Abundance of Phytoplankton and Physical Chemical Parameters as Indicators of Water Fertility in Lekok Coast, Pasuruan Regency, East Java Province, Indonesia

E Y Herawati *, A Darmawan¹, R Valina², R I Khasanah³

¹ Faculty of Fisheries and Marine Sciences, Universitas Brawijaya. Jl. Veteran, Malang 65145, East Java, Indonesia.
² Fisheries and Marine Sciences Graduate Program, Faculty of Fisheries and Marine Sciences, Universitas Brawijaya. Jl. Veteran, Malang 65145, East Java, Indonesia.
³ Marine Science Program, Faculty of Science and Technology, State Islamic University of Sunan Ampel, Surabaya, East Java, 60237. Indonesia

*herawati_ey@ub.ac.id

Abstract. The Lekok Coast is part of Pasuruan Regency which has various community activities. The condition of the waters is influenced by natural and anthropogenic factors which receive a lot of input loads from the mainland. These input load can come from human activities such as aquaculture, industry and domestic waste that enters through rivers and then empties into the coasts. These conditions can affect the fertility of eutrophic, mesotrophic or oligotrophic waters. This study aims to determine the conditions of the waters based on the abundance of phytoplankton and the physical and chemical parameters of the waters to see the fertility status of the waters. The descriptive method is the method used in this study and the determination of the sampling point uses the purposive sampling method, the research was conducted in April – May 2019. Based on the results of the abundance of phytoplankton in the coastal waters of Lekok, it is classified into waters that have oligotrophic fertility levels. The results of observations and measurements of physical and chemical parameters in the coastal waters of Lekok showed that several parameters that support the growth of phytoplankton are less than optimal, such as temperature, brightness and nitrogen elements.

1. Introduction

The fertility of coastal waters is very important for the life of aquatic organisms because it is the capacity or ability of coastal waters to produce nutrients for the life of these organisms. Water fertility is influenced by the availability of organic matter, nitrate, phosphate and phytoplankton. Water fertility can be seen through the biomass of phytoplankton because it has the ability to photosynthesize which produces oxygen and food for fish. While the growth of phytoplankton is very dependent on the availability of organic matter and nutrients in the form of nitrate and phosphate [1].

The high level of pollution in coastal waters has become one of the environmental problems. This pollution problem is caused by human activities such as land clearing for agriculture, industry, logging and mining in watersheds (DAS) as well as household waste living in coastal areas [2].

Pasuruan Regency is one of the regencies in East Java which has a coastal area located in a basin and is also the area closest to the Porong River area. Waste carried from the Porong River into the sea...
is likely to enter coastal areas and rivers in Pasuruan Regency, such as the coastal waters of Lekok Pasuruan as a producer of shellfish and fish which is quite high. Lekok Beach gets input from the Rejoso River and several small tributaries where along the river there are residential areas, industrial and agricultural activities that have the potential to dump their waste into the river which will eventually empties into the sea [3].

The input of organic matter carried through the waste produced by human activities will enter the waters and under certain conditions will disrupt the existing waters. The content of organic matter that is too high will cause the waters to experience eutrophication. Eutrophication is characterized by an increase in the biomass of phytoplankton and rapidly increasing aquatic plants (blooming algae) [4]. The purpose of this study was to determine the status of water fertility based on the abundance of phytoplankton and physicochemical parameters in Lekok waters, Pasuruan Regency, East Java Province.

2. Methodology
2.1 Time and place
This research was conducted in April–May 2019 on the coast of Lekok, Pasuruan Regency, East Java Province. Sample analysis was carried out in the Laboratory of the Technical Implementation Unit for Freshwater Fishery of Sumber Pasir, Faculty of Fisheries and Marine Sciences, Universitas Brawijaya and the Water Quality Laboratory of Perum Jasa Tirta I Malang.

2.2 Data collection
This plankton net is pulled horizontally across the sea surface from the boat at low speed. The plankton net that has been lifted from the sea is immediately sprayed from the outside so that the plankton that is still attached to the inner wall of the net body can all go down into the holding bottle. Plankton samples were transferred to collection bottles, added 1 ml of preservative (lugol 1%) with labels given the required field notes. The procedure for implementing this sampling according to [1].

