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Community structure of phytoplankton and its relationshp to waters quality in Lombok Strait, North Lombok District, West Nusa Tenggara, Indonesia

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Abstract

Phytoplankton is a biological parameter that can be used as an indicator to evaluate the quality and level of aquatic productivity, so it is necessary to study the phytoplankton community structure in relation to the quality of water in the Lombok Strait North Lombok District. Data collection was designed with a geographical information system (GIS) on 23 observation stations that were determined by simple random techniques. The results showed that the type and abundance of phytoplankton found in the Lombok Strait waters of North Lombok District varied considerably with a number of 18 genera which were divided into 5 classes. Phytoplankton abundance is strongly influenced by water (physical-chemical) environmental conditions. Correlation analysis shows that aquatic environmental parameters that influence phytoplankton dynamics are brightness, nitrate, and phosphate.

Keywords: phytoplankton, community structure, water quality, marine culture

INTRODUCTION

Plankton are group of organisms both animals and plants which floated in the water, a few mobility or mobiles and disable to counter water current. Plankton were divided into 2 groups, phytoplankton and zooplankton. The phytoplankton utilize light for growing and developing. Hence, as an autotroph can convert inorganic into organic materials by photosynthesis. A higher tropical organism use phytoplankton as feed (Lampman and Makarewicz, 1999).

Lombok straits water of North Lombok District is a marine protected area where consist three small islands. Gili Matra is a part of small islands that be utilized as marine culture area such as pearl, grouper, pomfret, seaweeds and spiny lobsters (KKP, 2014). Local communities have cultured potential commodities like south sea pearl, grouper and seaweeds. Marine culture is influenced waters quality including physical, chemical and biological (aquatic productivity). Phytoplankton is a parameter to determine the aquatic productivity condition when phytoplankton species composition abundance is identically a high aquatic productivity. Community concept is used to analyze marine environmental circumstance because community characteristics and compositions reveal condition of community existence. As result, phytoplankton is usually to provide useful information to establish marine condition (Roito *et al*., 2014; Mustofa, 2015; Fitriyah *et al*., 2016).

Phytoplankton observation including types and abundance describe the marine productivities in the certain aquatic ecosystem. Variance statistical analysis had been utilized to calculate phytoplankton and marine condition relationship such as regression or correlation (Gao and Song, 2005; Pirzan dan Pong-Masak, 2008; Garno, 2008; Simanjuntak, 2009; Makmur *et al*., 2012; Ismunarti, 2013; Novia *et al*., 2016). However, a few community concept analysis has been used to observe phytoplankton and marine productivity relationship for example types, abundance and ecological index (Radiarta, 2013; Damayanti *et al*., 2017).

Commonly, spatial ecological index method have been applied using geographical information system (GIS) to identify aquatic resources (Meaden and Kapetsky, 1991; Nath *et al*., 2000; Kapetsky and Anguilar-Manjarrez, 2007; Radiarta *et al*., 2008). The GIS data inform land marine degradation, environmental monitoring and marine culture suitability. Aquatic environment initial studies must be conducted to analyze marine culture site suitability (Radiarta *et al*., 2008; Junaidi *et al*., 2018). This research is aimed to observe phytoplankton communities including species types, abundance, ecological index, water quality, distribution and water quality in Lombok straits, North Lombok region.

MATERIALS AND METHODS

This research was locus in 116^o 6' 38" – 116^o 14' 33" east longitude and 8^o 14' 42" – 8^o 22' 2" south latitude in North Lombok region. This research observation applied 23 station that randomly distribution in four districts (Pemenang, Tanjung, Gangga, dan Kayangan). The observing station was figure out on Figure. 1. Primary data was collected consist of biological parameter (phytoplankton) and data supplementary included physical and chemical aquatic. Phytoplankton sample was collected by filtering sea water about 100 liter. Plankton net was used to filter the seawater with average mesh size 45 micron. Lugol was poured into sea water filtrate at 3 cc as preservative agent.

