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Phytoplankton Diversity as a Bioindicator for Coastal Water Quality of Kecinan Beach North Lombok Regency

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Abstract: Kecinan Beach is one of the beaches on Lombok Island with many tourism activities. The activities in Kecinan Beach can influence the water quality, as the waters may receive waste from surrounding areas, leading to potential pollution or a decline in water quality. Phytoplankton are living organisms that can indicate whether a water body is polluted, which can be marked by changes in the community structure of phytoplankton, particularly in abundance and diversity. Water quality based on phytoplankton diversity as a bioindicator in Kecinan Beach has not been reported. This study was conducted to analyze the water quality of Kecinan Beach based on phytoplankton diversity as a bioindicator. Samplings were carried out in 9 sites in 3 stations during the month of March to June 2024. Samples were collected using a plankton net of 20µm mesh size. Samples were preserved in 4% formalin preservation and laboratory observation was conducted in the biology laboratory of FMIPA University of Mataram. The study identified 56 species from 3 classes, 21 families and 30 phytoplankton genera. The phytoplankton abundance in the coastal waters of Kecinan Beach was 126.667 ind/L. The species dominance index of phytoplankton of coastal waters of Kecinan Beach was 0.258, indicating no species dominance to each other. *Rhabdonema arcuatum* was identified as the highest (158%) species importance value. The species diversity index of phytoplankton of the coastal waters of Kecinan Beach was a moderate category. Based on the species diversity index, it can be said that the waters of Kecinan Beach are not polluted.

Keywords: Abundance; Bioindicators; Diversity; Kecinan Beach; Phytoplankton.

Introduction

Malaka Village is one of the villages in the Pemenang Sub-district, North Lombok, West Nusa Tenggara Province. Malaka Village has an area of 12.41 km2 with a population of 8,959 people, consisting of 4,509 men and 4,450 women. Malaka Village has 12 hamlets, namely Teluk Kodek, Teluk Nara, Mentigi, Teluk Boro, Pandanan, Nipah, Malimbu, Badung, Setangi, Lendang Luar, Klui and Kecinan [1]. Malaka Village has one of the hamlets with a tourist spot that many visit, Kecinan Hamlet, because it has a fairly famous beach called Kecinan Beach.

Kecinan Beach is a fairly sloping beach based on its topography and has a stretch of white sand around it. This beach has potential and attractions for visitors. Visitors often do various tours such as swimming, playing, diving, snorkeling, camping, and fishing [2]. Not only as a tourist spot, there is also a hotel area and a port for fast boats to Gili Trawangan, Gili Meno, and Gili Air. Kecinan Beach is also close to residential areas. This certainly affects the quality of waters, where coastal waters will receive a lot of waste from activities in the vicinity, which can pollute them. Polluted waters will have a negative impact on the sustainability of living things in aquatic ecosystems. Water quality can be measured by taking physical, chemical, and biological measurements, such as measuring organisms that are indicators of water, one of which is phytoplankton [3].

Phytoplankton are organisms whose lives float or float in the waters. It is very small and must be seen using a microscope because it cannot only be seen with the naked eye [4]. Phytoplankton is important in the marine ecosystem as a primary producer because it can photosynthesize. Phytoplankton is able to produce organic matter needed in food chain activities in the sea [5]. As in plants, phytoplankton also contain chlorophyll. Phytoplankton is a single-celled organism that can photosynthesize to produce oxygen. Phytoplankton is estimated to contribute at least half of the total oxygen produced from photosynthetic activity globally [6].

Phytoplankton is one of the living things that can indicate whether a water body is polluted or not. It can be characterized by changes in the structure of the phytoplankton community, especially in terms of its abundance and diversity [7]. Therefore, phytoplankton are often used as bioindicators of water quality. Many studies have used phytoplankton as bioindicators of water quality, especially in Lombok Island waters, such as Armiani and Harisanti at Madayin Village Beach, East Lombok [8]. Armiani in Carik Harbor, North Lombok [9] and Diniariwisan and Rahmadani in Senggigi Beach Waters, West Lombok Regency [10]. However, from the studies that have been conducted on the island of Lombok, information on water quality using phytoplankton as bioindicators in the waters of Kecinan Beach has not yet been reported.

