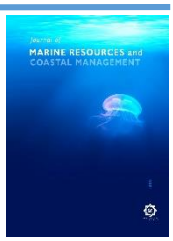
JOURNAL OF MARINE RESOURCES AND COASTAL MANAGEMENT
INDONESIAN JOURNAL OF MARINE LIFE AND UTILIZATION

e-ISSN : xxx-xxx
Vol. 1 Issue 1



Fertility Evaluation of Coral Reef Ecosystems By Phytoplankton as Bioindicators at Watu Lawang Sites, Pasir Putih Beach, Situbondo

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ABSTRACT

The level of aquatic fertility was closely related to the abundance and compositance of plankton. Phytoplankton was a biological parameter that can be used as an indicator of the fertility of a waters. The purpose of this study was to determined the community structure of phytoplankton and the level of fertility in the waters of Pasir Putih beach, Situbondo. The study was conducted in April 2018 at Watu Lawang, Pasir Putih Beach, Situbondo. The Sampling used purposive sampling method. Seawater samples were filtered on the surface of each station used plankton net number 25. Furthermore, water samples were identified in the Microbiology Laboratory of Sunan Ampel UIN Surabaya. The results of identification of phytoplankton in the waters of Watu Lawang, Pasir Putih Beach, Situbondo obtained 4 classes, consisted of family Bacillariophyceae, Cyanophyceae, Chlorophyceae, and Dinophyceae, with a composition of 9 genus. The phytoplankton composition found during the study was dominated by the Bacillariophyceae class. The genus Bacteriastrum sp. and Chaetoceros sp. were found in all observation stations. The highest phytoplankton abundance at station IV with an abundance value of 1670 cells L^{-1}. And the lowest abundance of phytoplankton at station I with an abundance value of 730 cells L^{-1}. The diversity of phytoplankton was categorized in the low diversity level (H'<2.3). The Uniformity index value was classified as unstable (0 <E <0.5). On the other hand, The average value of the Saprobic Index in the waters of Watu Lawang, Pasir Putih, Situbondo i.e. 1.6 which was classified as the Oligosaprobic phase (very slight polluted).

Keywords*:* Waters Fertility, Phytoplankton, Pasir Putih Beach, Situbondo

INTRODUCTION

Indonesian waters have considerable resource potential, either in shallow water or in deep waters (deep ocean). Long shallow waters allow the growth of species that have a high level of diversity. The high-level of diversity (biodiversity) and waters fertility in coastal and marine ecosystems is closely relate from the role of microscopic organisms (plankton) in aquatic ecosystems. The level of aquatic fertility is closely relate to the abundance and composition of phytoplankton. The ability of phytoplankton will be decrease if there is damage to the surrounding environment, such as waste pollution, damage on coral reefs, logging of mangrove forests, etc. [1]. When water use increases as a means of various types of community activities it can cause changes in biological, physical and chemical factors in a waters. The existence and activity of phytoplankton is relate to the aquatic environment and its surroundings. The existence of phytoplankton in a waters can provide information about the condition of a waters. So, phytoplankton is biological parameters that can be uses as indicators to determine the quality and fertility level of a waters [2].

The waters of Pasir Putih Beach, Situbondo, can not be separate from community activities such as fishing and tourism activities (diving or snorkeling). If they are done incorrectly, they will have a negative impact on the quality of the resources of the waters of Pasir Putih Situbondo. The decrease of the quality waters in Pasir Putih Beach, Situbondo, will be affect the abundance and community structure of phytoplankton in these waters. So, The research was aimed to determine the phytoplankton community structure and the level of waters fertility in the waters of Watu Lawang, Pasir Putih Beach, Situbondo. This studied can be add insight and can be give to provide scientific information about abundance, phytoplankton community structure and fertility conditions in the waters of Pasir Putih Situbondo.

