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PHYTOPLANKTON DIVERSITY AS A BIOINDICATOR FOR WATER QUALITY OF SIWAK BAY, SPECIFIC ECONOMIC ZONE (SEZ) MANDALIKA CENTRAL LOMBOK

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Abstract: The Mandalika Specific Economic Zone (SEZ) is a potential tourism industry for the province of West Nusa Tenggara, which has recently received very high attention due to the construction of the international MotoGP circuit. The construction of the MotoGP circuit has become an attraction for domestic and foreign tourists and has increased the number of tourists. The increase in tourism activity has negatively impacted the Mandalika SEZ's coastal waters, such as a decrease in water quality, including the water of Siwak Bay. Water quality monitoring can be done by using phytoplankton as a bioindicator. The study of phytoplankton species diversity as a bioindicator of water quality has never been carried out in the Siwak Bay waters. This research was conducted to analyze the status of Siwak Bay waters based on the phytoplankton diversity index. Samplings were carried out based on a purposive sampling method. This research was conducted for three months, from March to June 2023. The study found seven classes, 59 genera, and 127 phytoplankton species. The abundance of phytoplankton in Siwak Bay was 1025,185 ind/L. The highest abundance was the genus of Trichodesmium. The species diversity index was 3,33. Based on the species diversity index, it can be said that the waters of Siwak Bay are not polluted.

Keywords: *Siwak Bay, Phytoplankton, Bioindicator, Water Quality*

INTRODUCTION

West Nusa Tenggara (NTB) Province has a sea area of 29,159.04 km^{2,} and the length of the coastline is around 2,333 km [1]. The vastness of this marine water area makes NTB one area with a variety of water natural resource (SDA) potential. One area that has marine and coastal potential is Central Lombok, especially the Mandalika Special Economic Zone (SEZ).

SEZ Mandalika is one of the tourist attractions in the south of Lombok Island. The Mandalika SEZ was approved as a tourism SEZ through PP No. 52 of 2014 [2]. SEZ Mandalika is a potential tourism industry in NTB Province. This is an attraction for companies developing the tourism industry [3]. One of the tourism sectors that is currently receiving high attention is the international MotoGP circuit. The construction of this circuit is an attraction for domestic and foreign tourists. The increase in tourism activities in coastal areas impacts the amount of organic and inorganic pollutants in water bodies and other potential problems that can become coastal environmental problems.

Phytoplankton are microscopic organisms that are autotrophic or capable of producing food through photosynthesis [4]. Phytoplankton acts as primary producers, and it is estimated that 95% of primary production in the sea comes from phytoplankton [5]. Phytoplankton are the first organisms to be disturbed if pollutants enter the water. This is because phytoplankton utilize these pollutants directly. Thus, changes in waters are caused by changes in the phytoplankton community structure [6]. Therefore, phytoplankton can be used as a bioindicator in evaluating the level of pollution in waters.

Phytoplankton, as a bioindicator of water quality, has been studied by many researchers from the perspective of diversity, abundance, and dominance to determine the condition of a body of water. Japa research *et al*. said that the waters of the Mandalika SEZ have a moderate microalgae species diversity index of 3.145, with the dominant species being *Cahaetoceros*. Based on the species diversity index results, the water quality status of the Mandalika SEZ is not polluted [7]. Research has also been carried out at Klui Beach by Hadi *et al.*, who said that Klui coastal waters were classified as unpolluted and found as many as 48 species of phytoplankton from the Bacillariophyceae class with an average species abundance of 298.09 ind/L [8]. It was also reported that the waters of the Sekotong gold processing area were moderately to heavily polluted and had 41 phytoplankton species with a diversity ranging from 2,814 to 2,817 [9].

Siwak Bay is one of the locations still in the Mandalika SEZ, Central Lombok. This area has residents' houses and local community activities such as collecting seaweed, animal husbandry, agriculture, and *madak* activities when the water recedes. The location of Siwak Bay, which is still in the Mandalika SEZ, means that this area is indirectly affected by the development and management of Mandalika, which can result in a decline in environmental quality. Apart from that, reports regarding the condition of the

waters of Siwak Bay using phytoplankton as a bioindicator have never been carried out. Therefore, it is necessary to carry out this research to determine the status of the waters of Siwak Bay using phytoplankton as a bioindicator.