Filtrate sample was investigated using *Sedgewick Rafter Cell* (SRC) and microscope and replicated three times. Phytoplankton identification is purposes to observe the genus identification and compared to Newell and Newell book (1977). Water quality of parameters directly measured including temperature, salinity, pH, lightness and dissolved oxygen in the observing station. Laboratory work observed physical and chemical parameters (turbid, nitric and phosphate). Biological parameter phytoplankton was investigated ecological index, types and abundance. Phytoplankton abundance can be calculated using APHA modified (2005),

$$N = \frac{Oi}{Op}\ x\ \frac{Vr}{Vo}\ x\ \frac{1}{Vs}\ x\ \frac{n}{p}$$

where :

N = number of individual per liter; Oi = the glass area of the preparatory cover (mm^2); O_p = area of one field of view (mm^2); V_r = filtered water volume (ml); V_o = observed water volume (ml); V_s = volume of filtered water (L); n = the number of plankton on the entri filed of view; p = the number of observed field of view.

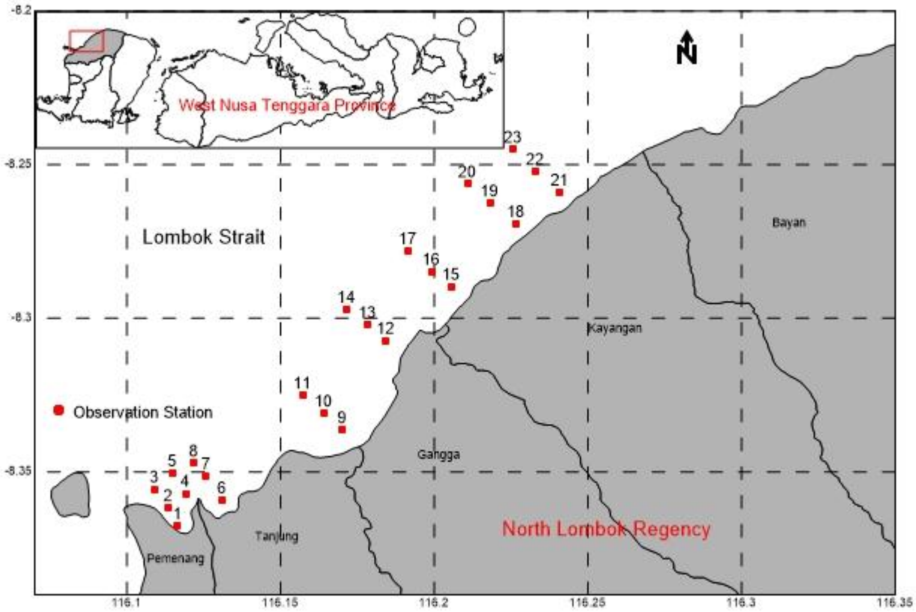

Figure 1. Research station in North Lombok District

Ecological index observation consisted of variance index *Shannon-Wiener Index*, (H'), *Evenness Index* (E), and dominate index *Simpson's Index* (D). Index calculation used Odum (1971):

$$H = -\sum_i^s P_i \ln(P_i);\ E = \frac{H}{\ln(S)};\ D = \sum_i^s (P_i^2)$$

where :

$P_i = N_i/N$, N_i = the number individul of genera i, N = total number induvidual of genera, S = the number of species.

Spatial analysis used Kriging method (Siregar dan Selamat, 2009) that can be accessed by Surfer 9 software (Golden Software, Inc). The software generated phytoplankton spatial distribution including abundance and ecological index. Kriging method provide accurately analysis that common regression method (Siregar dan Selamat, 2009; Hadi, 2013). Pearson correlation was also applied to observe environmental factors and phytoplankton relationship.

RESULT AND DISCUSSION

Community of Phytoplankton

Based on the phytoplankton sample, this research identified about 18 genus that classified into 5 classes i.e., Bacillariophyceae (8 genus), Coscinodiscophyceae (4 genus), Dynophyceae (3 genus), Fragilariophyceae (2 genus) dam Chrysophyceae (1 genus) (Tabel 1). Phytoplankton source from Bacillariophyceae, Coscinodiscophyceae, and Fragilariophyceae were grouped in Bacillariophyta phylum (diatom) where the most populated in marine ecosystem (Fig. 2). This finding was identically other researcher report that phytoplankton marine ecosystem were diatomic such as (Bacillariophyceae, Fragilariophyceae and Coscinodiscophyceae), Dinoflagellata (Dinophyceae) and blue algae (Cyanophyceae) (Nontji, 2008). Interestingly, some phytoplankton such as *Nitzschia* sp dan *Ceratium sp* will be harmful in high population (Garno, 2008; Radiarta, 2013).