RESEARCH METHODS

Sample Collection

This research was conducted in Batu Lawang, Pasir Putih Beach, Situbondo, East Java, in April - May 2018. Seawater sampling was conducted out in 5 (five) points on the coral reef area (**Fig. 1**). Seawater samples were

Fig. 1. Research Site

identified at the Microbiology Laboratory, Universitas Islam Negeri (UIN) Sunan Ampel Surabaya.

Collection of environmental parameter data of physical and chemical conditions of water were conducted at each of the determined observation stations. The parameters measured directly (in situ) included pH, temperature, salinity, Dissolved Oxygen (DO), and brightness. While, for chemical parameters, samples were analyzed in the laboratory using a spectrophotometric method from 1 L of water sampling in each location. The methods and tools used in measuring the physical and chemical parameters of the waters were presented (Table 1).

On the other hand, the measurement of plankton abundance was done by taking samples of sea water at each observation stations. The seawater sampling was conducted on the surface of the water as much as 100 liters which was then filtered using Plankton Net No. 25. The results of filter in the form of concentration of 100 liters of waters is 125 ml which is poured into a sample bottle, then preserved with lugol solution. Furthermore, samples were analyzed in the Microbiology Laboratory of UIN Sunan Ampel Surabaya.

Table 1. Methods and tools used in measuring physical and chemical parameters of waters

Parameters	Unit	Methods and Tools	Exp.
Physicals			
Transparency	m	*Secchi Disc*/visual	*In situ*
Temperature	^{o}C	DO meter/ visual	*In situ*
Chemicals			
Dissolve Oxygen	mg/L	DO meter/ visual	*In situ*
pH	-	pH paper/visual	*In situ*
Salinity	$^{0}/_{00}$	Salinometer/visual	*In situ*
Nitrate	mg/L	Spektofotometer/APHA 4500 NO_3-E, eds 2012	Lab
Phosphate	mg/L	Spektofotometer/APHA 4500 P-E, eds 2012	Lab

Data Analysis

Data obtained from observations were then analyzed to determine the abundance of plankton (N), Diversity Index (H'), Uniformity Index (E), and Waters Fertility Rate.

Plankton abundance analysis was calculated using a formula as follow [14]:

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

Where :
N : phytoplankton abundance (cells L-1);
Oi : cover-glass area (mm2);
Op : view area (mm2);
Vr : filtered water volume (ml);
Vo : observed water volume (ml);
Vs : volume of filtered sea water sample (L);
n : number of phytoplankton in the entire view area (cells);
p : number of view areas (mm2).

Diversity index value was used to determine the level of plankton diversity in a population. The Shannon-Wiener index equation is using a formula as follow [15]:

$$H' = \sum_{i=0}^{i} pi \ln pi$$

Where :
H' : diversity index;
pi : ni/N
ni : the number of individuals in species-i;
N : the total number of individuals in the community.

The Diversity index values can be classified as follows :
H' < 2.3 = low diversity level
2.3 < H' < 6.9 = moderate level of diversity
H' > 6.9 = high level of diversity

The uniformity index value was used to indicate the number of similarities between the types of plankton in a population. The uniformity index is using a formula as follows [16]:

$$E = \frac{H'}{Hmaks}$$

Where :
E : Evenness index;
H' : Shannon-Wiener indes;
Hmaks : ln S;
S : the total number of identified families.

Furthermore, if the value of E is 0-0.5, then equity among species is low, this means that the individual by each species is very much different. However, if E is 0.6-1, even distribution between species is relatively uniform, this mean that the number of individuals in each species is relatively the same.

Pollution level calculations used the Saprobic Qoutient. The Saprobic system was used to see only the dominant group of organisms to determine the level of pollution (Table 2) with the following formula [17] :

$$X = \frac{C+3D-B-3A}{A+B+C+D}$$

Where :
X : Saprobic quotient (-3 to 3);
A : The Cyanophyta abundance ;
B : The Dynophyta abundance;
C : The Chlorophyta abundance;
D : The Bacillariophyta/ Chrysophyta abundance.
A,B,C,D : the number of different organisms in each community.

