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Macroalgae Community Structure and Diversity in Peh Pulo Beach, Blitar Regency

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Abstract

The coastal area of Peh Pulo Beach, located in the Blitar Regency, has high potential biodiversity, including macroalgae. Hence, the present research aimed to comprehend the community structure and diversity of macroalgae at Peh Pulo Beach. The sampling was conducted in August 2023 utilizing the 1 x 1 m transect quadrate method. Macroalgae were collected at three observation stations, with three plots observed at each station. Abiotic environmental parameters measured included temperature, salinity, pH, light intensity, and substrate. The results of macroalgae identification at Peh Pulo Beach revealed 21 species belonging to 16 genera and 14 families. They were classified into *Chlorophyta* (9 species), *Phaeophyta* (4 species), and *Rhodophyta* (8 species). The Shannon Diversity Index value obtained was 2.84, indicating that the macroalgae diversity along the coast of Peh Pulo beach was classified as moderate.

Keywords: Biodiversity, Community Structure, Macroalgae, Peh Pulo Beach

Introduction

Coastal areas are known for their abundant biodiversity, including macroalgae (Rahardi & Suhardi, 2016). Previous studies have been conducted to elucidate the variety (Sodiq & Arisandi, 2020; Srimariana et al., 2020; Sriwajungningsih, Hernawati, & Raharjo, 2022) and distribution of macroalgae, as well as their potential uses as food, cosmetics, and medicines (Munifah, 2008; Pakidi & Suwoyo, 2017). Several investigations on the diversity and potential utilization of macroalgae have been carried out in coastal areas in Indonesia, such as the Prigi Bay Waters of Trenggalek (Prasetiyo & Arisandi, 2021), Air Berudang Beach (Ulfah, Agustina, & Hidayat, 2018), the Southern Coast of Gunungkidul (Sodiq & Arisandi, 2020), and the coastal area of Tunda Island (Srimariana et al., 2020). However, further study on macroalgae is still needed, especially in unexplored regions like Peh Pulo Beach in the Blitar Regency.

Macroalgae are one of the community structures of photosynthetic organisms (Prasetiyo & Arisandi, 2021) present along the coastline of Peh Pulo Beach. The community structure can be understood by calculating Diversity, Evenness, and Dominance Indices (Ariani et al., 2020; Ulfah, Agustina, & Hidayat, 2018; Ayhuan, Zamani, & Soedharma, 2017). The photosynthetic capability possessed by macroalgae impacts their role as producers in aquatic environments, making them ecologically

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significant (Latuconsina, 2019). Besides their ecological role, macroalgae hold considerable potential for utilization, with several types containing bioactive compounds (Sianipar et al., 2022; Sedjati et al., 2017; Malo, Saloso, & Sunadji, 2018; Ndahawali et al., 2021).

The diversity and abundance of macroalgae in nature are influenced by various factors, including the environmental conditions of the water (Prasetiyo & Arisandi, 2021; Rume & Yohanista, 2017; Sodiq & Arisandi, 2020). Typically, macroalgae inhabit intertidal zones, which exhibit higher environmental variations than other parts of the marine ecosystem (Rachmawan, Suryono, & Riniatsih, 2021; Handayani, 2020). These environmental factors include temperature, salinity, and substrate (Srimariana et al., 2020). Accordingly, different environmental characteristics impact the diversity of macroalgae species in aquatic environments (Sodiq & Arisandi, 2020; Ahsaniyah et al., 2021).

Understanding the diversity of macroalgae along the coastal shores is crucial for maintaining ecosystem balance and its potential uses. Over the past few decades, numerous human activities have disrupted coastal ecosystems, such as pollution (Salim, 2012), overfishing, and climate change (Latuconsina, 2019; 2010; Octavian et al., 2022). In Indonesia, the biodiversity of coastal areas is still relatively underexplored in detail. Therefore, investigating macroalgae diversity in Peh Pulo Beach, Blitar Regency, could provide valuable insights into Indonesia's coastal biodiversity. Ultimately, the findings can be utilized to develop strategies for the conservation and sustainable management of natural resources.

