and development of algae to build new biomass (amino acids, lipids, DNA) and Energy (ATP) for metabolisms (Smith, 1982). It could be then

affect phytoplankton species composition and bloom development.

In the Black Sea, an increase in the frequency of phytoplankton blooms is well documented. The enrichment of anthropogenic nutrients has been identified as a key ecological problem and associated with the alterations in phytoplankton structure communities (Moncheva *et al.*, 2001).

Evenness index (E) ranges from 0 to 1 (Odum, 1998), where the smaller value indicates the less of population uniformity, while the value is closed to 1, the population shows uniformity. This study exhibited that the Evenness index varied between 0.582 to 0.868 and was close to 1, where the maximum value was recorded at station III. This Evenness index indicates that the individual's number of each genera is not much different and there is no a tendency of a genus to dominate the population in Lemukutan Island waters. This reflects the equitable abundance of various genera throughout the study periods. In term of water conditions, the month of May is supposed to be a very conducive time for the growth and development of a various type of phytoplankton (Aryawati *et al.*, 2017), with the result that a lot of species can adapt, grow well, proliferate, and develop properly. This condition increases the species richness and abundance.

The value of dominance (C) index ranges between 0 to 1, and was utilized to determine the existence of a certain species dominance in the waters (Odum, 1998). This present study showed that the highest value of C (0.283) was recorded at the station I, while the least (0.094) at station II. In general, the dominance species index in Lemukutan Island waters was near to zero. This condition explained that phytoplankton groups indicate lower dominance or there was no genus that dominates in an aquatic ecosystem

Table 2. Variation of Diversity Indices in Lemukutan Island waters

Index	Stations				
	I	II	III	IV	V
Diversity (H')	1.959	2.579	2.460	2.245	2.574
Evenness (E)	0.582	0.834	0.868	0.749	0.859
Dominance (C)	0.283	0.094	0.113	0.174	0.105

Water quality Conditions in Lemukutan Island Waters

In the present investigation, water sample temperature ranged from 31 to 34 °C, the salinity varied from 30 – 32 ‰, the pH has found to be alkaline (7.92–8.52), the concentration of dissolved oxygen fluctuated between 11.8 to 15.6 mgL⁻¹, and the current speed ranged from 0.35 – 0.4 ms⁻¹. Water temperature is an important physical factor that plays a crucial role and influences the growth and the distribution of species as well as its productivity, community structure, and species abundance. The range of water temperature during the current study showed similarities with some of the Indonesian waters (Padang, 2011; Wibowo *et al.*, 2014; Setiabudi *et al.*, 2016; Aryawati *et al.*, 2017; Sahami *et al.*, 2017) and still optimum for the growth and development of marine biota.

According to the water quality standard, the salinity value that could be tolerated by phytoplankton to support their growth was from 30–33 ‰. During the investigation period, the readings of salinity were typical to the Indonesian seawater with the average 35‰ (Nybakken, 1988) and are approximately similar to the recorded by Padang (2011) in

Desa Suli Beach that ranged 14-30 ppm, Riniatsih *et al.* (2013) at Teluk Awur Jepara was 28-30 ‰, Setiabudi *et al.* (2016) in Pegametan Bay that was around 30.40 ‰, and by Aryawati *et al.* (2017) in coastal water of South Sumatera that reached to 33.05 ‰.

Nybakken (1988) showed that generally, marine water has a pH range from 7.5–8.4. Furthermore, the diatom grows well with the pH alkaline (7–8.5) and phytoplankton exhibits a negative response in acidic conditions (pH<6) (Effendi, 2003).

The concentration of Dissolved Oxygen (DO) in the natural environment represents a balance of the rate of supply and consumption and generally changes (Shams El-Din *et al.*, 2015). During the study period, the dissolved oxygen concentration can support the life of the aquatic organisms. Wibowo (2004) showed that the range of dissolved oxygen between 5 to 8 mg L⁻¹ is an optimum value to support the life of aquatic species.

Current velocity is to be an important parameter related to the distribution of phytoplankton. Current velocity affects the existence and the diversity of species in aquatic

ecosystem. Furthermore, the distribution of phytoplankton is affected by the variation of water flow (Aryawati *et al.*, 2017). The size of phytoplankton that is very small much depends on the movement of water (Romimohtarto and Juwana, 2004). The waters with current rate range between 0.05 to 0.9 ms⁻¹

would be dominated the epiphytic species such as *Nitzschia*, *Navicula*, *Synedra*, *Biddulphia*, *Coscinodiscus* (Riniatsih *et al.*, 2013; Wibowo *et al.*, 2014). In general, the environmental parameter values in Lemukutan Island waters are considered to be suitable for the growth of phytoplankton species.

Table 3. Physico- chemical Parameters in Lemukutan Island Waters

Parameters	Stations				
	I	II	III	IV	V
Temperature (°C)	34	33	32.5	31	34
Salinity (‰)	30	31	30	32	30
pH	8.52	8.08	7.92	7.58	8.41
Dissolved Oxygen (mgL ⁻¹)	12	15.6	13.4	12.4	11.8
Current velocity (ms ⁻¹)	0.4	0.35	0.38	0.4	0.35

CONCLUSION

The study found 31 genera of phytoplankton species, consisted of Bacillariophyceae (28 genera) and Dinophyceae (3 genera). In terms of contribution, Bacillariophyceae were found to be dominant (93.035%) than Dinophyceae (6.965%). The abundance of phytoplankton varied between 636.91 to 2034.48 cell.L⁻¹. The diversity index (H'), the Evenness (E) index, and the dominance (C) index ranged from 1.959–2.579, 0.582–0.868, 0.094–0.283, respectively. The result showed the diversity index was moderate, the Evenness index was high, and the dominance index was low. In general, the physico-chemical parameter values are considered to be suitable for the growth of phytoplankton species in Lemukutan Island ecosystem.

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