RESEARCH METHOD

Time and Place of Research

This research was carried out in March 2023 in Siwak Bay, Central Lombok. Phytoplankton samples were observed and identified at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, Mataram University.

This type of research is descriptive-exploratory, describing in detail the condition or phenomenon of phytoplankton in Siwak Bay. The sampling point is determined by the technique of purposive *sampling*, which is based on consideration of environmental conditions, consisting of 9 points (Figure 1). The coordinates of each sampling point are listed below in Table 1.

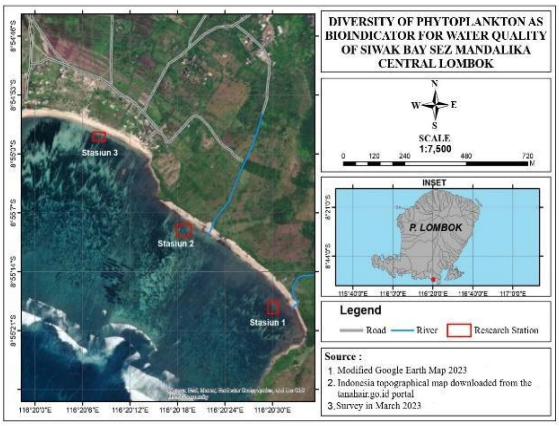

Figure 1. Map of Sampling Locations in Siwak Bay Waters, Central Lombok

Table 1. Sampling Point Coordinates

Station	Point	Geographical location	
		Longitude	Latitude
I	I	8°55’18”S	116°20’30”E
	II	8°55’16”S	116°20’27”E
	III	8°55’12”S	116°20’23”E
II	IV	8°55’09”S	116°20’19”E
	IN	8°55’08”S	116°20’18”E
	WE	8°55’07”S	116°20’16”E
III	VII	8°54’58”S	116°20’08”E
	VIII	8°54’57”S	116°20’05”E
	IX	8°54’56”S	116°20’03”E

Laboratory Sampling and Observations

Phytoplankton samples were taken at each sampling point at 08.00-13.00 WITA, using a plankton net with a mesh size of 20 µm. Seawater samples were preserved using formalin with a preservation concentration of 4%. Physical-chemical parameter measurements were carried out at each sampling station; the parameters measured were temperature, pH, salinity, current speed, and nitrate. Phytoplankton observations were carried out using an electric binocular microscope (Zeiss Primo Star) with magnifications of 10x10 and 40x10. The results of observations of phytoplankton observed in a microscope were photographed using a camera cell phone 48 megapixels (MP). The phytoplankton species obtained were then identified using books*The Marine and Freshwater Plankton*, Algae Second Edition, *Illustrations of The Marine Plankton of Japan 3rd Edition*, *The Freshwater Algae of United States of America* [10-13]

Data analysis

The equations used in calculating observational data in this study include species abundance, species diversity index (H'), and species dominance index (C). The individual abundance of each phytoplankton species was calculated using the equation [14]. The phytoplankton species diversity index was calculated using the Shannon-Wiener index [15]. Criteria for assessing the phytoplankton species diversity index are listed in Table 2[16]. The phytoplankton species dominance index can be calculated using the Simpson equation [15]. Criteria for assessing the dominance index of phytoplankton species are listed in Table 3[16]. Criteria for assessing the level of pollution of a body of water based on the phytoplankton species diversity index are listed in Table 4[17].