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The ongoing activities in the waters of Kecinan Beach make this research important in measuring the quality of Kecinan Beach waters using phytoplankton as bioindicators. This research can be the first step for effective management of conservation areas and marine tourism in the waters of Lombok Island in particular and West Nusa Tenggara Province in general.

Research Methods

Time and Place of Research

This research is descriptive and quantitative, and it describes the diversity of phytoplankton species mathematically. This research was conducted in March 2024 in the waters of Kecinan Beach, North Lombok Regency. The research location map can be seen in (Figure 1). Samples were observed and identified at the Marine Laboratory, Faculty of Mathematics and Natural Sciences, Mataram University.

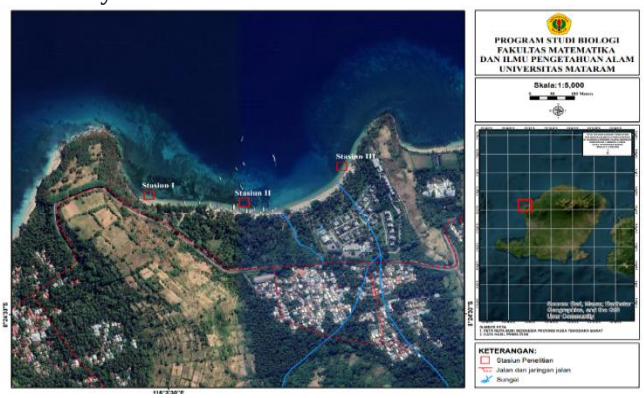

Figure 1: Research location map

Equipment and Materials

The equipment used in this research is stationery, a plankton net with a mesh size of 20 µm, a 5-liter plastic bucket, 9 50 ml sample bottles, a Thermometer, a pH meter, a Refractometer, a current meter, and a DO meter. Equipment used in the laboratory for sample observation is a microscope and camera, a drop pipette, glass objects, and cover glass. Materials needed in this study include distilled water and formalin.

Sampling and Laboratory Observations

Sampling was conducted at 9 points from 3 stations (Figure 1). Station 1 is located in the tourist area and biota collection site, Station 2 is located in the travel and boat breeding area, and the last is Station 3, which is located in the hotel tourist area.

Sampling was done using a plankton net with a mesh size of 20 µm. Samples of 50 ml were concentrated from 100 L of seawater and then preserved with formalin at a preservation concentration of 4%. Furthermore, each sample bottle was marked using label paper [11]. Aquatic parameters measured in-situ (directly) in the field include temperature, pH, salinity, current velocity, and dissolved oxygen. Observation and identification of phytoplankton using a microscope with a magnification of 10 x 10 and 10 x 40. Objects that have been observed are documented using a camera. Phytoplankton were identified based on the Identification Book: [12], [13], [14], [15].

Data analysis

Data analysis of the results of this research includes the abundance of individuals of each species, the species diversity index (H'), the dominance index of species dominance (C), and Important Value Index (INP). The abundance of individuals of each phytoplankton species was calculated using the equation [16]. The diversity index of phytoplankton species was calculated using the Shannon-Wiener index [17]. Criteria for assessing phytoplankton species diversity index [18]. The dominance index of phytoplankton species can be calculated using Simpson's equation [17]. Phytoplankton species dominance index assessment criteria [18]. The Important Value Index is calculated using the equation [19]. The criteria for assessing a water body's pollution level are based on the value of the phytoplankton species diversity index [20].