Research Method

Time and Place of Research

The study was conducted in the coastal area of Peh Pulo Beach, Blitar Regency (Figure 1). This beach is located in Sumbersih Village, Panggungrejo Subdistrict, Blitar Regency, with coordinates 8° 20' 26.65"-8° 21' 11.36" S and 112° 13' 7.89"-112° 14' 34.54" E.

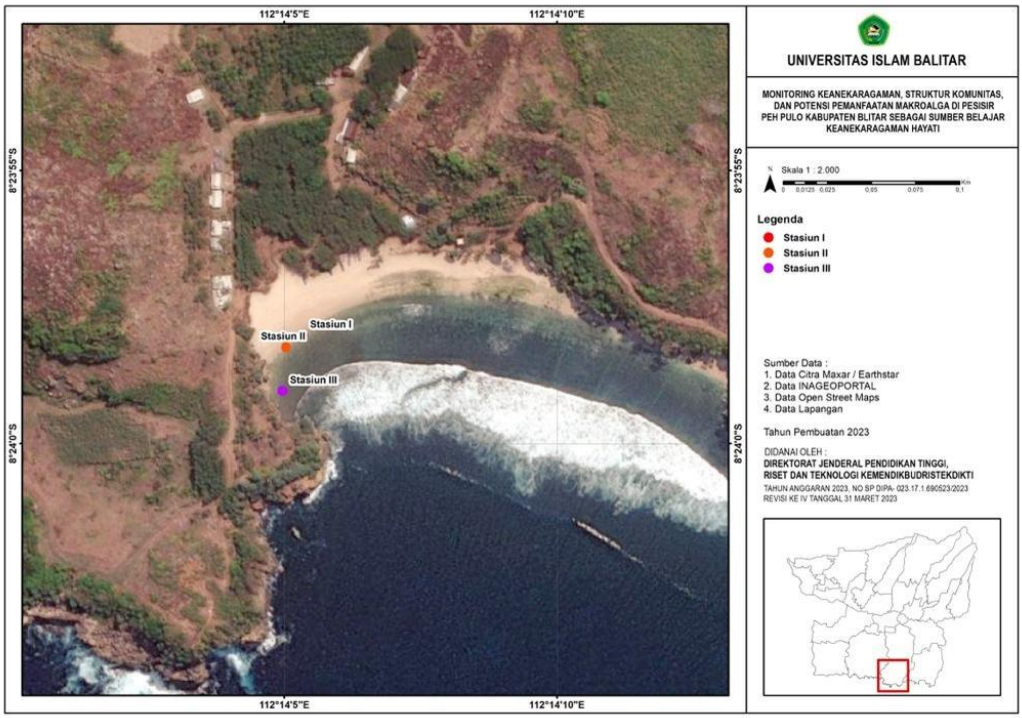
Research Materials and Tools

The researchers utilized the following tools and materials: a camera, measuring tape, pH indicator, refractometer, thermometer, sample bottles, tweezers, droppers, raffia, stationary, 70% alcohol, distilled water, regular water, label paper, macroalgae samples, tissue, and observation tables. Macroalgae samples were identified using a microscope.

Research Samples

The sampling technique employed in this research was purposive sampling. Macroalgae samples were collected during the lowest tide. They were taken at three different stations, determined based on the availability of macroalgae along the coast. At each station, the samples were collected from three randomly selected 1x1 m plots. They were subsequently labeled, placed in plastic bags, and transported to the laboratory for sorting and identification by genus and species. The measured abiotic variables included temperature, pH, light intensity, salinity, and substrate conditions.

Figure 1
The sampling location for macroalgae at Peh Pulo Beach, Blitar Regency. The sampling was conducted at three different stations, each with three plots.