Table 2.Species Diversity Index Value Criteria

Diversity Index	Category
H’ < 1	Low
1 < H’ < 3	Currently
H’ > 3	Height

Table 3. Species Dominance Index Value Criteria

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

Table 4. Aquatic Status Criteria Based on Diversity Index

Diversity Index	Pollution Level
> 2.0	Not polluted
1.6 – 2.0	Lightly polluted
1.0 – 1.6	Moderately polluted
< 1.0	Heavily polluted

RESULTS AND DISCUSSION

Phytoplankton Composition

Based on the results of research carried out at three stations divided into nine sampling points in the waters of Siwak Bay, it is known that the composition of phytoplankton includes seven classes, 59 genera and 127 species of phytoplankton, namely class

Bacillariophyceae (48 genera), class Cyanophyceae (4 genera) , class Dinophyceae (3 genera), class Chlorophyceae (1 genus), class Coscinodiscophyceae (1 genus), class Ulvophyceae (1 genus), and class Florideophyceae (1 Genus).

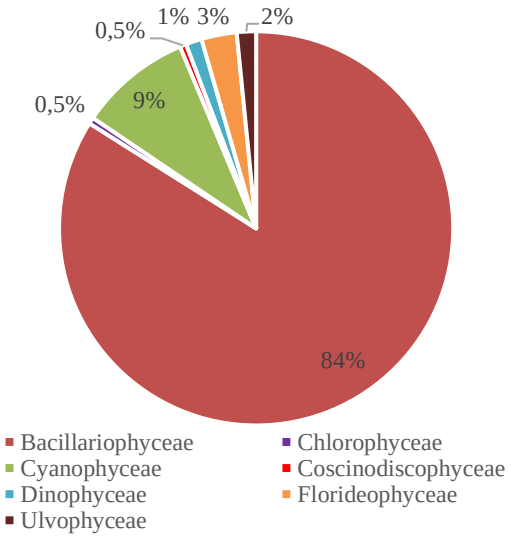

Figure 2. Percentage of Phytoplankton Presence in Siwak Bay Waters

In general, based on the results found, species from the Bacillariophyceae class were most commonly found in all research stations (**Figure 2**). The research conducted by Purwaningtyas in Teluk Gerupuk obtained species from the Bacillariophyceae class that are the most common [18]. Class Bacillariophyceae is also found in the waters of Sungai Jangkok in as many as 84 species [19]. This shows that the Bacillariophyceae class has a wide distribution in both fresh and marine water. Phytoplankton from the class Bacillariophyceae are often found in aquatic environments due to their excellent adaptability, tolerance to extreme temperatures, cosmopolitan nature, and high reproductive capacity [20]. Phytoplankton species in the waters of Teluk Siwak that come from the Bacillariophyceae class are listed in (Figure 3).

The phytoplankton found in the waters of Siwak Bay are very diverse and have a very potential role in the sea. Genus *Amphora* of the Bacillariophyceae class, most commonly found in the waters of Siwak Bay, namely 11 species. Genus Amphora is useful as a natural food for shellfish and shrimp larvae because it contains high protein, fat, and carbohydrates [21]. It also has an essential role in water, namely as a primary producer. Apart from being a primary producer, *Nitzschia* also serves as natural food for the larvae of marine organisms such as crustacea, bivalves, and fish [22]. Besides that, *Nitzschia* can be used as a basic material for developing biodiesel because organisms produce potential lipids [23].

