J. Pijar MIPA, Vol. 18 No. 5, September 2023: 816-821
DOI: 10.29303/jpm.v18i5.5487

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

PHYTOPLANKTON DIVERSITY AS A BIOINDICATOR FOR WATER QUALITY OF TANJUNG AAN, SEZ MANDALIKA CENTRAL LOMBOK

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Received: August 3, 2023. Accepted: August 16, 2023. Published: September 30, 2023

Abstract: Coastal waters of the Special Economic Zone (SEZ) Mandalika must be given more attention as it is the centre of tourism activities, including the International GP motor circuit on the island of Lombok. One of the bioindicators used in determining water quality is phytoplankton. Phytoplankton is tiny organisms that float on the water, have very weak swimming abilities, and their movements are heavily influenced by water flow. This research aimed to determine the diversity of phytoplankton as a bioindicator in the waters of Tanjung Aan, Central Lombok. Sampling sites in Tanjung Aan were determined by purposive sampling. This research was conducted from March to June 2023. The research results showed that there were six classes, 56 families, and 56 genera with 128 species in the community of phytoplankton. Species 113 were members of the class Bacillariophyceae. The phytoplankton abundance in three sampling sites ranged from 488 ind/L to 1109 ind/L. The species diversity indexes of phytoplankton in the three sampling sites ranged from 2.4 to 2.9, which means that the diversity is in the low category, and the species dominance index ranges from 0.12 to 0.15. This indicates that the condition of the waters of Tanjung Aan is slightly polluted.

Keywords: *Phytoplankton, Diversity, Bioindicator, Water Quality, Tanjung Aan*

INTRODUCTION

The Mandalika Special Economic Zone (KEK) is a special economic area focusing on tourism development in the southern part of Lombok Island, Central Lombok Regency, West Nusa Tenggara. The Mandalika SEZ is stipulated in Government Regulation 52 of 2014 with an area of 1,035.67 Ha, stretching directly into the Indian Ocean. KEK Mandalika has become a tourist area with beautiful white sandy beaches and underwater charm [1].

The coastal waters of the Mandalika SEZ need attention because they are the centre of tourist activities on Lombok Island, including the CircuitmotoGP International. These activities cause the number of tourists to continue to increase so that the amount of organic and inorganic waste produced will be greater. This will harm water areas, namely the entry of waste into water bodies, which results in changes in water quality.

Observing changes in water quality is carried out using various approaches, including chemical, physical, and biological analysis. Chemical and physical analysis of water is less accurate in describing water quality because the measured values can be influenced by changing environmental conditions. On the other hand, measuring biological factors can provide a more accurate picture of water quality because it better reflects overall water conditions [2]. Aquatic organisms can be used as bioindicators of water pollution because they have characteristics that can reflect water conditions. These characteristics include mobility, habitat, and a relatively long lifespan [3].

Phytoplankton are microscopic organisms whose life hovers on the water's surface, has passive movement, and is strongly influenced by the mass of the water. Phytoplankton can be a bioindicator of water quality because it can provide information about water conditions. The composition of phytoplankton in waters can change to indicate a response to physical, chemical, and biological environmental changes. Changes in the type, size, and number of phytoplankton populations can describe community structure. Phytoplankton are aquatic organisms that can photosynthesize to produce carbohydrates as an energy source. Phytoplankton absorb carbon from their environment to form carbohydrates. The amount of carbon absorbed by phytoplankton is almost the same as that of carbon absorbed by plants on land. Globally, almost half of the amount of carbon absorbed in photosynthesis is carried out by phytoplankton [5].

Phytoplankton are autotrophic organisms that play an important role in aquatic ecosystems. Phytoplankton produces oxygen and nutrients needed by other aquatic organisms. A polluted environment causes the abundance and diversity of phytoplankton species to decrease. This can affect the quality or productivity of water [6].