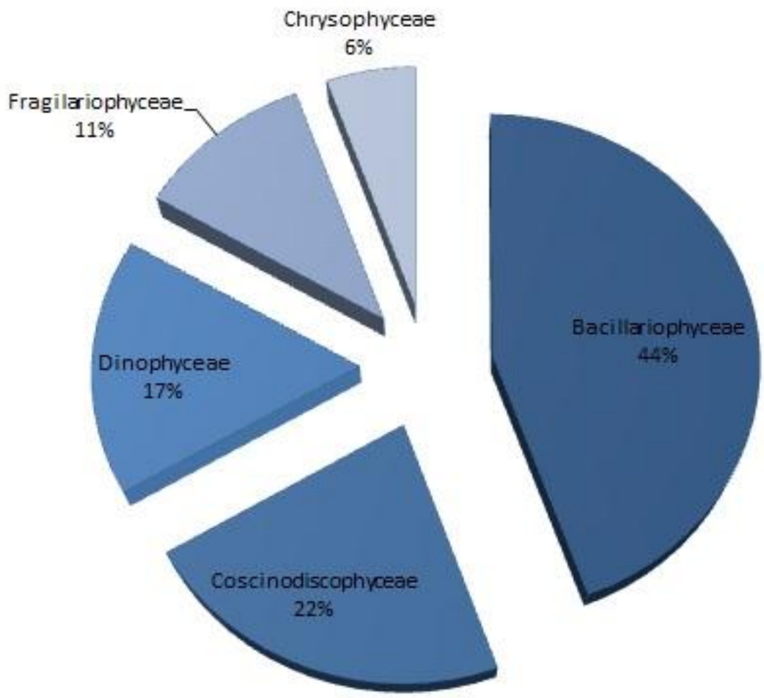

Figure 2. Phytoplankton class composition in Lombok Straits, North Lombok District

This research found a variety phytoplankton that dominated four genus from classes Bacillariophyceae: *Rhizosolenia* sp, and Coscinodiscophyceae: *Coscinodiscus* sp, *Skeletonema* sp, dan *Chaetoceros* sp in the location. The population were calculated 227 ind.L^{-1}, 320 ind.L^{-1}, 150 ind.L^{-1} and 177 ind.L^{-1} (Table 1) or 22,01%, 25,48%, 11,93% dan 14,11%, respectively (Fig. 3).

Table 1. Phytoplankton relative population in Lombok Straits, North Lombok District

Classes	Genus	Abundance (cell/l)	Relative abundance(%)
Bacillariophyceae	Rhizosolenia sp.	277	22.01
	Pleurosigma sp.	23	1.86
	Cylindrotheca closterium	3	0.27
	Diploneia crabro	7	0.53
	Amphiprora sp.	7	0.56
	Nitzschia sp.	33	2.63
	Navicula sp.	54	4.27
	Bellerochea hologicales	3	0.24
Coscinodiscophyceae	Coscinodiscus sp.	320	25.48
	Skeletonema sp.	150	11.93
	Bacteriastrum sp	20	1.59
	Chaetoceros sp.	177	14.11
Dinophyceae	Protoperidinium sp.	20	1.56
	Ceratium	57	4.51
	Pyrodinium sp.	3	0.24
Fragilariophyceae	Thalassionema sp.	73	5.83
	Asterionella sp.	13	1.03
Chrysophyceae	Dictyocha fibula	20	1.59