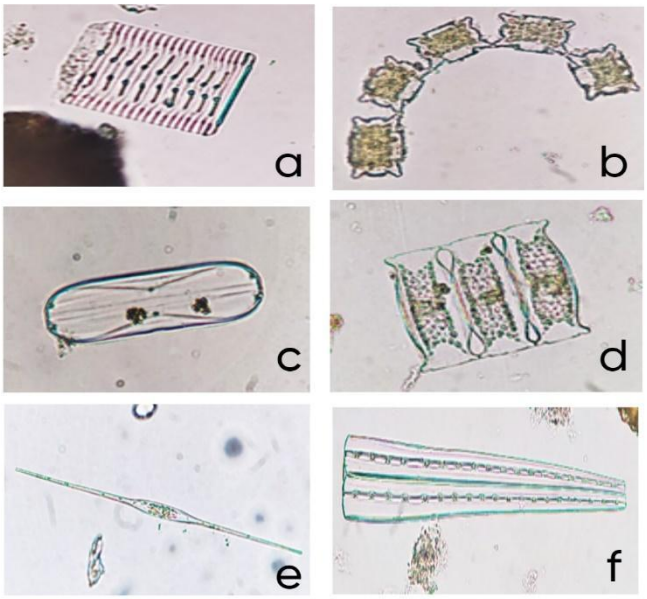

Figure 3. Several species of phytoplankton found in Siwak Bay are from the Bacillariophyceae class, namely: a.*Rhabdonema arcuate*; b. *Biddulphia mobiliensis*; c. *A very smooth vessel*; d. *Bellerochea malleus*; It is.*Nitzschia closterium*; f. *Climacosphenia moniligera*.

Phytoplankton Abundance

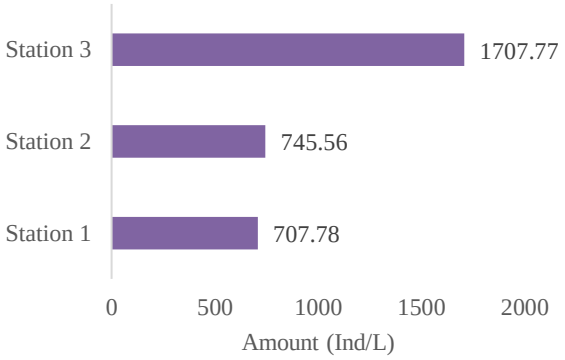

Figure 4. Comparison of Phytoplankton Abundance Between Research Stations

The abundance of phytoplankton in the waters of Siwak Bay is 1031.48 ind/L and varies from one station to another. The highest abundance of phytoplankton was at station III, namely 1720 ind/L, followed by station II, namely 745.56 ind/L, while the lowest abundance was at station I, namely 711,111 ind/L. Environmental conditions and activities can influence differences in abundance values for each station in the waters of Siwak Bay. A comparison of abundance data for each station is listed below—f**igure 4**. The physical and chemical parameters of Siwak Bay waters are listed in **Table 6**.

Table 5. Physical Chemical Parameters of Siwak Bay Waters

Parameter	Station			Quality Standards
	I	II	III	
Temperature (^{O}C)	28.8	28.9	29.8	28 - 30
pH	8	7.9	7.8	7 – 8.5
Salinity (ppt)	30	32	30	33 - 34
Current (m/s)	0.4	0.9	0.6	-
Nitrate (ppm)	0.05	0.05	0.1	0.06

The highest species abundance was found at station III at 1720 ind/L. The high phytoplankton abundance value at this station can be influenced by physical and chemical water parameters such as temperature, salinity and nitrate. This is thought to be because the location of observation station III is close to residential areas. The water temperature at station III was found to be 29.8^{O}C, where this value is higher compared to other stations. In accordance with Puspitasari's opinion, high and low temperatures can influence the abundance of phytoplankton [24]. Campbell confirmed that increasing temperature can cause an increase in plankton growth rates [25]. The abundance of phytoplankton is also influenced by salinity, where salinity in the range of 30-35 is the optimum value for the survival of phytoplankton [26]. The salinity measured in the waters of Siwak Bay is 30-32 ppt. Apart from that, nitrate is one of the factors that influences the abundance of phytoplankton. The nitrate value at station III is higher compared to stations I and II, namely 0.1 mg/L (Table 5). This was due to the fact that at station III there were grass cultivation activities and there were landslides that entered the water body during sampling.

The lowest abundance was found at station I at 711.11 ind/L. The low abundance value obtained is thought to be due to the lack of nitrate concentration at this station because, at the time of sampling, there was no water resulting from community activities, which usually enters the waters of Siwak Bay. Water entering the coast will carry waste in the form of anthropogenic activities (nitrate, nitrite, and phosphate), where the high level of incoming waste greatly influences the high and low values of nitrate [24].