Research related to phytoplankton diversity as a bioindicator of water quality has been widely carried out, including research on phytoplankton as a bioindicator in the waters of the Mandalika SEZ, Central Lombok, 72 phytoplankton species with a medium diversity index were identified and the waters were in the unpolluted category [7]. In research on phytoplankton as bioindicators on Klui Beach, North

Lombok, 48 species of Bacillariophyceae were identified with a medium diversity index and water conditions included in the unpolluted category [8]. Furthermore, in research in the waters of Kotok Besar Island, 18 types of phytoplankton were identified with a medium diversity index and water conditions included in the light to moderate pollution category [9].

Phytoplankton can describe water quality because, as unicellular organisms, they are sensitive to changes in the aquatic ecosystem. High phytoplankton diversity can reflect high primary productivity in aquatic ecosystems. Therefore, phytoplankton is a group of microscopic organisms used as bioindicators in measuring water quality. Reducing the amount of phytoplankton by up to 5% in the waters can reduce fish production by up to 70,000 tons per year [10].

Tanjung Aan is one of the bays in the Mandalika Special Economic Zone (SEZ), Central Lombok, which has enchanting sea beauty. The Tanjung Aan area includes recreation, tourism, fishing, *memadak*, and livestock farming. Tanjung Aan is one of the waters affected by the development and management of the Mandalika SEZ. One of the impacts that can occur is a decrease in water quality. A decline in water status can disrupt marine biota and affect the balance of the surrounding ecosystem, including phytoplankton diversity. Therefore, this research must be carried out to determine the diversity of phytoplankton as a bioindicator of water quality in Tanjung Aan, Central Lombok Regency.

RESEARCH METHODS

Time and Place of Research

This research was carried out from March to June 2023 in the waters of Tanjung Aan, Central Lombok Regency (Figure 1). The samples were then observed and identified at the Advanced Biology Laboratory, Faculty of Mathematics and Natural Sciences, Mataram University.

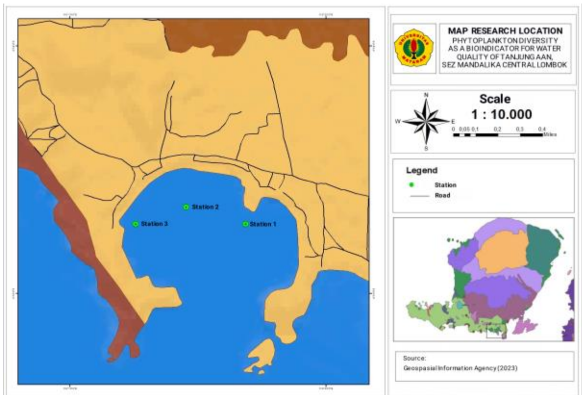

Figure 1. Sampling Map

Sampling Procedure

Phytoplankton water samples were taken from three collection points at each station from 09.00 to 13.00. The location of the sample is determined based on the purposive sampling technique, which consists of 3 stations with 3 points for each station. Tools and materials used include a 20 µm plankton net, sample bottle, identification book, camera, binocular microscope, glass slide, cover glass, dropper pipette, thermometer, digital pH meter, nitrate testing sticks, hand refractometer, stationery, current meter, Dry disks, label paper, water samples, 40% formalin, tissue, and distilled water.

A 50 mL seawater sample was obtained by filtering 100 L of seawater using a plankton net. The water samples are filtered using a plankton net with a mesh size of 20 µm. Samples were preserved with formalin at a preservation concentration of 4%. The samples were observed, and their species were identified at the Advanced Biology Laboratory, FMIPA University Mataram. The species of phytoplankton obtained were identified based on morphological characteristics based on identification books from [11-15].

Data analysis

The observation data calculated the species' abundance, diversity, and dominance. The individual abundance of each phytoplankton species was calculated using the equation [16]. The phytoplankton species diversity index is calculated using the Shannon-Wiener diversity index and the dominance index using the dominance index equation *Simpson* [17]. Water pollution criteria based on the phytoplankton species diversity index can be seen in Table 1, and species dominance index criteria can be seen in Table 2 [17].