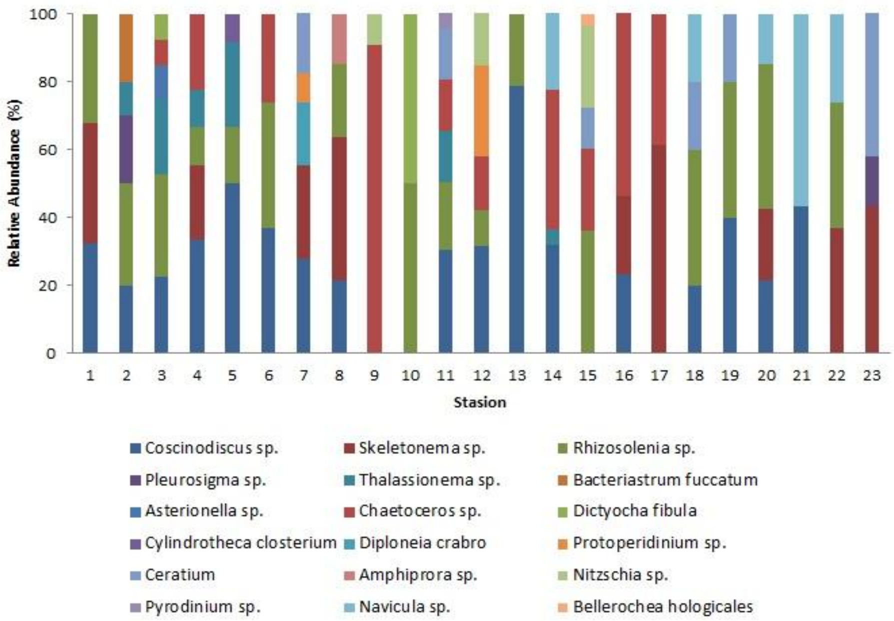

Fig 3. Phytoplankton relative abundance in Lombok Straits, North Lombok Districk.

Diatomic dominated in the marine ecosystem due to easily adapt in the environment condition, resist to extreme condition, and highly reproductive (Odum, 1971; Thoha and Amri, 2011; Fahrur, 2012). Cell regeneration diatomic depend on environment and species. Generally, cell regeneration come up between 10-12 hours and other species around 18-48 hours. However, researchers argued that diatomic cell regeneration is rapidly in tropical marine at about 4 hours. Diatomic can be found in Jakarta gulf (Yuliana *et al*., 2012), Sekotong and Kodek Bay, West Nusa Tenggara (Sutomo, 2013; Fathurrahman dan Aunurohim, 2014; Cokrowati *et al*., 2014), Pabean gulf, West Java (Andriani *et al*., 2017), Jailolo, West Halmahera (Juliana, 2015), Bali straits (Agustiadi *et al*., 2013), North Minahasa marine, (Usman et al., 2013) and East west Hindian ocean (Novia *et al*., 2016). Diatomic existence influences aquatic ecosystem because play a role as food resource in food chain and carbon supplies (Dahlgren *et al*., 2010). Other function is water quality indicator and aquatic productivity (Roito *et al*., 20114; Fitriyah *et al*., 2016).

Spatial distribution phytoplankton abundance was presented on Figure 4a. The research investigated that highly abundance phytoplankton is raised close to river downstream and mangrove because those location has a large nutrient supply from land mass effect (river water stream to sea). This finding is similar with Surabaya east coast water stream that affected highly phytoplankton population (Putri dan Sari, 2015). Thoha (2007) and Pouladi *et al*. (2017) reported tropical coastal and river downstream cotained a large diatomic population because of and mass effect source from farm, industrial waste, domestic waste and sea wave turbulance.

Phytoplankton ecology indexes have been calculated to ensure aquatic environment stability such as diversity index (*Shannon-Wiener Index*, H’), uniformity index

(*Evenness Index*, E) and domination index (*Simpson's Index*, D) (Table 2). Diversity index describes plankton varieties abundance; uniformity index figures out composition balancing and domination index defines domination possibility one or a group of plankton (Odum, 1971). Stability diversity is showed a high diversity index.

Spatial index distribution was presented on Figure 4b. Diversity index was observed between 0.30-1.68 or average index was 1.15. The diversity index result is classified into low diversity index that identified unstable communities. Diversity index was identified less than 1.00 can be investigated at station number 9, 10, 17 and 21; rest of stations was above 1.00. On the other hand, uniformity index showed a satisfaction at mean index 0.91 (see Figure 4c) or categorized high uniformity (Odum,1971). Domination index was calculated from 0.14 to 0.83 or average 0.36. The domination index close to 1.00 showed any phytoplankton species dominated in the aquatic culture. Some observation station resulted uniformity index above 0.5 at stasiun 9, 10, 13, 17 and 21 (Figure 4d).