The abundance at station II was found to be 751.11, which is lower than the abundance value obtained at station III. Environmental factors influence this. Current is something that influences the abundance value obtained at station II, which is lower than at station III; the current speed value obtained is 0.9 m/s. In line with the argumentation from Roioto et al.., the low abundance of phytoplankton can be influenced by phytoplankton carried along with the movement of water due to fairly strong current movements [27].

Genus *Trichodesmium* is the genus that has the highest abundance in the waters of Siwak Bay. Environmental factors can influence the abundance of Trichodesmium, namely the resistance of these organisms to high temperatures [28]. The temperature in the waters of Siwak Bay ranges from 28.8-29.8^{O}C. This temperature range can support the development of *Trichodesmium*. This is in line with Devassy's opinion that waters have temperatures ranging between 27-32℃, which is the best temperature for the growth *Trichodesmium* [29]. In addition, the abundance of the genus Trichodesmium is also due to its ability to bind nitrogen from the air in marine waters that have low nitrate content [30]. The nitrate content measured in the waters of Siwak Bay is 0.05-0.1 mg/L, where nitrate levels in the range of 0-1 mg/L include waters with low nutrient levels (oligotrophic) [31]. This is what causes this genus to easily reproduce its individuals in a short time [32]. *Trichodesmium*, which is a member of the phylum Cyanophyta, is found in abundance because *Trichodesmium* has high adaptability due to its unique personality and abilities, which make this organism different from aquatic organisms in general. Besides that, *Trichodesmium* can also reproduce in a very short time to double the number [29].

Diversity and Dominance of Phytoplankton Species

There are 127 phytoplankton found in the waters of Siwak Bay, Central Lombok, which fall into seven classes, namely Bacillariophyceae, Cyanophyceae, Dinophyceae, Chlorophyceae, Coscinodiscophyceae, Ulvophyceae, and Florideophyceae. The species diversity index for each station is presented in Table 5.

Table 5.Diversity Index (H') and Dominance Index (C) in Siwak Bay Waters

Sampling Location	Diversity (H')	Dominance (C)
Station 1	2.70	0.09
Station 2	2.72	0.11
Station 3	3.25	0.06
Overall	3.33	0.06

The diversity index shows the number of species that are able to adapt to the environment occupied by an organism [14]. An area's ecosystem is said to be balanced and can be characterized by a high species diversity index; on the other hand, aquatic ecosystems that are unstable or do not support biota life have low diversity values. The phytoplankton species diversity index in the waters of Siwak Bay is 3.353 and differs between stations (Figure 4). According to Fachrul, the species diversity index with a value of H'>3 is included in the high category [16].

The physical and chemical factors of a body of water influence the level of phytoplankton diversity. Phytoplankton diversity in Siwak Bay is influenced by environmental parameters that support phytoplankton life, for example, pH. The pH value of Siwak Bay waters ranges from 7.8-8. The pH value range of 6-9 is the optimum value for phytoplankton growth, and this is because the pH of the water affects minerals from the decomposition of organic matter.

The phytoplankton dominance index in Siwak Bay waters ranges from 0.06-0.11. The values obtained indicate that there are no dominant species in the waters of Siwak Bay. This follows Fachrul's opinion that a dominance index value close to 0 indicates no dominant species. Conversely, if the dominance index value is close to 1, it indicates a dominating species in the waters [16]. Thus, it can be concluded that in the waters of Siwak Bay, there is no dominance. The phytoplankton samples that have been analyzed also show an important value index (INP) for phytoplankton, namely 200.0605, where the highest important value is obtained from the genus *Trichodesmium* amounting to 79,678. High INP of the genus *Trichodesmium* This is because *Trichodesmium* is often found in oligotrophic waters and waters that have a temperature range between 20-34℃ [33]. The waters of Siwak Bay are oligotrophic and have a temperature range of 28.8-29.8^{O}C. It supports the growth of *Trichodesmium* in the waters of Siwak Bay.

Based on the research results, the phytoplankton diversity index value in the waters of Siwak Bay was 3.33 (high category). Therefore, it can be said that the water quality of Siwak Bay, Central Lombok, based on the phytoplankton species diversity index as a bioindicator, is in the non-polluted category. This is in line with Barus' opinion, namely that if a body of water has a species diversity index greater than 2, it indicates that the water is not polluted [17].