Data Analysis

Sorensen Similarity Index

The Sorensen Similarity Index, or the Czekanowski Index, determines vegetation similarity across all sample units. It was employed for analyzing binary data (presence or absence) of species at sampling stations, with a scale ranging from 0 (no similarity) to 1 (high similarity) (Sofiyana, 2011). The formula for calculating the Sorensen Similarity Index is as follows:

$$IS = \frac{2a}{2a + b + c}$$

Notes:

S : Sorensen Similarity Index
a : Number of species shared between Station A and Station B
b : Number of species found only in Station A
c : Number of species found only in Station B

To assess the dissimilarity between stations, the overall Sorensen Index for all stations was utilized to create a Dissimilarity Index (DI), in which DI = 100 - SI. The criteria for determining the level of similarity among stations are presented in Table 1.

Table 1.
Determination of the level of vegetation similarity at sampling stations

Similarity Index (%)	Level of Similarity
>75	Very high
50-75	High

25-50	Low
<25	Very low

Diversity Index

The diversity index was calculated using the Shannon-Wiener formula (Ariani et al., 2020; Srimariana et al., 2020; Awal, Tantu, & Tenriawaru, 2015; Sofiyana, 2023; 2022; 2014). The diversity index (H') was calculated using the following formula:

$$H' = -\sum \left(\frac{ni}{N}\right) \ln\left(\frac{ni}{N}\right)$$

In the formula, *ni* represents the number of colonies for each species, and *N* represents all species' total number of colonies. The Shannon-Wiener diversity index (H') value was adjusted based on the criteria presented in Table 2.

Table 2. Shannon-Wiener Diversity Index Criteria

Diversity Index	Level of Diversity
H' ≤ 1	Low Diversity
1 < H' < 3	Medium Diversity
H' ≥ 3	High Diversity

