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Diversity and Abundance of Phytoplankton in Coastal Areas in Kendari Southeast Sulawesi Indonesia

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ABSTRACT

Phytoplankton is a microscopic algae that can be found in almost all aquatic habitats. Phytoplankton have an important ecological role in the waters, as the basis of the food chain and as a producer of oxygen, where their composition and abundance are strongly influenced by various environmental factors. This study aims to determine the community structure of phytoplankton including the diversity, abundance and dominance of phytoplankton found in various locations in coastal waters in Kendari, Southeast Sulawesi. Sampling was carried out in several coastal waters in Southeast Sulawesi including Nambo, Bokori, Batu Gong, Toronipa and Tanjung Tiram beaches. Plankton sampling was carried out by filtering about 100 L of seawater using a plankton net with a mesh size of 20 µm. The filtered plankton samples were then preserved in 4% formalin for further observation in the laboratory. Water quality measurements of temperature, salinity, brightness and pH were carried out in situ while nitrate, phosphate and ammonia were carried out ex-situ. The results showed that there were about 30 species of phytoplankton found where the most species were found in Bokori Island (22 species) followed by Tanjung Tiram beach (21 species), Toronipa beach (19 species) and both Nambo and Batu Gong beaches with 17 species. The highest abundance of phytoplankton was found on Bokori Island (563 individuals/L) and the lowest abundance was found on Batu Gong beach (237 individuals/L). The highest diversity index value was found at Toronipa Beach (2.72) while the lowest diversity index value was found at Batu Gong Beach (2.13). For the dominance index value, the highest value was obtained at Batu Gong Beach (0.18) and the lowest value was obtained at Toronipa Beach (0.08). The difference in the structure of the phytoplankton community found in different locations is due to variation of the environmental conditions.

INTRODUCTION

Phytoplankton are prokaryotic or eukaryotic photosynthetic microorganisms that can be found in all ecosystems both aquatic and terrestrial (Richmond 2004; Mata et al. 2010) and they are an extremely heterogeneous group of microorganisms which are potentially rich source of important chemicals with potential

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application in the feed, food, nutritional, cosmetics, pharmaceuticals and even in fuel industries (Olaizola 2003). Beside the ability of phytoplankton to produce various important chemicals, they have a very important role for life on earth and maybe even the most important living organisms on this planet. They play an important role in CO_2 sequestration (Jia et al. 2022). Phytoplankton are the basis of food webs in waters that provide food for higher trophic levels in the food web or for larger organisms higher up in the food web, such as zooplankton, fish and mammals. Phytoplankton contribute to roughly half of global primary production occurs in the oceans (Cermeño et al. 2013; 2016). It is estimated that 95% of primary production in the ocean comes from of phytoplankton (Nybakken, 2005).

There is a positive correlation between the abundance of phytoplankton and aquatic productivity. If phytoplankton abundance is high then the waters tend to have high productivity as well (Raymont, 1980). Phytoplankton is abundance in marine ecosystems and they are autotroph or capable of producing organic materials from inorganic material through photosynthesis with the help of sunlight. During photosynthesis, phytoplankton produce oxygen which is needed for aquatic biota (Richardson & Bendtsen 2017). In addition, the existence of Phytoplankton can be used as a useful indicator of water quality because its distribution both spatially and temporally reflects both short-term and long-term environmental changes (Padisak et al. 2006). Therefore, information about the structure and diversity of the phytoplankton community is important in order to understand and evaluate environmental impacts on ecosystem change.

Kendari Regency located in Southeast Sulawesi Indonesia has large coastal areas functioned as recreational and fishery areas. In an attempt to support this region into a sustainable tourism areas and sustainable fisheries resources, the water quality must be maintained and monitored to suit the purposes. Phytoplankton are biological parameters that can be used as bioindicators to evaluate the quality and productivity of waters. The presence of phytoplankton in waters can provide information about water conditions. Therefore, the aim of this study was to determine community structure of phytoplankton including abundance, diversity and dominance of phytoplankton in several coastals area in Kendari, Southeast Sulawesi, Indonesia.

MATERIALS AND METHODS

***Sampling Locations*.** This study was conducted from March-June 2018. The sampling sites of this study were located in several coastal areas in Kendari, Southeast Sulawesi, Indonesia including Tiram Cape (4^{o}2’24”BT-122^{o}40’1”LS), Nambo Beach (4^{o}0’5”BT-122^{o}36’58”LS), Batu Gong Beach (3^{o}52’43”BT-122^{o}30’45”LS), Toronipa Beach (3^{o}54’0”BT-122^{o}39’36”LS) and Bokori Island (3^{o}55’34”BT-122^{o}40’0”LS) (Figure 1).