Table 1. Species Diversity Index Value Criteria

Diversity Index	Diversity Category	Pollution Category
H' < 1	Low	Heavily polluted
1 < H'< 3	Currently	Lightly polluted
H'> 3	Height	Not polluted

Table 2. Species Dominance Index Value Criteria

Dominance Index	Dominance Category
0 < C < 0.5	Low
0.5 < C< 0.75	Currently
0.75 < C< 1	Height

RESULTS AND DISCUSSION

Phytoplankton Species Composition

Based on the identification results, it was found that there were 128 phytoplankton species consisting of 6 classes, 56 families, and 56 genera. The most species come from the Bacillariophyceae class, namely 113 phytoplankton species, then the Cyanophyceae class with nine species, the Demospongiae class with three species, the Dinophyceae class with one species, the

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Florideophyceae class with one species, and one species from the Ulvophyceae class.

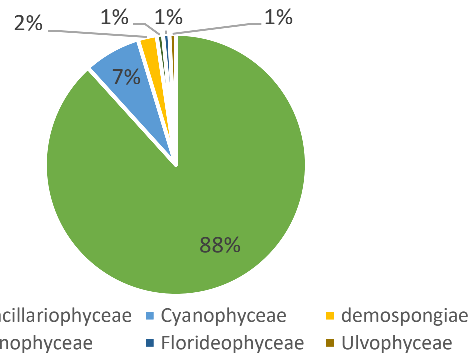

Figure 2. Percentage of Phytoplankton Class Presence in Tanjung Aan Waters

The percentage of phytoplankton presence in Tanjung Aan waters at the three stations can be seen in Figure 2. The percentage of presence of the Bacillariophyceae class was the highest at 88%, followed by the Cyanophyceae class at 7%, the Demospongiae class at 2%, the Dinophyceae class, the Florideophyceae class, and the Ulvophyceae class at 1%.

The diversity of phytoplankton species from the Bacillariophyceae class in Tanjung Aan waters is the highest because this class has a high tolerance for changes in environmental conditions and can adapt well to waters with high temperatures [18]. Temperature is one of the most important factors for the survival of phytoplankton. The temperatures measured at the three stations ranged between 30.2 – 31.4 °C. The measured temperature is suitable. Namely, phytoplankton can live well in the temperature range of 30°C-33°C [19]. Apart from that, the large number of Bacillariophyceae classes is due to the cosmopolitan nature of this class, which has a high reproductive power compared to other classes [20]. The results of this research align with previous research conducted in the waters of the Lombok Strait, which showed that the Bacillariophyceae class was the most commonly found phytoplankton class, namely 74% [21]. Bacillariophyceae are found in aquatic ecosystems as single cells, colonies, and filaments with 200 genera or more than 100,000 species and have high photosynthetic activity [22].

Most of the Genus Chaetoceros from the Bacillariophyceae class were found, especially at station 3, namely 14 species. Diversity of Genus species *environmental factors, both physical and chemical factors, such as light intensity, temperature, pH, and other factors influence Chaetoceros*. Light intensity is the main factor in carrying out the photosynthesis process [23]. In Table 3, The measured brightness values are considered good for growth. Similar research was carried out in the coastal waters of the Mandalika SEZ, with the Genus *Chaetoceros* found most often [7]. Research in the Tanjung Luar Fishing Harbor (PPI) waters also reported the highest abundance of the Genus Chaetoceros found compared to other genera [24]. The abundance of *Chaetoceros*, which is high, is due to having a unique body size and body shape in the form of a chain or collection of cells, which herbivorous predators less favour. *Chaetoceros* are adaptable to extreme environments and can carry out photosynthesis optimally, thus producing many species in this area [25].