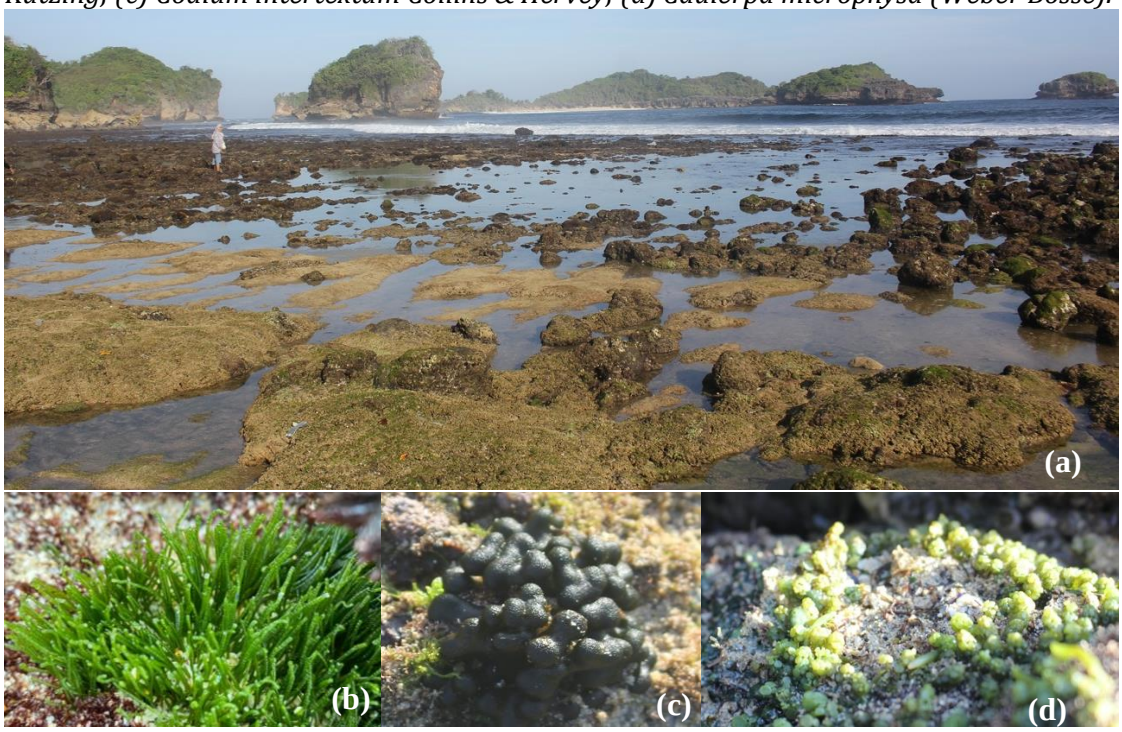
Research Results and Discussion

Community Structure and Diversity of Macroalgae at Peh Pulo Beach

The coastal area of Peh Pulo Beach exhibits an ecological type similar to the beaches in South Java, which are characterized by large waves due to being part of the open Indian Ocean. The tidal profile at the macroalgae sampling location is depicted in Figure 2. Macroalgae are located 50-150 meters from the shoreline towards the sea and are associated with hard substrates such as dead corals. The discovered macroalgae belonged to three divisions: *Chlorophyta* (9 species), *Phaeophyta* (4 species), and *Rhodophyta* (8 species) (Table 3). The distribution of these three divisions overlapped at three stations. Norashikin et al. (2013) argue that varied environmental factors based on location can influence the distribution of macroalgae communities.

The results of macroalgae identification at Peh Pulo Beach demonstrated that 21 species belong to 16 genera and 14 families (Table 3). The number of macroalgae species found at Peh Pulo Beach was higher compared to those found at Jungwok Beach in Gunungkidul (5 species) (Setyorini et al., 2021) and Krakal Beach in Gunungkidul (9 species) (Sodiq & Arisandi, 2020). However, the number was lower than the macroalgae found along the southern coast of Garut Beach (44 species) (Handayani, 2019) and Sindangkerta Beach (25 species) (Handayani et al., 2020). The variation in the number of species found was influenced by substrate, geography, coastal topography, geographical location, and macroalgae season (Norashikin et al., 2013).

Figure 2
(a) The coastal area of Peh Pulo Beach depicting the macroalgae substrate and examples of macroalgae found at Peh Pulo Beach; (b) Chaetomorpha melagonium (F.Weber & D.Mohr) Kützing; (c) Codium intertextum Collins & Hervey; (d) Caulerpa microphysa (Weber Bosse).



Overall, the macroalgae community along the coast of Peh Pulo Beach was predominantly composed of *Chlorophyta*, with a larger species composition than *Rhodophyta* and *Phaeophyta*. *Chlorophyta* accounted for 43% of the community and comprised 9 species, including *Ulva* and *Codium*. *Rhodophyta*, on the other hand, was mainly represented by *Gracilaria*. The high abundance of *Chlorophyta* found at all observation stations could be attributed to the substrate type at the research location. The presence of sand and coral made it a suitable habitat for *Chlorophyta*. These algae have cylindrical sheet thalli with densely overlapping tissues, contributing to their dominance at the observation stations. *Chlorophyta* is known to thrive on various subtidal substrates, such as sand, mud, rocks, and dead seagrass beds, at depths ranging from 0 to 50 meters (Mushlihah et al., 2021; Ulfah et al., 2018). This adaptability gives *Chlorophyta* the potential to expand its range along the coastline. Furthermore, macroalgae from the *Chlorophyta* group generally respond rapidly to nutrient conditions and dominate shallow water environments (Teichberg et al., 2013). They are well-suited to grow on sandy substrates in the intertidal zone and tolerate lower salinities. Although sandy substrates are less stable and more prone to disturbance by large waves, *Chlorophyta* members can still grow (Setyorini et al., 2021).