This type of research is a descriptive study using a survey method. In determining the sampling point, it is done based on purposive sampling in terms of the influence of human activities around the sampling point. Station 1 is the estuary area of the Rejoso river, station 2 is a fishing port and station 3 is a residential area. The sampling location can be seen in Figure 1.

![Figure 1. Sampling Site](image)

The data were analyzed using the Trophic Index method to see the fertility level of a waters. The samples taken were the quality of sea water and phytoplankton vertically with a dept of 110 cm based on the brightness value. Sampling was carried out 4 times with an interval of 7 days. Samples were taken and measured based on physical parameters (temperature, brightness, and current velocity), chemical parameters (salinity, pH, DO, alkalinity, orthophosphate, nitrate, silica), total phosphate and total nitrogen) and biological parameters (chlorophyll-a, abundance of phytoplankton, relative abundance, diversity index, and dominance index).
2.3 Data analysis

2.3.1 Phytoplankton Abundance
Sampling of plankton was carried out by a filtration method using a plankton net. Calculating the number of phytoplankton per liter using the formula APHA, AWWA, WPOF:

\[ N = \frac{T \times V}{L \times v \times P \times W} \times n \]

Information:
- \( T \): Cover glass area (mm\(^2\))
- \( V \): Volume of plankton concentrate in storage bottle
- \( L \): is the field of view in the microscope (mm\(^2\))
- \( v \): Volume of plankton concentrate below cover glass
- \( P \): Total field of view
- \( W \): Volume of filtered sample water
- \( N \): abundance of plankton (cells/L)
- \( n \): The number of plankton in the field of view

2.3.2 Diversity Index
The plankton diversity index is calculated based on the following Shannon – Wiener (H‘) formula:

\[ H' = - \sum_{i=1}^{s} P_i \ln P_i \]

Information:
- \( H' \): Diversity Index of Shannon-Wiener
- \( P_i \): \( n_i/N \)
- \( n_i \): Number of individuals of type \( i \)
- \( N \): Total number of individuals

2.3.3 Dominance Index
The calculation of the dominance index uses the Simpson's Dominance Index with the following formula:

\[ D = \sum_{i=1}^{s} \left( \frac{n_i}{N} \right)^2 \]

Information:
- \( D \): Dominance index
- \( n_i \): Number of individuals of the type genus \( i \)
- \( N \): The total number of individuals of the entire genus

2.3.4 Trophic Index (TRIX)
According to [7] The TRIX index includes the parameters DIN (total nitrogen) and DIP (total phosphate), \% \( O_2 \) (oxygen saturation), and chlorophyll-a. The TRIX index is calculated using the following equation:

\[ \text{TRIX} = \log_{10} \left( \frac{\text{Chl-a} \times \text{DO saturation}}{1,2} \times \text{DIN} \times \text{DIP} \right) + 1.5 \]

Information:
- \( \text{Chl-a} \): Concentration of chlorophyll-a
- DO saturation: percentage oxygen saturation
DIN: Total nitrogen (mg/L)
DIP: Total phosphate (mg/L)
1.5 and 1.2: coefficient scale

3. Results and Discussion
3.1 Water Quality Measurement
The results of the measurement of the physicochemical and biology parameters of the waters are as follows:

3.1.1 Temperature

![Temperature Graph]

Figure 2. Temperature

Figure 2 shows the temperature value of 29.8 – 30.8 °C. The highest temperature was at station 2 on the fourth week and the lowest was at station 1 on the second week. The highest temperature value exceeds the threshold for optimal growth of phytoplankton. This is in accordance with the statement of [5], that in general the optimal temperature for the development of plankton is 20 °C - 30 °C. The minimum temperature for phytoplankton to carry out photosynthesis is 5°C and the maximum temperature for phytoplankton to carry out photosynthesis is 30 °C [6]. Water temperature is an abiotic factor that plays an important role in the life of aquatic organisms including plankton. According to [7], the plankton community is affected by temperature, salinity and nutrients.