Results And Discussion

Phytoplankton Composition

Based on the results of research that has been conducted at 3 stations with 9 different sampling points in the waters of Kecinan Beach, phytoplankton composition is obtained consisting of 3 classes, 21 families, 30 genus, and 56 species. Bacillariophyceae class (17 families and 25 genus), Cyanophyceae class (2 families and 3 genus) and Dinophyceae class (2 families and 2 genus).

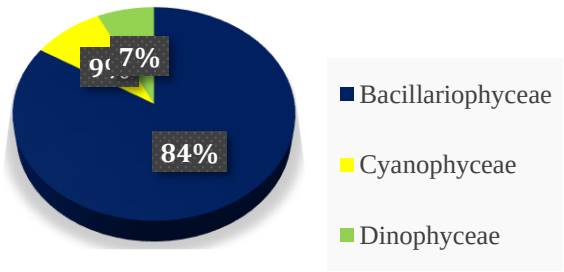

Figure 2. Percentage Comparison of Phytoplankton Presence by Class in Kecinan Beach Waters

Bacillariophyceae is a class with the most number of species found in all research stations with a percentage of 84% (Figure 2). The Bacillariophyceae class is the most dominating phytoplankton class and is often found in waters compared to other classes of phytoplankton species [21]. This opinion is supported by discovering the most Bacillariophyceae class phytoplankton (48 species) in the waters of Klui Beach, North Lombok [22].

Phytoplankton from the Bacillariophyceae class are widely found and distributed in waters because Bacillariophyceae can survive at various water temperatures, including phytoplankton that have high survival because they have high adaptation and can live in various water conditions, including extreme conditions or what is usually called cosmopolite supported by high reproductive power

[23]. The Bacillariophyceae class has cosmopolite properties because, in addition to being found in phytoplankton marine waters, it is also found in freshwater waters such as 20 species from the Bacillariophyceae class in the waters of the Sumi Dam, Bima Regency [24] and 24 species identified in the waters of the Batu Dendeng River, West Lombok [25]. The composition of the Bacillariophyceae class was found mostly in the waters of Kecinan Beach; this can be caused by the condition of the waters of Kecinan Beach, which is close to land and human activity. The presence of phytoplankton Bacillariophyceae class is highest in water areas adjacent to the mainland [22]. In addition to being close to land, there are also several activities in Kecinan Beach, such as the activity of fast boat crossings to Gili Trawangan, Gili Meno, and Gili Air, fishing activities, residential areas around the waters of Kecinan Beach, then the hotel area around the sampling area. Activities and conditions like this greatly affect the presence of phytoplankton.

Phytoplankton Abundance

The abundance of phytoplankton in the waters of Kecinan Beach is 126,667 ind/L, and each station has different values.

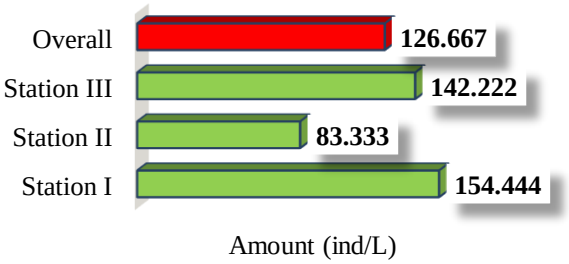

Figure 3. Comparison of Phytoplankton Abundance at Each Station and Kecinan Beach Waters Area

The highest abundance of phytoplankton is found at station I, which is 154.444 ind/L, then station III, which has an abundance of 142.222 ind/L, while the lowest abundance is found at station II, which is 83.333 ind/L. Environmental conditions and activities can influence different abundance values at each station in the waters of Kecinan Beach. A comparison of phytoplankton abundance in Kecinan Beach Waters can be seen in Figure 3. The Physical and Chemical parameters in Kecinan Beach Waters are listed in **Table 1**.