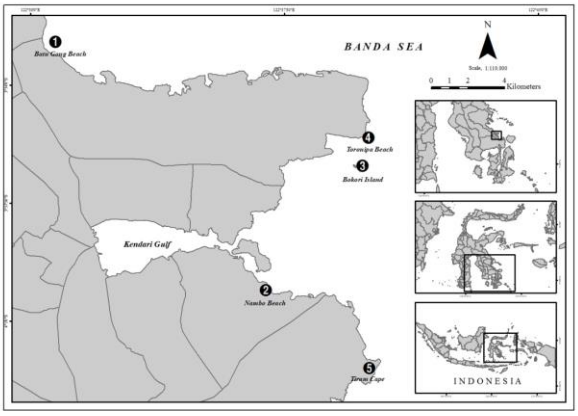

Figure 1. Sampling Sites

Sample collection and preservation. Phytoplankton samples were collected by filtering 100 Liters of seawater using plankton net mesh size 20 μm. Samples were collected at 3 sub-stations in each location. The filtered seawater collected in a 50 mL conical tube was transferred to a small bottle (160 mL) and then preserved with 4% formalin. The preserved samples were then brought to the Analytical Laboratory of Faculty of Fisheries and Marine Science, Halu Oleo University for further analysis.

Phytoplankton Abundance. The abundance of phytoplankton was determined by counting the cell numbers of the phytoplankton in the sample using Sedgewick Rafter Chamber. The abundance of the phytoplankton was calculated following the below equation (APHA 1998):

$$N = n \times (1/V_d) \times (V_t/V_{cg}) \times (O_t/O_p)$$

Where :

N : abundance of phytoplankton (cells/L)

n : number of phytoplankton counted
V_d: volume of water filtered (L)
V_t : volume of filtered sample (mL)
V_{cg}: volume of sample in SRC (mL)
O_t : area of SRC (mm^2)
O_p: area of observation (mm^2)

Phytoplankton Diversity. The Diversity Index of phytoplanktonk was determined using Shannon and Wiener index (Odum 1971) with the following formula:

$$H' = -\sum_{i=1}^{n} \text{pi} \ln \text{pi}$$

Where:
H'=Shannon-Wiener diversity index;
pi=ni/N; ni=number of individual species-i^{th};
N=total number of individuals.

Species diversity index criteria (H') Shannon-Wiener are as follows:
H' < 1: low community diversity (unstable)
1 < H' < 3: moderate community diversity (moderate stability)
H' > 3: high community diversity (stable).

Phytoplankton Dominancy. The Dominance Index was determined using the following formula (Odum 1971):

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

Where:
D=Simpson dominance index;
ni= number of individual-i^{th};
N=total number of individuals;
S=number of genera.

The criteria used for the Dominance Index is:
< 0.5: Low species dominance
0.5 < 0 < 1: Medium species dominance
> 1: High species dominance

Identification of Phytoplankton. Phytoplankton was identified based on the morphological characteristics using a light microscope and phytoplankton identification books (Tomas 1997; Yamaji 1996). The phytoplankton was identified up to genus level.

Water Quality Measurements. The water quality parameters of the sampling locations were measured including temperature, salinity, water transparency, pH, nitrat, phosphat and ammonia. Temperature, salinity, water transparency and pH were measured insitu whereas nitrat (SNI 06-2480-1991), ammonia (SNI 19-6964.3-2003) and phosphat (APHA 4500-P-D-1998) were measured exsitu. Nitrat and ammonia were fixed with H_2SO_4 whereas phosphat was filtered through Whatman filter paper no 42.

RESULTS AND DISCUSSION

The results of this study showed that there were 30 species of phytoplankton obtained. The highest numbers of phytoplankton species were found in Bokori Island (22 species) followed by Tanjung Tiram beach (21 species), Toronipa beach (19 species) and both Nambo and Batu Gong beaches with 17 species (Table 1).