3.1.2 Brightness

![Brightness Graph]

Figure 3. Brightness
Figure 3 shows the brightness value of 35 – 100.5 cm. The highest brightness is at the station 2 on the first week and the lowest is at the station 3 on the first week. Based on the brightness value obtained, the Lekok coast has a low level of brightness. According to [8], brightness below 100 cm is classified as a low brightness level. Brightness directly affects the growth of phytoplankton because the deeper sunlight enters the water, the more light that can be used by phytoplankton to photosynthesize. At several stations in Lekok waters, the brightness value is not optimal for phytoplankton growth. A good brightness value for the survival of aquatic organisms is > 45 cm [6].

3.1.3 Current Velocity

![Figure 4. Current Velocity](image)

Figure 4 shows the results of the current velocity of 0.0098 – 0.285 m/s. The highest current is at the station 2 on the first week and the lowest is at station 1 on the first week. Based on these results, the Lekok coast is classified into waters that have slow currents [9]. Currents smaller than 0.5 m/s are classified as very slow currents. Such current speed allows plankton activity to run well [10]. According to [11], high current velocity causes phytoplankton to not develop properly.

3.1.4 Salinity

![Figure 5. Salinity](image)

Figure 5 shows the results salinity value of 17 – 31 ‰. The highest salinity was on the first week at station 2 and the lowest was on the third week at station 1. The salinity value is low because it is still influenced by river flow. Salinity values in coastal areas range from 32 – 34 ‰ [12]. However, this
value is still quite good for the growth of phytoplankton. Phytoplankton can thrive well at salinity 15 – 32 ‰ [13].

3.1.5 pH

![Figure 6. pH](image)

Figure 6 shows the results of pH measurements of 7 – 9.2. The highest pH was at station 3 on fourth week and the lowest was at station 3 on second week. The pH value in Lekok waters is high for optimal growth of phytoplankton. According to [14], the ideal pH for the growth of phytoplankton in the waters is 6.5 – 8.0.

3.1.6 Dissolved Oxygen

![Figure 7. Dissolved Oxygen](image)

Figure 7 shows the results of the measurement of dissolved oxygen of 4.4 – 7.2 mg/l. The highest DO is at station 1 on the second week and the lowest is at station 1 on the first week. Based on the value of dissolved oxygen the coastal waters of Lekok are still classified as good. Oxygen content of 5 mg/l with a water temperature of 20 – 30 °C is still relatively good for living organisms [15]. This is also supported by the statement of [16], that the DO content of 2 mg/l is sufficient to support the life of aquatic organisms.
3.1.7 Alkalinity

Figure 8 shows the results of the alkalinity measurement of 150 – 211 mg/l. The highest alkalinity was at station 2 on the fourth week and the lowest at station 3 on the first week. The alkalinity values at coastal waters of Lekok are included in the high category. According to [17], a good alkalinity value for living organisms ranges from 100-150 ppm.

3.1.8 Orthophosphate

Figure 9 shows the results of orthophosphate measurements of 0.008 – 0.090 mg/l. The highest value at station 1 on the third week and the lowest at station 3 on the fourth week. Based on the value of orthophosphate, the coastal waters of Lekok are still feasible in the aquatic environment. According to [18], the optimal value of orthophosphate for phytoplankton growth ranges from 0.09 to 1.80 mg/l.
3.1.9 Nitrate

Figure 10 shows the results of nitrate measurement of 0.031 – 0.211 mg/l. The highest value on the first week at station 1 and the lowest on the second week at station 2. The results of nitrate in Lekok waters are far below the specified threshold. Optimal nitrate levels for phytoplankton growth are in the range of 3.9 – 15.5 ppm [19]. The nitrate content in the waters based on the fertility level is 0 – 1 mg/l including the oligotrophic category and 1 – 5 including the mesotrophic category [20].