Table 1. Physical and Chemical Parameters of Kecinan Coastal Waters

Parameter	Station			Quality Standard
	I	II	III	
Temperature (°C)	30	30	30	20-30
Salinity (ppt)	32	30	30	33-34
pH	8.4	8.1	8	7-8.5
Current (m/s)	0.3	0.2	0.4	-
Do (mg/L)	8.7	8.7	8.4	>5

The highest abundance value was found at station I at 154.444 ind/L, Which physical parameters of water chemistry such as salinity can influence. Phytoplankton abundance is influenced by salinity where salinity plays an important role in supporting the development of marine biota. The highest salinity value is found at station 1 at 32 ppt, while the salinity value at stations 2 and 3 is the same at 30 ppt. Salinity distribution can be caused by various factors such as water circulation patterns, evaporation, rainfall and river flow [26]. However, the salinity value at each station is sufficient for phytoplankton growth. This is supported by the statement that the optimum salinity for phytoplankton life ranges from 30-35 ppt [27].

Rhabdonema arcuatum abundance value is the highest at each station. Rhabdonema arcuatum was found to have the highest abundance value at station 1 of 77.778 ind/L, then at station III of 73.333 ind/L, and the lowest abundance value was at station II with a value of 38.889 ind/L. Rhabdonema arcuatum abundance value is the highest in all stations because Rhabdonema arcuatum is a phytoplankton that is usually attached to the rocks so it is not susceptible to currents and usually live in waters that tend to have warm temperatures and temperate [28]. The temperature in the waters of Kecinan Beach is 30°C. This result is in accordance with the quality standards according to PP RI Number 22 of 2021 Appendix VIII concerning Seawater Quality Standards [29]. Rhabdonema arcuatum is also a species of phytoplankton, which is a natural food for fish [30]. As a member of the Bacillariophyceae class, Rhabdonema arcuatum is able to adapt to the surrounding environmental conditions that can make its presence dominate in waters [31].

Diversity and Dominance of Phytoplankton Species

Phytoplankton found in the waters of Kecinan Beach, North Lombok, is from 3 classes, including Bacillariophyceae, Cyanophyceae, and Dinophyceae. The species diversity index (H') of phytoplankton is generally used as a reference to determine the quality of a water body [32]. This phytoplankton species diversity index is used to calculate the level of species diversity. In contrast, the species dominance index is used to see whether or not there are phytoplankton species that dominate in a community [33].

High diversity indicates that the area has a good, stable or balanced ecosystem or waters. If the value of the phytoplankton species diversity index is high, the plankton community will be more diverse and not dominated by just one species [34]. If the value of the species dominance index is close to 1, then there is a species that dominates other species, but conversely, if the dominance index value is close to 0, then there is no species that dominates other species [35]. Data on the comparison of diversity index values and dominance of phytoplankton species at each station can be seen in Table 2.

The phytoplankton species diversity index in the waters of Kecinan Beach is 2.503 and has a different phytoplankton species diversity index value at each station (Table 2). The ecosystem of an area can be said to be balanced if a high species diversity index characterizes it, but on the contrary, an aquatic ecosystem with an unstable state or less supportive of phytoplankton life has a low species diversity index value [36]. Based on the category that, the index value of phytoplankton species diversity in the waters

of Kecinan Beach is classified as moderate [18]. This shows that the waters of Kecinan Beach still have good productivity and ecosystem conditions that are still quite balanced.

Table 2. Diversity Index and Dominance Index of phytoplankton species in Kecinan Beach.

Sampling Location	Diversity (H')	Dominance (C)
Station I	2.239	0.270
Station II	2.152	0.244
Station III	2.064	0.284
Overall	2.503	0.258

Based on the category of phytoplankton species diversity index with a value >2 indicates that the waters of Kecinan Beach are not polluted [20]. Physical and chemical factors of a water body can influence high or low diversity of phytoplankton species. The diversity of phytoplankton species in the waters of Kecinan Beach is influenced by physical and chemical parameters that affect the life of phytoplankton. Physical chemical parameters such as pH, dissolved oxygen (DO), and current velocity can affect phytoplankton diversity. Kecinan Beach waters have the highest pH value at station 1 of 8.4, then station 2 of 8.1, and the lowest value at station 3 of 8. The pH value can be influenced by several factors, including temperature, the presence of ions in the waters, and biological activity such as photosynthesis and organisms' respiration [37]. The pH value at each station is at a value that is in accordance with the quality standards of PP RI Number 22 of 2021 Appendix VIII concerning Seawater Quality Standards [29]. This is also in accordance with the opinion that the optimum pH value for phytoplankton growth is a value range of 6-9; the pH value in a body of water affects the material from the decomposition of organic matter in the waters [36].