Table 2. Water Pollution Levels Based on Saprobic Qoutient (X)

Load	Pollutions Level	Saprobic Phase	Saprobic Qoutient (X)
Many Organic Substances	Very severe	Polysapobric	(-3)/(-2)
		Poly/α-mesosaprobic	(-2)/ (-1.5)
	Considirable	α-meso/ polysaprobic	(-1.5)/ (-1.0)
		α-mesosaprobic	(-1.0)/ (-0.5)
Organic and	Moderate	β-mesosaprobic	(-0.5)/ (0)

Load	Pollutions Level	Saprobic Phase	Saprobic Qoutient (X)
Inorganic Substances	Slight	β/ α mesosaprobic	(0)/(0.5)
		β- mesosaprobic	(0.5)/ (1.0)
		β- meso/ oligosaprobic	(1.0)/ (1.5)
Few Organic and Inorganic Substances	Very Slight	Oligo/ β- mesosaprobic	(1.5)/ (2.0)
		Oligosaprobic	(2.0)/ (3.0)

RESULTS AND DISCUSSIONS

Phytoplankton research on coral reef ecosystems in Watu Lawang Waters, Pasir Putih Beach, Situbondo found phytoplankton composition in the form of 15 genus of phytoplankton which were included Bacillariophyceae (11 Genus), Dinophyceae (1 Genus), Cyanophyceae (2 Genus), and Chlorophyceae (1 Genus). The classes of Bacillariophyceae were found at each observation station. The value of phytoplankton abundance of the Bacillariophyceae class from each studied location ranged between 190 - 1340 cell L^{-1} (**Fig. 2**).

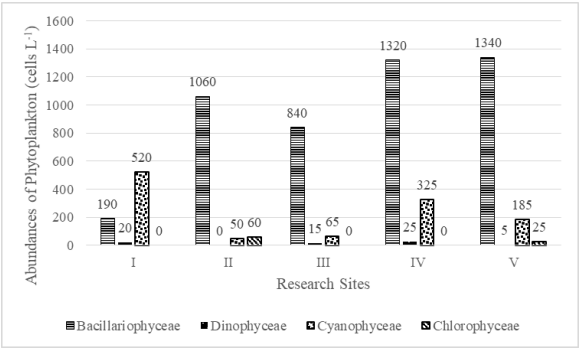

Fig. 2. Comparison chart of phytoplankton composition and abundance

The results of the identification were showed that the genus Chaetoceros sp and Bacteriastrum sp from the Bacillariophyceae class dominated compared to several other genus. On the other hand, phytoplankton from the Cyanophyceae class were also found in all locations with abundance values ranging from 50 - 520 cells L-1. The phytoplankton of the Dinophyceae class were only found in research locations I, III, IV and V with abundance values ranging from 5 - 25 cells L-1. Further, the phytoplankton of the Chlorophyceae class were found in research locations II and V with abundance values of 60 and 25 cells L-1.

The abundance of phytoplankton at each station ranged between 730 - 1670 cells L-1. The highest value of phytoplankton abundance was found in station IV which was 1670 cells L-1 and the lowest was found at station 1 which was 730 cells L-1 (**Fig. 3**).

The high value of abundance at locations IV and V that were possible because in the region there are artificial reefs structure form concrete and it able to fertilize the waters. The existence of artificial reefs in a waters can affect the conditions of temperature, salinity and transparency, even can increase the amount of plankton abundance in the waters [21]. The existence of artificial reefs, made the nutrients carried away by currents would be trapping in artificial reef areas, which are then used by phytoplankton to grow.