3.1.10 Silica

Figure 11 shows the silica value of 1.405 – 5.202 mg/l. The highest value was at the first week at station 1 and the lowest was on the third week at station 3. The result of Silica in the Lekok coast are still in good condition. According to [21], if the silica content is less than 0.5 mg/l, the phytoplankton, especially diatoms, can’t develop properly.

3.1.11 Total Phosphate

Figure 12. Total Phosphate
Figure 12 shows the total phosphate value of $0.017 - 0.576$ mg/l. The highest value was on the fourth week at station 2 and the lowest was on the first and second week at station 2. Based on the total P values, the Lekok coast is classified as a medium to high fertility level. According to [22], the classification of trophic status based on nutrient content is as follows: low fertility with total phosphate levels $0 - 0.01$ mg/m$^3$, fertility moderate with levels $> 0.01 - 0.1$ mg/m$^3$ and high fertility with levels $> 0.1$ mg/m$^3$.  

3.1.12 Total Nitrogen

Figure 13 shows the total nitrogen value of $0.011 - 0.650$ mg/l. The highest value was on the first week at station 1 and the lowest on the first week at station 3. Based on the total N value, Lekok waters are classified as low to medium fertility. According to [23], low fertility with a Total N value of $0 - 0.1$ mg/m$^3$, moderate fertility with a Total N value of $> 0.1 - 1$ mg/m$^3$ and a high fertility rate with a Total N level of $> 1$ mg/m$^3$.

3.1.13 Chlorophyll-a

Figure 14 shows the value of chlorophyll-a of $0.417 - 3.222$ mg/l. The highest chlorophyll-a was on the second and third week at station 3, the lowest value was on the fourth week at station 3. The fertility status of Lekok waters based on chlorophyll-a content is classified as oligotrophic – mesotrophic waters. Fertility status based on chlorophyll-a values $0 - 2$ mg/l is classified as oligotrophic, $2-5$ mg/l is classified as meso-oligotrophic, $5 -20$ mg/l is classified as mesotrophic, $20 – 50$ mg/l is classified as eutrophic and $> 50$ mg/l is classified as hyper-eutrophic [24].

3.2 Abundance of Phytoplankton
Figure 15 shows the abundance value of phytoplankton of 251 – 9765 cell/l. The highest abundance was on the third week at station 2 and the lowest was on the first week at station 1. Because in this location (station 2) the nitrate concentration is higher than other locations. Lekok coastal waters are classified as oligotrophic - mesotrophic waters. According to [25], oligotrophic waters with an abundance of phytoplankton ranging from 0 – 2000 cell/l, mesotrophic waters with an abundance of phytoplankton at 2000 – 15,000 cell/l and eutrophic waters with a range of >15,000 cell/l.

3.3 Diversity Index
The diversity index value was 0.187 – 0.652. Phytoplankton diversity index in Lekok waters is in the low category. The diversity index shows a low value which means that these waters are polluted. This is in accordance with the statement of [26], that the value of $H' \leq 3$ includes moderate diversity and the value of $1 \leq H' \leq 3$ includes moderate community stability.

3.4 Dominance Index
The results of the dominance index was 0.018 – 0.390. The value is close to 0 meaning that there is no certain species that dominates in the coastal waters of Lekok. This is in accordance with the statement of [25], a dominance index value of $0 < C > 0.5$ indicates that there is no dominant species and $0.5 < C < 1$ indicates the presence of a dominant species in these waters.

3.5 Trophic Index (TRIX) Data Analysis
Figure 16 shows the Trophic Index value of 0.146 – 0.995. The highest value was on the second week at station 1 and the lowest was on the first week at station 2. Based on the Trophic Index values, the fertility status of Lekok coastal waters is classified as oligotrophic waters. This is supported by the low abundance of phytoplankton, chlorophyll-a and several water quality parameters that support phytoplankton growth such as temperature, brightness, nitrate, and total nitrogen are less than optimal. The waters criteria based on the TRIX index are oligotrophic waters with an index scale of 0-4, mesotrophic waters with an index scale of 4-5, eutrophic waters with an index scale of 5-6, and hypereutrophic with an index scale of 6-10 [5].