CONCLUSION

The results of this research concluded that there were 131 phytoplankton species in the waters of Siwak Bay with a high species diversity index (H'= 3.353), and an abundance of phytoplankton species of 1031.48 ind/L. The highest abundance belongs to the genus *Trichodesmium*, with an abundance of 408.51 ind/L. The water quality of Siwak Bay based on the phytoplankton species diversity index shows that the water condition is good and not polluted.

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REFERENCES

[1] KKP. (2018). *Potensi Usaha dan Peluang Investasi Kelautan dan Perikanan Provinsi Nusa Tenggara Barat*. Jakarta. KKP.

[2] Dewan Nasional Kawasan Ekonomi Khusus Republik Indonesia. (2015). *Profil Kawasan Ekonomi Khusus Mandalika.* https://kek.go.id/kawasan/kek-Mandalika (Accessed on February 20, 2023)

[3] Utami, F. P., Karnan, K., Handayani, B. S., & Mahrus, M. (2021). Identifikasi Kemampuan Literasi Kelautan Siswa Sekolah Menengah Pertama (SMP) di Kawasan Ekonomi Khusus (KEK) Mandalika, Lombok Tengah. *Jurnal Ilmiah Profesi Pendidikan*, *6*(1), 81-86.

[4] Triawan, A. C., & Arisandi, A. (2020). Struktur komunitas fitoplankton di perairan muara dan laut Desa Kramat Kecamatan Bangkalan Kabupaten Bangkalan. Juvenil: Jurnal Ilmiah Kelautan dan Perikanan, 1(1), 97-110.

[5] Ariana, D., Samaji, J., & Nasution, S. (2014). Komposisi Jenis dan Kelimpahan Fitoplankton Perairan Laut Riau. *Doctoral Diseertation*. Universitas Riau

[6] Apridayanti, E. (2008). Evaluasi Pengelolaan Lingkungan Perairan Waduk Lahor Kabupaten Malang Jawa Timur. *Doctoral Diseertation*. Universitas Diponegoro

[7] Japa, L., Karnan, K., & Handayani, B. S. (2022). Quality Status of Coastal Waters of Special Economic Zone of Mandalika Central Lombok Based on the Community of Microalgae as Bioindicator. *Jurnal Penelitian Pendidikan IPA*, *8*(6), 2864-2871.

[8] Hadi, Y. S., Japa, L., & Zulkifli, L. (2023). Bacillariophyceae Diversity as Bioindicator of Pollution in the Coastal Waters of Klui Beach, North Lombok. *Jurnal Biologi Tropis*, *23*(1), 73-79.

[9] Rohmi, Y. (2019). Keanekaragaman dan kelimpahan fitoplankton sebagai bioindikator kualitas lingkungan di area pengolahan emas tradisional Sekotong Kabupaten Lombok Barat. *Thesis*. UIN.

[10] Davis, C,C. (1955). *The Marine and Freshwater Plankton*. Michigan State University Press. Chicago.

[11] Graham, L.E., J.M. Graham, L.W. Wilcot. (2009) *Algae Edisi Kedua*. Pearson Education Inc. publishing as Pearson Benjamin Cumming. San Francisco, USA.

[12] Yamaji, I. (1984). *Illustrations of The Marine Plankton of Japan 3rd Eddition*. Hoikusha Publishing Co, Ltd. Japan.