Amongst the 30 species of phytoplankton identified, they were dominated by phytoplankton species from class of Bacillariophyceae. Phytoplankton species from Bacillariophyceae class found in all locations were *Amphora* sp., *Chaetoceros* sp., *Cocconeis* sp., *Coscinodiscus* sp., *Synedra* sp., *Navicula* sp., *Gyrosigma* sp., dan *Diatoma* sp. The reason for the common Bacillariophyceae class in marine waters is due their capability to adapt well to environmental conditions compared to other classes (Arinardi et al. (1997). In addtion, according to Sachlan (1972) bacillariophyceae is class of the most abundant and numerous phytoplankton found in Indonesian waters. The results of this study are in line with the previous study done by Yuliana (2015) in West Halmahera Jailolo Waters, Rahmatullah et al. (2016) in the Kualai Rigaih Estuary Aceh Jaya District and Rismawan (2000) in Jakarta Bay.

The abundance of phytoplankton found in each location varied with the highest abundance of phytoplankton found in Bokori Island (563 cells/L) and the lowest abundance in Batu Gong beach (237 cells/L) (Figure 2). The higher abundance of phytoplankton at Bokori Island compared to other locations influenced by several factors, among them are environmental parameters which supports the growth of phytoplankton including light and nutrients. Bokori Island had a water transparency of 100% indicating that the light

Table 1. Species composition of phytoplankton found in Several Coastal Areas in Kendari

No	Microalgal Species	Locations				
		Tanjung Tiram Beach	**Nambo Beach**	**Batu Gong Beach**	**Toronipa Beach**	**Bokori Island**
1	*Amphora sp*	+	+	+	+	+
2	*Amphipleura*	-	+	+	+	-
3	*Asterionella*	-	+	-	+	-
4	*Ceratium*	+	-	+	-	-
5	*Chaetoceros sp*	+	+	-	+	+
6	*Cyclotella*	+	+	+	+	+
7	*Cocconeis*	+	+	+	+	+
8	*Coscinodiscus sp*	+	+	+	+	+
9	*Diatoma*	+	+	+	+	+
10	*Dinobryon sp*	+	-	-	-	+
11	*Eutonia*	-	-	+	-	-
12	*Fragillaria*	-	-	-	-	+
13	*Gomponema*	+	-	-	+	+
14	*Gymnodinium*	-	-	-	-	+
15	*Gyrosigma*	+	+	+	+	+
16	*Imnodinium*	-	-	-	-	+
17	*Mellosira sp*	+	-	+	+	+
18	*Navicula*	+	+	+	+	+
19	*Nitzchia sp*	+	-	+	+	+
20	*Oscillatoria*	-	-	-	-	+
21	*Pinullaria*	+	+	+	+	+
22	*Peridium*	+	+	+	-	-
23	*Propecentrum sp*	+	-	-	-	-
24	*Surirella*	+	+	-	+	-
25	*Cyanobacteria*	+	+	+	+	+
26	*Stephanodiscus*	+	+	+	-	+
27	*Synedra sp*	+	+	+	+	+
28	*Tabellaria sp*	+	+	-	+	+
29	*Thallasionema*	-	-	-	-	+
30	*Urosolenia sp*	-	-	-	+	-
	Numbers of species	**21**	**17**	**17**	**19**	**22**

Note : (-) = not present; (+) = present

intensity can penetrate deeper into water colomn so that phytoplankton can carry out photosynthesis well. In contrast, Batu Gong Beach had a lower water transparency, temperature and salinity compared to other locations so that it has an impact on the low density of phytoplankton cells. Environmental conditions in Batu Gong Beach are affected by run off from the mainland and sediments carried by the river currents that empty into Batu Gong beach. Low brightness or high turbidity can limit light penetration into the waters so that the availability of light to support the photosynthesis process is also limited. As stated by (Iachetti and Llames, 2015), a high level of turbidity will reduce light penetration which will reduce the production of primary productivity of the waters (Anneville et al., 2017).

The highest diversity index was found at Toronipa Beach (2.72) while the lowest diversity index value was found at Batu Gong Beach (2.13) (Figure 3). Differences in the diversity of phytoplankton species in various locations are caused by differences in environmental conditions including physical and chemical parameters as reflected in the differences in the measured environmental parameters. This is in accordance with the statement of Wiltshire et al. (2015) which states that the structure of the phytoplankton community is very dynamic which changes rapidly in response to environmental changes. The assemblage structure and abundance of phytoplankton change spatially and temporally, influenced by seasonal changes and in response to light conditions, temperature, nutrient inputs, or the presence of certain producers and consumers. For the dominance index value, the highest value was obtained at Batu Gong Beach (0.18) and the lowest value was obtained at Toronipa Beach (0.08) (Figure 4). The dominance index used in this study is the dominance index of Simpson with a value range of 0-1. An index value close to 1 indicates the presence of high dominance species and conversely an index value close to 0 indicates low or no dominant species. Based on the value range of the dominance index, the value of all stations was below 0.5 indicating that the dominance was low or no dominant species (Odum 1971).