Table 3
Diversity of macroalgae species found in Peh Pulo Beach, Blitar Regency

Filum	Family	*Genus*	Species	Station 1	Station 2	Station 3
Chlorophyta	*Caulerpaceae*	*Caulerpa*	*Caulerpa microphysa* (Weber Bosse)		√	√
	Codiaceae	*Codium*	*Codium fragile* (Suringar) Hariot	√	√	√
			Codium intertextum Collins & Hervey	√	√	
			Codium intricatum Okamura	√	√	
	Cladophoraceae	*Chaetomorpha*	*Chaetomorpha melagonium* (F.Weber & D.Mohr) Kützing	√	√	√
		Valoniopsis	*Valoniopsis pachynema* (G.Martens) Børgesen	√		√
	Ulvaceae	*Ulva*	*Ulva conglobata* Kjellman	√	√	√
			Ulva intestinalis Linnaeus	√	√	√
			Ulva lactuca Linnaeus	√	√	√
Phaeophyta	*Dictyotaceae*	*Dictyota*	*Dictyota dichotoma* (Hudson) J.V.Lamouroux		√	√
		Spatoglossum	*Spatoglossum asperum* J.Agardh			√
	Sargassaceae	*Sargassum*	*Sargassum polyceratium* Montagne			√
	Laminariaceace	*Laminaria*	*Laminaria sp.*			√
Rhodophyta	*Lithophyllaceae*	*Amphiroa*	*Amphiroa foliacea* J.V.Lamouroux			√
	Caulachantaceae	*Caulacanthus*	*Caulacanthus ustulatus* (Turner) Kützing		√	√
	Furcellariaceae	*Furcellaria*	*Furcellaria lumbricalis* (Hudson) J.V.Lamouroux		√	√
	Phyllophoraceae	*Mastocarpus*	*Mastocarpus stellatus* (Stackhouse) Guiry			√
	Gracilariaceae	*Gracilaria*	*Gracilaria confervoides* (Linnaeus) Greville		√	√
			Gracilaria salicornia (C.Agardh)		√	√
	Galaxauraceae	*Galaxaura*	*Galaxaura rugosa* (J.Ellis & Solander) J.V.Lamouroux		√	
	Palmariaceae	*Palmaria*	*Palmaria palmata* (Linnaeus) F.Weber & D.Mohr		√	√

The similarity index among stations ranged from 41% to 82% (Table 4). The highest similarity, 82%, was found between Station 1 and Station 2, while the lowest, 41%, was found between Station 1 and Station 3. The similarity index consistently ranks the highest and shows a linear correlation. However, this index only considers species' binary data (presence or absence) and does not estimate species abundance. Therefore, it does not capture the actual ecological patterns in the data (Mushlihah et al., 2021).

Table 4
Similarity and Dissimilarity Index of Three Macroalgae Observation Stations

SIMILARITY INDEX			
Stations	Station 1	Station 2	Station 3
Station 1		0.824	0.417
Station 2	0.176		0.727
Station 3	0.583	0.273	
DISSIMILARITY INDEX			

The calculated Shannon Diversity Index value was 2.84, indicating that the macroalgae diversity along Peh Pulo Beach was categorized as moderate. The presence of substrates such as sand, rocks, and coral provides a beneficial environment for macroalgae growth. Likewise, the substrate's stability, hardness, and surface texture are vital in supporting their development. Habitats with stable substrates, particularly coral and rubble, tend to exhibit higher species diversity compared to less stable substrates like sand or silt (Ariani et al., 2020; Ayhuan et al., 2017; Setyawan et al., 2015).

Abiotic Variables and Their Influence on Macroalgae Diversity

This research examined several abiotic variables: pH, light intensity, salinity, and substrate condition (Table 5). The distribution of the macroalgae community is influenced by abiotic factors such as temperature and significant wave height (Setyorini et al., 2021). In addition, it is worth noting that macroalgae distribution is also affected by other abiotic variables, including sunlight, temperature, and salinity.

Conclusion

The identification of macroalgae species at Peh Pulo Beach yielded 21 species, which belonged to 16 genera and 14 families (Table 3). These species could be classified into three main groups: *Chlorophyta* (9 species), *Phaeophyta* (4 species), and *Rhodophyta* (8 species). *Ulva* and *Codium* represented *Chlorophyta*, while *Gracilaria* dominated the *Rhodophyta*. The calculated Shannon Diversity Index value was 2.84, indicating a moderate level of macroalgae diversity along the coast of Peh Pulo Beach.

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References

Ahsaniyah, Shinta, Rahmad Lingga, Henri Henri, Nadila Puspita Sari, Putri Ayu Indah Suryani, and Inayah Assyifa. 2021. "Keanekaragaman Jenis Makroalga Di Perairan Pulau Nangka Kabupaten Bangka Tengah." *EKOTONIA: Jurnal Penelitian Biologi, Botani, Zoologi Dan Mikrobiologi* 6 (1): 17–22. https://doi.org/10.33019/EKOTONIA.V6I1.2573.