4. Conclusions
Based on the results of the abundance of phytoplankton in the coastal waters of Lekok, it is classified into waters that have oligotrophic fertility levels. The results of observations and measurements of physical and chemical parameters in the coastal waters of Lekok showed that several parameters that support the growth of phytoplankton are less than optimal, such as temperature, brightness and nitrogen elements.

Acknowledgement
We appreciate the Chancellor of Universitas Brawijaya about Research Grant Program for Professors and Doctors which financially supports activities that produce quality research-based innovations to improve academic quality.

References
[1] Meliala E G, P W Purnomo dan A Rahman 2019 Journal of Maquares 8(3): 162-168
[2] Fransisca A 2011 Jurnal Perencanaan Wilayah dan Kota 22(2): 145 – 160
[3] Haryono M G, Mulyanto dan Y Kilawati 2017 Jurnal Ilmu Teknologi Kelautan Tropis 9(1): 1-7
[4] Alfionita A N A, Patang dan E Kaseng 2019 Jurnal Pendidikan Teknologi Pertanian 5(1):9-23
[5] Tammi T, Niken T M, Pratiwi, S Hariyadi dan I N Radiarta 2015 Jurnal Riset Akuakultur 10(2): 271-281
[6] Sofarini D 2012 Enviroscientea 8. 30-34
[7] Panjaitan R 2017 Universitas Riau
[8] Iswanto C L, S Hutabarat dan P W Purnomo 2015 Diponegoro Journal of Maquares 4(3): 84-90
[9] Soliha E, S Y Rahayu dan Triastinurmi 2016 Ekologia 16(2): 1 -10
[10] Khasanah R I, Sartimbul A, dan Herawati E Y 2013 Ilmu Kelautan 18(4):193-202
[11] Tambaru R, A H Muhidin dan H S Malida 2014 Jurnal Ilmu Kelautan dan Perikanan. 24(3):40 48
[12] Darmawan A, B Sulardiono dan Haeruddin 2018 Journal of Maquares 7(1): 1 -8
[13] Patty S, H Arafah dan M Abdul 2015 Jurnal Pesisir dan Laut Tropis 1(1): 44-50
[14] Lantang B dan C Pakidi 2015 Jurnal Ilmiah Agribisnis dan Perikanan 8(2): 13-19
[15] Mustofa A 2015 Jurnal Disprotek 6(1): 13-19
[16] Panggabean L S dan P Prastowo 2017 Jurnal Biosains 3(2): 81-85
[17] Yulfiperinus, M Z Toelihere, R Affandi dan D S Sjafei 2004 Jurnal Iktiologi Indonesia 4(1):1-5
[18] Permatahari, R D Djuwito dan Irwani 2016 Diponegoro Journal of Maquares 5(4): 224-232
[19] Patty S, D Nurdiansyah dan N Akbar 2020 Jurnal Ilmu Kelauran Kepulauan 3(1): 77 – 87
[20] Rumanti M, S Rudiyanti dan M N Suparjo 2014 Diponegoro Journal of Maquares 3(1): 168 – 176
[21] Isnaeni N, Suryanti dan P W Purnomo 2015 Diponegoro Journal of Maquares 4(2): 75-81
[22] Umiatun S, Carmudi dan Christiani 2017 Scripta Biologica 4(1): 61 -67
[22] Irawati N 2014 *Jurnal Ilmu Perikanan dan Sumberdaya Perairan* 193-200
[23] Adani N G, M R Muskanonfola dan I B Hendrarto 2013 *Diponegoro Journal of Maquares* 2(4): 38-45
[24] Sidaningrat I G A N, I W Arthana dan E W Suryaningtyas 2018 *Jurnal Metamorfosa* 5(1): 79-84
[25] Yuliana, E M Adiwilaga, E Harris dan N T M Pratiwi 2012 *Jurnal akuatika* 3(2): 169 – 179
[26] Anggara, N E Kartijono dan P M H Bodijantoro 2017 *Jurnal MIPA* 40(2): 74-79