[13] Smith, GM. (1950). *The Fresh Water Algae of United States of America*. McGraw Hill. New york. America

[14] Romimuhtarto, K., dan Juwana, S. (2001*). Biologi Laut: Ilmu Pengetahuan Tentang Biota Laut*. Djambatan. Jakarta.
[15] Odum, E.P. (1993). *Dasar-Dasar Ekologi Edisi Ketiga*. Gadjah Mada. Yogyakarta.
[16] Fachrul, F.M. (2007). Metode Sampling Bioekologi, Bumi Aksara. Jakarta.
[17] Barus, T.A. 2020. *Limnologi*. Nas Media Pustaka. Makassar.
[18] Purnamaningtyas, S. E. (2019). Distribusi dan Kelimpahan Fitoplankton di Teluk Gerupuk, Nusa Tenggara Barat. *Akuatika Indonesia*, *4*(1), 24-30.
[19] Firdaus, M.A. 2023. Keanekaragaman Fitoplankton dan Potensinya Sebagai Bioindikator di Perairan Sungai Jangkok Pulau Lombok. *Thesis.* Fakultas Matematika dan Ilmu Pengetahuan Alam. Universitas Mataram.
[20] Odum, E. P. (1998). *Dasar-dasar Ekologi (Fundamental of Ecology).* Diterjemahkan oleh T. j. Samingan. Gadjah Mada University Press, Yogyakarta.
[21] Risjani, I. Y., & DEA, P. D. (2021). Identifikasi Morfologi dan Pertumbuhan Diatom Genus Amphora yang di Isolasi dari Substrat Pasir di Perairan Pantai Tanjung Batu Landangan, Kabupaten Situbondo. *Thesis*. Universitas Brawijaya.
[22] Puspitasari, R. (2017). Pengembangan Nitzschia sp. Sebagai Biota Uji Sedimen. *OSEANA*, *42*(1), 28-35.
[23] Campbell, M. N. (2008). Biodiesel: Algae as a Renewable Source for Liquid Fuel. *Guelph Engineering Journal*, *1*(1), 2-7.
[24] Zainuri, M., Indriyawati, N., Syarifah, W., & Fitriyah, A. (2023). Korelasi Intensitas Cahaya Dan Suhu Terhadap Kelimpahan Fitoplankton Di Perairan Estuari Ujung Piring Bangkalan. *Buletin Oseanografi Marina*, 12(1), 20-26.
[25] Sartimbul, A., Ginting, F. R., Pratiwi, D. C., Rohadi, E., Muslihah, N., & Aliviyanti, D. (2021). Struktur Komunitas Fitoplankton pada Perairan Mayangan Probolinggo, Jawa Timur. *JFMR (Journal of Fisheries and Marine Research)*, 5(1), 146-153.
[26] Faturohman, I., Sunarto, & Nurruhwati, I. (20160. Korelasi Kelimpahan Plankton dengan Suhu Perairan Laut di Sekitar PLTU Cirebon. *Jurnal Perikanan Kelautan*, 7(1), 115-122.
[27] Roito, M., Siregar, Y. I., & Mubarak, M. (2014). Analisis Struktur Komunitas Diatom Planktonik di Perairan Pulau Topang Kabupaten Kepulauan Meranti Provinsi Riau. *Jurnal Perikanan dan Kelautan*, 19(2), 22-32.
[28] Asriyana dan Yuliana. 2012. *Produktivitas Perairan. Bumi Aksara*. Jakarta
[29] Devassy, V. P. (1984). Trichdesmium erythaerun blooms (red tide) in Arabia Sea. *Nat. Inst. Oceanografi*, Dona Paula. Goa, India.
[30] Basu, S., Gledhill, M., de Beer, D., Prabhu Matondkar, S. G., & Shaked, Y. (2019). Colonies of marine cyanobacteria Trichodesmium interact with associated bacteria to acquire iron from dust. *Communications biology*, 2(1), 284.
[31] Mustofa, A. (2015). Kandungan nitrat dan pospat sebagai faktor tingkat kesuburan perairan pantai. *Jurnal Disprotek*, 6(1), 13-19.
[32] Kardinaal, W. E. A., & Visser, P. M. (2005). Dynamics of cyanobacterial toxins. Harmful Cyanobacteria. *Aquatic ecology series*, 41-63.
[33] Novriyanti. (2013). Mekanisme Pengendalian Alami Ledakan Populasi Trichodesmium Erythraeum. Universitas Jambi. https://novriyanti.staff.unja.ac.id/?p=582 (Accesed on 25 July 2023).