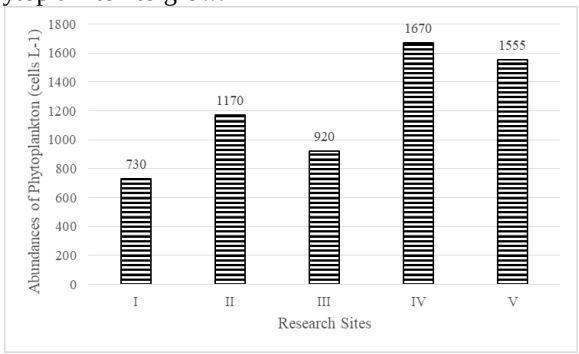

Fig. 3. Comparison of phytoplankton abundance value

The population of phytoplankton in the coral reefs area in Watu Lawang, Pasir Putih beach, Situbondo waters was dominated by the Bacillariophyceae class with a population percentage of 79%. Furthermore, phytoplankton from the Cyanophyceae class with a percentage of the population was 19%. Phytoplankton from the Chlorophyceae and Dinophyceae classes have a population value of only 1% (**Fig. 4**).

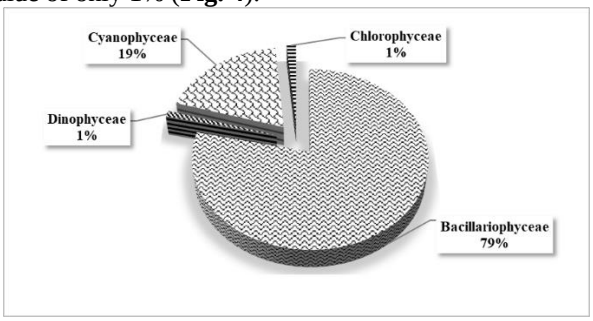

Fig. 4. Percentage of phytoplankton population

The phytoplankton composition found during the observation was dominated by the Bacillariophyceae class. The Bacillariophyceae class able to adjust itself well of the waters environment, compare to other phytoplankton classes [18]. Bacillariophyceae class is find in tropical waters with a high abundance value, because phytoplankton from this class has a faster multiplication rate compare to other classes of phytoplankton [19]. However, some of the Bacillariophyceae Class there are also classes of phytoplankton which were also find in open waters. Phytoplankton from the Cyanophyceae and Dinophyceae classes are also often find in waters even though their abundance and distributance values not always the same [20].

Adaptability of the Dinophyceae class is lower than the Bacillariophyceae class, so its existence in the waters is lower than that of the phytoplankton of the Bacillariophyceae class. The class of Dinoflagellata (Dinophyceae) is a group of phytoplankton commonly find in waters after diatoms (Bacillariophyceae) [12]. The Chlorophyceae class was found in this study, due to the sampling location point close to the estuary. Freshwater phytoplankton species (Chlorophyceae) are carried by the river flow to the estuary area to the sea waters [18].

Based on the result (**Fig. 5**), it was found that the highest diversity was saw at station I with the measurement

results of 0.69. Then followed by station IV with a diversity value of 0.57. On the other hand, station V has a diversity value of 0.47. Furthermore, with a diversity value of 0.38, it was found at station II. The station with the lowest diversity value was found at station III, with a diversity value of 0.34.

The research sites has a diversity index value ranging between 0.34 - 0.69. Based on the range of index values, the diversity of phytoplankton in the coral reefs ecosystem in the waters of Watu Lawang, Pasir Putih beach, Situbondo was categorized in the low diversity level, which was H ' < 2.3 [15]. This was due to the dominating species of the genus Chaetoceros sp and Bacteriastrum sp from the Bacillariophyceae class. The higher the value (H') in a waters, shows the more diverse life in these waters, as well as the stable condition of the waters [25].