Ariani, Susanty, Agil Al Idrus, Lalu Japa, and Didik Santoso. 2020. "Struktur Komunitas Makroalga Sebagai Indikator Ekologi Ekosistem Perairan Pada Kawasan Konservasi Laut Daerah Di Gili Sulat Lombok Timur." *Jurnal Biologi Tropis* 20 (1): 132–38. https://doi.org/10.29303/JBT.V20I1.1690.

Awal, Jumadil, Hammado Tantu, and Eka Pratiwi Tenriawaru. 2015. "Identifikasi Alga (Algae) Sebagai Bioindikator Tingkat Pencemaran Di Sungai Lamasi Kabupaten Luwu." *Dinamika* 5 (2). http://www.journal.uncp.ac.id/index.php/dinamika/article/view/36/32.

Ayhuan, Hendrik Victor, Neviaty Putri Zamani, and Dedi Soedharma. 2017. "Analisis Struktur Komunitas Makroalga Ekonomis Penting Di Perairan Intertidal Manokwari, Papua Barat." *Jurnal Teknologi Perikanan Dan Kelautan* 8 (1): 19–38. https://doi.org/10.24319/JTPK.8.19-38.

Handayani, Tri. 2020. "Struktur Komunitas, Peranan, Dan Adaptasi Makroalga Di Intertidal Berbatu." *Oseana* 45 (1): 59–69. https://www.researchgate.net/profile/Tri-Handayani-3/publication/342446019_struktur_komunitas_peranan_dan_adaptasi_makroalga_di_intertidal_berbatu/links/5f6828d692851c14bc8bcc46/struktur-komunitas-peranan-dan-adaptasi-makroalga-di-intertidal-berbatu.pdf.

Latuconsina, Husain. 2010. "Dampak Pemanasan Global Terhadap Ekosistem Pesisir Dan Lautan." *Agrikan: Jurnal Agribisnis Perikanan* 3 (1): 30–37. https://doi.org/10.29239/J.AGRIKAN.3.1.30-37.

———. 2019. *Ekologi Perairan Tropis: Prinsip Dasar Pengelolaan Sumber Daya Hayati Perairan - Husain Latuconsina - Google Buku*. Yogyakarta: Gadjah Mada University Press. https://books.google.co.id/books?hl=id&lr=&id=mbOeDwAAQBAJ&oi=fnd&pg=PR7&dq=Kemampuan+fotosintetik+yang+dimiliki+makroalga+berdampak+pada+peran+makroalga+sebagai+produsen+di+perairan+dan+memiliki+peran+ekologi+yang+penting&ots=TCDbi8eedr&sig=ZXn94PuE9FRvotXSx7tCRv7YxGI&redir_esc=y#v=onepage&q&f=false.

Malo, Arlinda, Yuliana Saloso, and Sunadji Sunadji. 2018. "Kandungan Senyawa Aktif Makroalga Yang Diambil Di Perairan Pantai Arubara Kabupaten Ende." *Jurnal Aquatik* 1 (1): 91–97. https://ejurnal.undana.ac.id/index.php/jaqu/article/view/2442.

Munifah, Ifah. 2008. "Prospek Pemanfaatan Alga Laut Untuk Industri." *Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology* 3 (2): 58–62.

https://doi.org/10.15578/SQUALEN.V3I2.159.

Ndahawali, Suryaningsih, Nurbety Tarigan, Yatris Rambu Tega, Krisman Umbu Henggu, and Firat Meiyasa. 2021. "Analisis Kandungan Fitokimia Beberapa Jenis Makroalga Dari Perairan Pantai Londalima Kabupaten Sumba Timur." *Jambura Fish Processing Journal* 3 (2): 46–50. https://doi.org/10.37905/JFPJ.V3I2.10234.