Table 2. Abundance and ecological index of phytoplankton in Lombok Strait, North Lombok District.

Variable	Average	Range
Abundance (ind.L^{-1})	55	20 – 133
Diversity index (*Shannon-Wiener Index*, H'),	1.15	0.30 – 1.68
Uniformity index (*Evenness Index*, E)	0.91	0.44 – 1
Domination index (*Simpson's Index*, D)	0.36	0.14 – 0.83

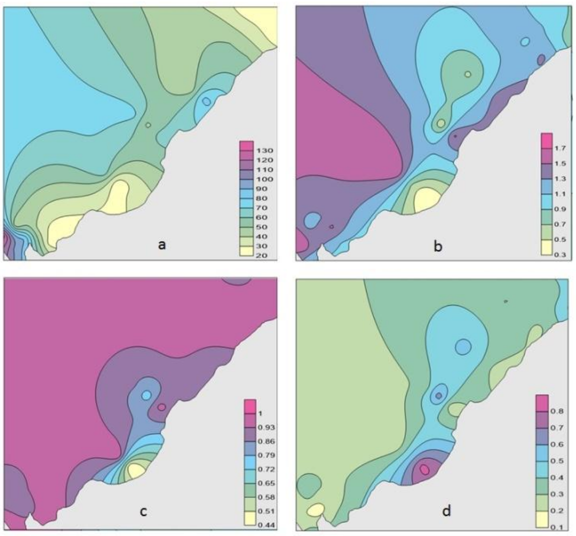

Fig 4. Distribution spacial of phytoplankton in Lombok Strait, North Lombok District.

a : Abundance of phytoplankton (ind.L^{-1}), b : Shannon-Wiener index

c: Evenness index, d : Simpson's index

Water quality parameters

Phytoplankton abundance and distribution are influenced by aquatic environment condition (Setiadi, 2004; Setyadji and Priatna, 2011; Palleyi *et al*., 2011; Susilo and Pancawati, 2014; Wulandari *et al*., 2014; Karuwal, 2015; Adriana *at al*., 2017). Phytoplankton is used to measure aquatic quality both biological parameter and productivity (Hariyati *et al*., 2010). Physical and chemical aquatic environment in this research was showed on Table 3.

Physical parameter such as temperature is an important factor in the growth and distribution organism due to effect on algae growth and photosynthesis. Waters temperature observed between 30.7-31.7 ^{o}C or average 31.06 ^{o}C. The average temperature is susceptible for phytoplankton growth although other research recommended optimum temperature growth range from 20-30 ^{o}C (Effendi, 2003). Other physical parameter like lightness showed supporting for phytoplankton growth with lightness average number 14.3 m. This research found the lightness value enhancing phytoplankton photosynthesis and well growth. Reversely, Sungai Porong Sidoarjo do not support for phytoplankton growth because of lower lightness number (Abida, 2010).

Table 3. Water quality conditions in Lombok Strait, North Lombok District

Variable	Units	Range	Average	Standar Deviation
Temperature	^{o}C	30..7 – 31.7	31.06	0.27
Lightness	m	4.0 – 22.0	14.3	5.3
Turbinity	NTU	0.13 – 0.45	0.3	0.07
pH		8.0 - 8,2	8.09	0.07
Salinity	ppt	29 - 32	30.5	0.8
Disolved oxygen	$mg.L^{-1}$	6.8 – 8.7	7.46	0.41
Nitrate (NO_3-N)	$mg.L^{-1}$	0.152 – 0.165	0.158	0.0034
Phosphate (PO_4-P)	$mg.L^{-1}$	0.026 – 0.042	0.033	0.0041