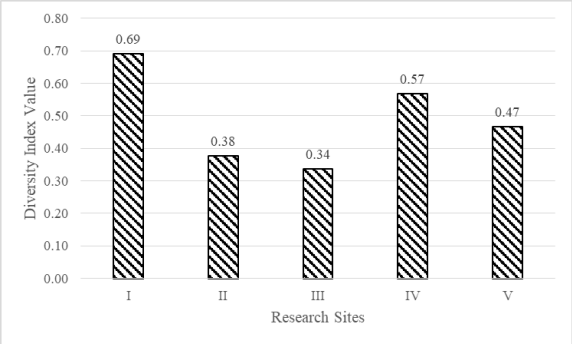

Fig. 5. Phytoplankton diversity level

On the other hand, the uniformity index value ranged from 0.17 - 0.35, where the highest level of uniformity was found at station I with a value of 0.35 (**Fig. 6**). While the location of the study with the lowest uniformity value was at station II with a value of 0.17. This showed that in all observation locations there a low level of uniformity between species, in other words there are several species that dominate. A high uniformity index value was indicated that the plankton community in good condition (stable). This was because the number and uniformity do not differ greatly or do not dominantly [10]. This event can be caused by changes in the condition of waters ecosystems, so that only a few species was able to adapt well to these conditions. Availability of nutrients in the waters can be affect the level of phytoplankton uniformity in a waters [22].

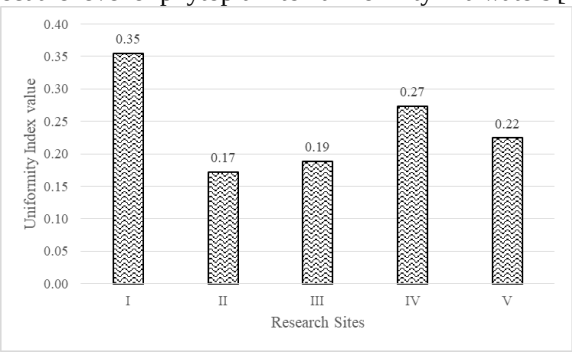

Fig. 6. Uniformity index value

The water quality (physics and chemistry) were measuremed in the research sites which were representations of the coral reefs ecosystem in Watu Lawang waters, Pasir Putih beach, Situbondo (**Table 3**).

Table 3. The waters phyisical-chemical parameters

Parameters	Research Sites				
	I	II	III	IV	V
Temperature (°C)	30.5	30.6	30.8	30.9	32.8
Transparency (Meters)	4.6	3.9	4.7	6.3	6.5
DO (mg/l)	7.01	6.83	7.02	7.2	7.7
Salinity (°/₀₀)	33.03	33.2	32.8	32.9	32.8
pH	7	7	7	8	8
Nitrate (mg/l)	0.014	-	-	0.013	-
Phosphate (mg/l)	0.031	-	-	0.024	-

The temperatures were measured in all research sites, the result were ranged from 30.5 to 32.8 oC. The difference in temperature range between stations can caused due to differences in research sites and measurement time differences. Temperature is one of the factors that can affect the plankton abundance. Temperature can affect the photosynthesis rate of plankton in a waters. The rates of photosynthesis of Phytoplankton at a certain level are following the rate of temperature rise [19].

The transparency values at each station was ranged from 3.9 to 6.5 meters. Brightness is an important factor for the life of phytoplankton. Brightness will affect the photosynthesis rate of phytoplankton. The waters that has high transparency levels can be affecting abundance of the plankton in these waters [23,24].

Dissolved Oxygen (DO) played an important role for waters biota. The results of the measurements showed DO values at the study location ranged from 6.83 to 7.70 mg /L. The waters that have low oxygen levels will inhibit the growth of biota, can even cause death in waters biota [24].

The Salinity levels in the waters of Watu Lawang, Pasir Putih beach, Situbondo were ranged from 32.8 to 33.2 0/00. Salinity is a factor that can affect the distribution pattern of plankton. The high level of salinity can be affected by the existence of differences in water circulation patterns, wherein each ecosystem has a different basic shape as which as allowed different current patterns [12].

The results of pH measurements at each research sites obtained of pH values from 7 to 8. The degree of acidity (pH) is one of the factors that can influence the rate of photosynthesis. The process of photosynthesis by plankton will run optimally with pH under normal conditions [10].