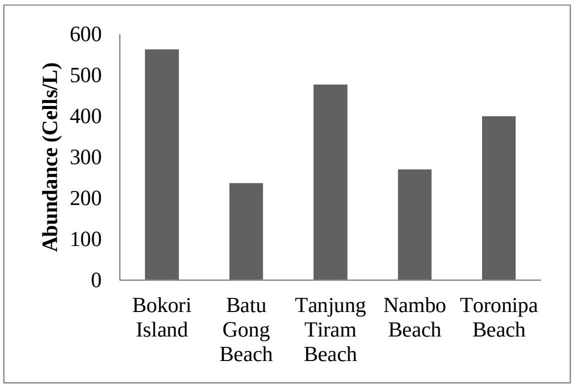

Figure 2. Abundance of Phytoplankton at Several Coastal Areas in Kendari

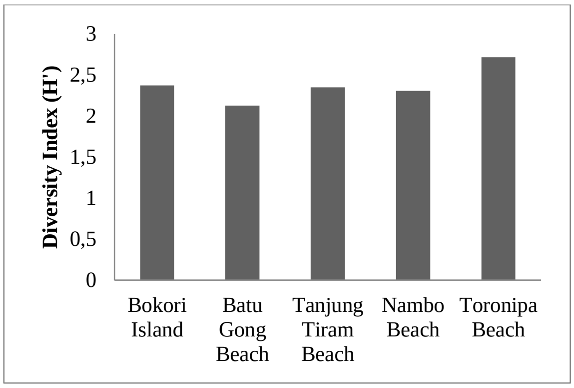

Figure 3. Diversity Index (H') of Phytoplankton at Several Cioastal Areas in Kendari

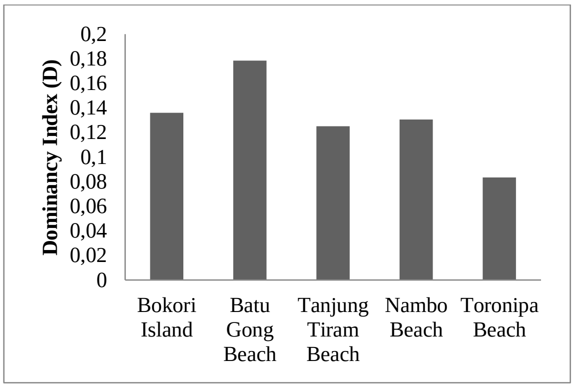

Figure 4. Dominancy Index (D) of Phytoplankton at Several Coastal Areas in Kendari

The water quality parameter measurement showed that the water temperature of all locations ranged from 30-33ºC. The water temperature in Nambo Beach, Toronipa Beach and Bokori Island was similar at 33ºC while the water temperature in Bato Gong Beach was the lowest at 30ºC. The salinity ranged from 30-33 ppt where the highest salinity was obtained at Nambo Beach, Toronipa Beach and Bokori Island at 33ppt and the lowest was at Batu Gong Beach. For water transparency, all locations had water transparency of 100% except Batu Gong Beach which has only 85% of water transparency (Figure 5). The dynamics of abundance and the community structure of the phytoplankton are influenced by physical and chemical factors, including water temperature, salinity, transparency, and the availability of nutrients (i.e., nitrate, phosphate and ammonia). Water temperature in all locations ranged from 30-33ºC. This temperature is a temperature commonly found in tropical waters as stated by Thomas et al. (2012) that in tropical areas the water temperature ranges from 30-33ºC. The temperature in the waters of Nambo Beach, Toronipa Beach and Bokori Island is higher than the temperature of the waters at Batu Gong Beach. The differences in the temperatures at different locations were possibly due to different weather conditions at the time of measurement. The temperatures measurements in Nambo, Toronipa and Bokori beaches were carried out in hot sunny days while temperature measurements at Batu Gong Beach coincided with cloudy weather with rain resulting in slightly lower temperature at 30ºC.

The salinity of all location ranged from 30-33ppt. The salinity of the Batu Gong Beach is slightly lower than the other locations because there is a river estuary not far from the sampling location. This is also explaining why the water transparency of the Batu Gong Beach was low due to higher river run-offs during sampling.