Phytoplankton diversity is also influenced by dissolved oxygen (DO) because oxygen is needed by aquatic biota for metabolic processes or respiration [38]. The dissolved oxygen (DO) concentration in the waters of Kecinan Beach ranges from 8.4-8.7 mg/L. The highest dissolved oxygen value was obtained at stations 1 and 2 at 8.7 mg/L and the lowest at station 3 at 8.4 mg/L. Based on the location of the study, station 3 has more turbid water compared to stations 1 and 2 because at station 3 there is a river estuary flow. High turbidity values can cause a lack of light presentation into the waters it can cause photosynthetic organisms to produce less oxygen optimally [38]. However, the value of dissolved oxygen (DO) at all stations is still in accordance with the quality standards of PP RI Number 22 of 2021 Appendix VIII concerning Seawater Quality Standards, which is> 5 mg / L and supports the life of aquatic biota [29].

Current speed can also affect phytoplankton growth. Kecinan Beach waters at each station have a current speed ranging from 0.2-0.4 m / s, including moderate currents that are good for phytoplankton life. Current speeds of 0-0.1 m/s include very weak currents, current speeds of 0.1-1 m/s include moderate currents, and current speeds of more than 1 m/s are considered strong currents [39]. The low diversity of phytoplankton at station III can be caused by the current speed at this station being higher than at other stations. Strong currents at station III because this station is adjacent to the estuary so as to increase the volume of water in the waters of Kecinan Beach. This is in line with the opinion that strong currents can be caused by rain, which impacts increasing the volume of water in the waters [40]. In addition, the low diversity of phytoplankton species at station III can be caused by phytoplankton carried by the movement of water due to the movement of strong currents [41].

The dominance index of phytoplankton species in the waters of Kecinan Beach is 0.258. The dominance value at each station is not much different in the range between 0.244-0.284. The value obtained indicates that there is no dominant species in the waters of Kecinan Beach. This is in line with the opinion that if the dominance value is close to 1, it means that there are species that dominate other species; otherwise, if it is close to 0, it means that there are no species that dominate other species [42]. It can be said that the waters of Kecinan Beach have a low dominance value or no dominating species.

The index of importance (INP) of phytoplankton waters of Kecinan Beach is highest in Rhabdonema arcuatum species with the highest value of 158%. Rhabdonema genus can be bound or attached to the rocks [28]. The genus of the bacillariophyceae class also has cosmopolite properties, which are not susceptible to currents and can even live in polluted water environments [43]. The greater the INP of a species, the greater the role of the species in the community. The high index of importance of a species is directly proportional to the role of the species in the community. The higher the index of importance of a species, the higher the function of the species [44].

Conclusion

Based on the study's results, the phytoplankton composition of Kecinan Beach waters consists of 3 classes, 21 families, 30 genus, and 56 species, with a total abundance of 126,667 ind/L. The phytoplankton species diversity index of Kecinan Beach waters is in the medium category (H'= 2.503), which shows that the waters of Kecinan Beach are not polluted.

Author's Contribution

Dwi Auliya Shofiana: Conceptualizing and designing the research, collecting data, analyzing data and writing the article; Dining Aidil Candri: Helped design the research, revised the data analysis, and revised the article; Lalu Japa: Helped design the research, revised the data analysis and revised the article; Tri Wahyu Setyaningrum: Helped revise the article and Anggi Nurhardiyanti Munawaroh: Helped revise the article.

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