The result measured of Nitrate in each research sites were not much different, i.e from 0.013 to 0.014 mg /L. Nitrate is an important element as a nutrient for plankton growth. The nitrate is a limiting factor and can affect the rate of productivity of phytoplankton [7].

On the other hand, the results of the Phosphate in each research sites were obtained value from 0.024 to 0.031 mg /L. Phosphate is an important nutrient for the growth of phytoplankton. Nutrient phosphate is a limiting factor for phytoplankton growth, if the content in the waters is in a less than optimal condition. On the other hand,

phytoplankton has a high adsorption capacity of phosphate nutrients on the surface of the waters [7].

The results of environmental parameters of Watu Lawang, Pasir Putih beach, Situbondo waters, which included physical parameters (transparency and temperature) and chemical parameters (DO, salinity, pH, nitrate and phosphate) were under normal conditions. The condition means that the waters in point of physical-chemical parameters were in good condition for the growth of marine biota, especially phytoplankton.

The level of pollution in the waters of Watu Lawang, Pasir Putih beach, Situbondo was measured by the Saprobic coefficient. The phytoplankton saprobic index values along with the level of pollutions and indications of pollutants (**Table 4**).

Table 4. The results of analysis of saprobic coefficient (X) phytoplankton

Sites	Saprobic Qoutient (X)	Saprobic Phase	Pollutions Level	Load
I	-1.4	α-meso/ poly-saprobic	Consi-dirable	Many Organic Substances
II	2.6	Oligo-saprobic	Very Slight	Few Organic and Inorganic Substances
III	2.5	Oligo-saprobic	Very Slight	
IV	1.8	Oligo/ β- meso-saprobic	Very Slight	
V	2.2	Oligo-saprobic	Very Slight	

The value of Saprobic coefficients of phytoplankton in 5 (five) stations on the coral reef ecosystem in Watu Lawang waters , Pasir Putih beach, Situbondo ranged from -1.4 to 2.6. Based on the pollution level criteria, the pollution levels were categorized form considerable until very slight.

The condition of the waters with a considerable level of pollution occured at station I with the saprobic index value i.e. -1.4, it was classified as the α-polisaprobic phase. The indication of pollutants at station I was organic matter. The heavy condition of pollution waters is due to tourism activities or domestic activities around the waters. The calculation result of this saprobic coefficient was directly proportional to the low phytoplankton abundance at station I. It was indicated that the organic material found at station I has not been utilized by The phytoplankton. Phytoplankton has a different level of sensitivity and tolerance to pollutants, so it can be use as an indicator of changes in the quality of the waters environment. When phytoplankton has a very tolerant of pollutants, make the phytoplankton is able to survive in environmental conditions with high condition pressure [26].

On the other hand, at stations II, III, IV and V have very slight pollution levels with the Oligosaprobic phase with saprobic coefficient values were ranged from 1.8 to 2.6. However, if viewed as a whole, the average value of the Saprobic Index in the waters of Watu Lawang, Pasir Putih beach, Situbondo i.e. 1.6 which was classified as the Oligosaprobic phase, in another sense which was very slightly polluted.

CONCLUSIONS

The average value of the Saprobic Index in the waters of Watu Lawang, Pasir Putih beach, Situbondo was 1.6. The condition was classified as the Oligosaprobic phase (very slight polluted). This could be seen in the highest phytoplankton abundance at station IV with an abundance value of 1670 cells L-1. And the lowest abundance of phytoplankton at station I with an abundance value of 730 cells L-1. The diversity level of phytoplankton was categorized in the low diversity level (H’ < 2.3). On the other hand the Uniformity index value was classified as unstable (0 < E <0.5).

ACKNOWLEDGMENT

The authors thank to Ministry of Marine Affairs and Fisheries Indonesia and Ministry of Research for funding this research.

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