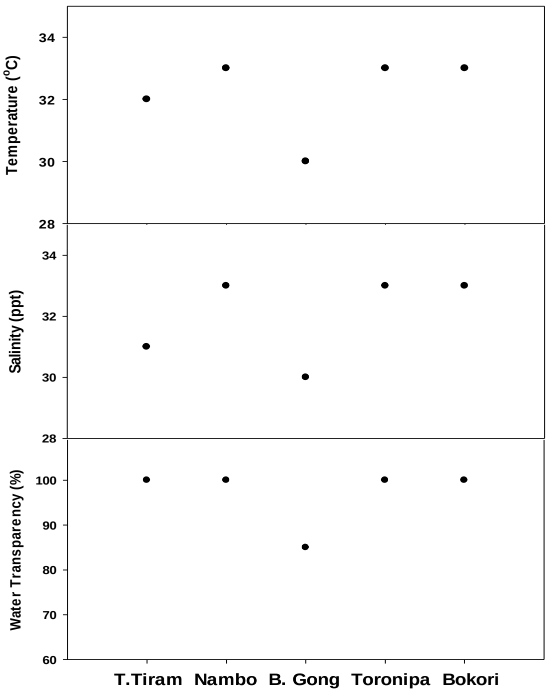

Figure 5. Temperature, salinity and water transparency at Sampling Locations

For the measurement of water chemistry parameters, the highest nitrate concentration value (0.018 mg.L^{-1}) was obtained at Nambo Beach and the lowest nitrate concentration (0.014 mg.L^{-1}) was obtained at Tanjung Tiram Beach. The highest phosphate level (0.0046 mg.L^{-1}) was found at Toronipa Beach while the lowest phosphate level (0.0022 mg.L^{-1}) was found at Batu Gong Beach. The highest ammonia (NH_3) level (0.031 mg.L^{-1}) was found at Tanjung Tiram Beach while the lowest ammonia level (0.017 mg.L^{-1}) was found at Nambo Beach (Figure 6). Nutrients are essential for the growth phytoplankton. Nitrate and phosphate are macronutrients that control the growth and productivity of phytoplankton. Phytoplankton require nitrate content in the range of 0.9-3.5 mg/l and phosphate 0.09-1.80 mg/l (Yuliana, 2015). Overall, the nitrate concentration in all locations was low ranged from 0.014-0.018 mg.L^{-1}. Similarly, the phosphate concentration ranged from 0.0022-0.0045 mg.L^{-1} was also below the minimum requirements of phytoplankton growth.

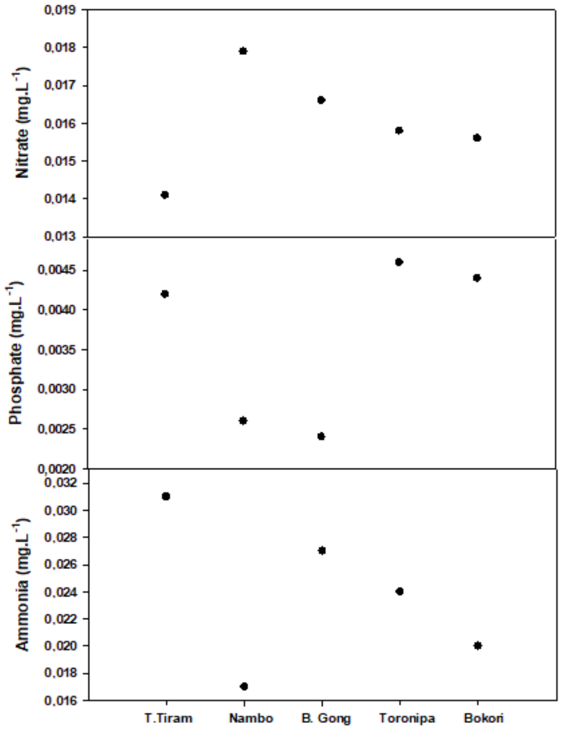

Figure 6. Concentration of Nitrate, Phosphate and Ammonia at Sampling Locations

CONCLUSION

The diversity and abundance of phytoplankton varies in each water and will fluctuate to varying degrees in response to those changes of aquatic environmental conditions both physical, chemical, and biological. The structure of phytoplankton community at several locations studied showed that phytoplankton from the class Bacillariophyceae was the most abundant species with the highest diversity and density found on Bokori Island while the lowest diversity and abundance of phytoplankton with the largest dominance index were found in Batu Gong coastal waters. Variations in community structure in various locations are strongly influenced by aquatic environmental parameters, especially temperature, nutrients and water transparency. Water quality parameters at all locations were not too different except at Batu Gong beach which had lower water temperature, salinity and brightness which could explain the low value of diversity and abundance of phytoplankton at this location.

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