Turbidity plays a negative effect to water quality such as DO-BOD parameter, temperature that implies fish varieties, photosynthesis inhibition, plankton population, algae (James, 1979; Makmur *et al*., 2012). Our studies investigated turbidity range between 0.13-0.45 NTU and average number 0.3 NTU (Table 3). The turbidity value fulfilled sea biota requirement i.e below 5 NTU (MNLH, 2004). Other chemical parameter has been observed as acidity level to monitor aquatic stability. Acidity is influenced some factors for example sea water temperature, dissolved oxygen, anionic and cationic content (Effendi, 2003; Simanjuntak, 2009). This research revealed aquatic station acidity range 8.0-8.2 or average 8.09 (Table 3). Acidity result complied acidity standard for sea biota ecology 7.0-8.5 (MNLH, 2004).

Salinity has been collected from 29-32 ppt or average 30.5 (Table 3). This observation indicated that Lombok strait is categorized as coastal water than oceanic water properties (salinity > 34.5) (Simanjutantak, 2009). Dissolved oxygen was recorded range between 6.8-8.7 mg/l or average 7.46 mg/l. The dissolved oxygen number submitted sea biota requirement number (MNKLH, 2004). Nutrients content were defined nitric and phosphate level that effect for sea biota muscles and photosynthesis plankton (Risamasu dan Prayitno, 2011; Paiki dan Kalor, 2017). Nutrients are influenced domestic waste contamination, farming or villages. Nitric and phosphate has been investigated 0.158 mg/l and 0.33 mg/l (Table 3).

Phytoplankton and Water Quality Relationship

Phytoplankton and environmental circumstance have been reported many analysis methods (Gao and Song, 2005; Pirzan dan Pong-Masak, 2008; Garno, 2008; Simanjuntak, 2009; Makmur *et al*., 2012; Radiarta, 2013; Novia *et al*., 2016). On the other hand, this research analyzed phytoplankton and water quality relationship using Pearson correlation method. Data analysis showed significantly correlation between environment factors and phytoplankton level 99% (0.01) or 95% (0.05). Phytoplankton abundance had correlation with species quantity (0.673), diversity index (0.592), lightness (-0.620) and phosphate (0.601), domination index (-0.527) and nitric (0.460). This findings has a similar result with other research who explored phytoplankton abundance and environment factors such as nutrients, turbidity, sea wave amplitude, run off volume, and predator in North West Hindia ocean (Novia *et al*., 2016).

Table 4. *Pearson* correlation between phytoplankton and water quality parameters in Lombok Strait, North Lombok District

Variable	Abudance of phytoplankton	Number of species	Diversity index (*Shannon-Wiener index*)	Uniformity index (*Evenness index*)	Dominattion indeks (*Evenness index*)
Number of species	0,673**	1	0,948**	0,213	-0,839**
Diversity index (*Shannon-Wiener index*)	0,592**	0,948**	1	0,473*	-0,951**
Uniformity index (*Evenness index*)	0,064	0,213	0,473*	1	-0,638**
Dominattion indeks (*Evenness index*)	-0,527*	-0,839**	-0,951**	-0,638**	1
pH	-0,044	-0,400	-0,407	-0,096	0,371
Salinity	-0,088	-0,027	-0,156	-0,326	0,300
Lightness	-0,620**	-0,431*	-0,404	-0,081	0,405
Disolved oxygen	0,308	-0,045	0,096	0,280	-0,243
Temperature	-0,007	-0,113	-0,010	-0,003	-0,030
Turbinity	-0,205	-0,121	-0,099	-0,009	-0,038
Nitrate (NO_3-N)	0,460*	0,359	0,374	0,341	-0,300
Phosphate (PO_4-P)	0,601**	0,475*	0,357	-0,127	-0,147

** Significant in level 99% (0.01); * Significant in level 95% (0.05)

CONCLUSION

This research resumed varieties and phytoplankton abundance in Lombok straits about 18 genus that classified into 5 classes and 4 dominant genus *Rhizosolenia* sp., *Coscinodiscus* sp., *Skeletonema* sp., dan *Chaetoceros* sp. Ecology index calculation was classified stable oceanic in Lombok Straits, North Lombok. Correlation analysis observed aquatic environment parameters influencing phytoplankton dynamic such as lightness, nitric, phosphate.

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