Chaetoceros have an important role: they can become natural food for aquatic biota in the larval phase with high nutrition, are small in size, easy to cultivate, and reproduce quickly, so it is very important for aquatic ecosystems [26]. Besides *Chaetoceros*, Genus is found *Nitzschia*. It can also be used as natural food in the larval phase of marine organisms such as crustaceans, fish, and bivalves. This Genus has high reproductive power and is easy to cultivate [27].

Phytoplankton Abundance

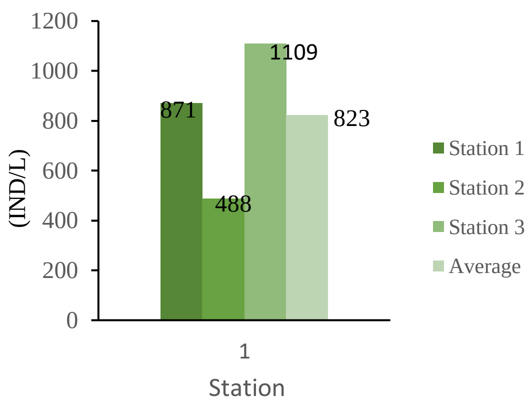

Figure 3. Comparison of Phytoplankton Abundance at Each Research Station

The most abundant phytoplankton was found at station 3, with an abundance value of 1109 ind/L. Station 1 has a lower abundance, namely 871 ind/L. Station 2 has the lowest abundance, namely 488 ind/L. (Figure 3). Differences in abundance in Tanjung Aan waters are caused by activities around the waters and environmental conditions at each station. Each region has different anthropogenic influences, and environmental conditions can influence phytoplankton abundance in waters [28].

The high abundance of phytoplankton at station 3 is due to environmental factors such as temperature, salinity, and nitrate, which are good for phytoplankton growth. Nitrate is one of the factors that play an important role in determining the abundance of phytoplankton because it is a nutrient needed by phytoplankton [18]. The nitrate concentration measured at Station 3 was higher than at Stations 1 and 2, namely 0.1 mg/L (Table 3). The abundance of phytoplankton at station 3, which is higher than the other stations, can be caused by the presence of estuaries at this station. Estuaries are a rich source of nutrients to support phytoplankton's growth. Apart from that, the influencing environmental factor is salinity. The optimum salinity for phytoplankton survival is 30-35 ppt [29]. The salinity value measured during observation was 30 ppt, so this value was categorized as a good value for the survival of phytoplankton.

At station 1, high abundance values were obtained after station 3 because this area had little activity, so the community of phytoplankton species was stable. **Table 3** shows that the physical and chemical conditions of the water are in optimal conditions, allowing phytoplankton activity to run well.

Table 3**.** Parameter values for the Physics and Chemistry of Tanjung Aan Waters, Central Lombok Regency

Parameter	Station I	Station II	Station III
pH	8	7.9	7.9
Temperature	30.2	31.3	31,4
(°C)	33	35	30
Salinity (ppt)	0.3	0.4	0.2
Current speed			
(m/s)	0.05	0.05	0.1
Nitrate (mg/L)	100	75	100
Brightness (%)			

Station 2 has the lowest phytoplankton abundance value because this area is used as a place for fishing boats to dock and bathing activities for tourists. This activity can impact the abundance of phytoplankton in Tanjung Aan waters. Apart from that, environmental factors greatly influence the abundance of phytoplankton, one of which is brightness. The brightness at station 2 is lower than at station 1 and station 3. This is caused by the large seagrass substrate, making it difficult for light to penetrate the water. This can disrupt the growth of phytoplankton, which needs light to photosynthesize.

The species with the highest abundance (311 ind/L) is *Trichodesmium erythraeum* found at station 3. *Trichodesmium erythraeum* is a genus from the class Cyanophyceae. this species has a long cylindrical shape and has a partition. There is a high abundance of the species Trichodesmium e*rythraeum* because it can bind nitrate elements in waters, making it easy to reproduce individuals quickly. In addition, this species is cosmopolitan and resistant to extreme environmental conditions. This species plays an important role in biogeochemical processes in marine waters [30]. The nitrate concentration at station 3 is higher than at stations 1 and 2, so phytoplankton abundance is also higher. In addition, the species *Trichodesmium erythraeum* can live at high water temperatures. Phytoplankton can grow and develop well at temperatures of 30°C-33°C. The temperature conditions of Tanjung Aan waters are within this range, so these waters can still support phytoplankton life [19].

Diversity and Dominance of Phytoplankton Species

The phytoplankton species diversity index (H') can be used to determine water quality [31]. Communities with a high level of diversity indicate that the area has a good, stable, or balanced ecosystem or waters and vice versa [32]. If the phytoplankton species diversity index (H') value is high, the plankton community will be more diverse and not dominated by just one species [33]. Comparative data on the species diversity index values for each station can be seen in Table 4.

Table 4. Diversity Index (H') and Phytoplankton Species Dominance Index (C) in Tanjung Aan Waters

Sampling Location	Diversity (H')	Dominance (C)
Station 1	2.4	0.14
Station 2	2.6	0.15
Station 3	2.9	0.12

Based on data in Table 4, the phytoplankton species diversity index in Tanjung Aan waters at Station 1, station 2, and Station 3 are all in the medium range. This shows that Tanjung Aan waters have a mildly polluted environmental condition. This statement is supported by research by Shannon and Wiener (1949), who stated that a decrease in the species diversity index indicates polluted environmental conditions. [17]. Waters with a species diversity index of 1< H' < 3 indicate that these waters have relatively stable and balanced environmental conditions. Optimal environmental conditions, such as pH and currents, support phytoplankton's growth and development, so the phytoplankton diversity index is high. Data from pH measurements in Tanjung Aan waters shows that the pH value of these waters ranges from 7.9 - 8. The optimum water pH value for phytoplankton growth is between 7-8.5. Thus, the pH conditions of Tanjung Aan waters still allow phytoplankton to grow and develop [34]. The results of the data analysis show that the current speed of Tanjung Aan waters at the three stations ranges between 0.2-0.4 m/s. This current speed is classified as a moderate current, which allows phytoplankton to grow and develop well [35].

The species with the highest Importance Value Index (INP) is *Trichodesmium erythraeum.* High INP of the species *Trichodesmium erythraeum* because it can bind nitrate elements in waters, making it easy to reproduce individuals quickly. In addition, this species is cosmopolitan and resistant to extreme environmental conditions. This species plays an important role in biogeochemical processes in marine waters [29].

Based on data in Table 4, it can be seen that Tanjung Aan waters have a low phytoplankton dominance index (C), which ranges from 0.12-0.15. A low dominance index value indicates that no phytoplankton species dominate the waters. This is supported by environmental conditions suitable for the growth of phytoplankton species, so competition between species does not occur. Stable environmental conditions and the absence of pressure on the biota in this habitat also support the diversity of phytoplankton species.

CONCLUSION

Phytoplankton identified in Tanjung Aan waters consists of 6 classes, 56 families, and 56 genera with 128 species. The abundance of phytoplankton species ranges from 488 ind/L - to 1109 ind/L. *Trichodesmium erythraeum* is a phytoplankton species with the highest importance value index (INP) and abundance in Tanjung Aan waters. The species diversity index is medium, and the dominance index is low (no dominant species). The condition of Tanjung Aan waters is in the lightly polluted category.

ACKNOWLEDGEMENTS

Thank you to the supervisor, Mrs. Dr. Dining Aidil Candri, S.Si., M.Si., and Drs. Lalu Japa, M.Sc.St., was willing to provide ideas, input, and suggestions and was always patient in guiding researchers. Thank you to Mr. Dwi Ampera Hananto, Laboratory Assistant for Advanced Marine Biology, who has helped researchers during the observation and identification of phytoplankton samples. Izma Paryantini, who always helped with sampling until the research was completed. Thank you to Salman Al Farisi and Nurhairani; this research would not have been possible without the support and assistance of all parties.

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