Norashikin, A, Muta Z Harah, and Japar B Sidik. 2013. "Intertidal Seaweeds and Their Multi-Life Forms." *Journal of Fisheries and Aquatic Science* 8 (1): 80–86.

Octavian, Amarulla, marsetio, Abimanyu Hilmawan, and Rizqi Rahman. 2022. "Upaya Perlindungan Pesisir Dan Pulau-Pulau Kecil Pemerintah Provinsi Sumatera Barat Dari Ancaman Abrasi Dan Perubahan Iklim." *Jurnal Ilmu Lingkungan* 22 (2): 302–15. https://www.researchgate.net/profile/Amarulla-Octavian/publication/357883196_Upaya_Perlindungan_Pesisir_dan_Pulau-Pulau_Kecil_Pemerintah_Provinsi_Sumatera_Barat_dari_Ancaman_Abrasi_dan_Perubahan_Iklim/links/6383e9aa7b0e356feb8fdcb9/Upaya-Perlindungan-Pesisir-dan-Pulau-Pulau-Kecil-Pemerintah-Provinsi-Sumatera-Barat-dari-Ancaman-Abrasi-dan-Perubahan-Iklim.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail&_rtd=e30%3D.

Pakidi, Chalvyn S, and Hidayat Suryanto Suwoyo. 2017. "Potensi Dan Pemanfaatan Bahan Aktif Alga Cokelat Sargassum Sp." *Octopus* 6 (1): 551–62.

Prasetiyo, Heri, and Apri Arisandi. 2021. "Struktur Komunitas Makroalga Di Perairan Teluk Prigi Kabupaten Trenggalek." *Juvenil:Jurnal Ilmiah Kelautan Dan Perikanan* 2 (1): 1–9. https://doi.org/10.21107/JUVENIL.V2I1.9654.

Rachmawan, Ega Widyatama, Chrisna Adhi Suryono, and Ita Riniatsih. 2021. "Perbandingan Tutupan Antar Lamun, Makroalga Dan Epifit Di Perairan Paciran Lamongan." *Journal of Marine Research* 10 (4): 508–14. https://doi.org/10.14710/JMR.V10I4.31986.

Rahardi, Wira, and Rizal M Suhardi. 2016. "Keanekaragaman Hayati Dan Jasa Ekosistem Mangrove Di Indonesia." *Prosiding Symbion (Symposium on Biology Education), Prodi Pendidikan Biologi, FKIP, Universitas Ahmad Dahlan,* , August, 499–510. http://symbion.pbio.uad.ac.id/prosiding/prosiding/ID_339_Wira Rahardi_Hal 499-510.pdf.

Rume, Maria Imaculata, and Maria Yohanista. 2017. "Struktur Komunitas Makroalga Di Pantai Selata Desa Pruda Kabupaten Sikka." *Jurnal UIN Ar-Raniry* 5 (1): 387–91.

Salim, Dafiuddin. 2012. "Pengelolaan Ekosistem Terumbu Karang Akibat Pemutihan (Bleaching) Dan Rusak." *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology* 5 (2): 142–55. https://doi.org/10.21107/jk.v5i2.870.

Sedjati, Sri, Suryono Suryono, Adi

Santosa, Endang Supriyantini, and Ali Ridlo. 2017. "Aktivitas Antioksidan Dan Kandungan Senyawa Fenolik Makroalga Coklat Sargassum Sp." *Jurnal Kelautan Tropis* 20 (2): 124–30. https://doi.org/10.14710/JKT.V20I2.1737.

Sianipar, Erlia Anggrainy, Natasha Satriawan, Juliana Sumartono, and Pretty Falena Atmanda Kambira. 2022. "Pengujian Aktivitas Antioksidan Dan Makro Alga Sumbawa Dalam Hubungannya Dengan Kandungan Senyawa Bioaktif Dan Efek Farmakologi." *Jurnal Riset Kesehatan Nasional* 6 (2): 151–57. https://doi.org/10.37294/JRKN.V6I2.457.

Sodiq, Ach Qoidus, and Apri Arisandi. 2020. "Identifikasi Dan Kelimpahan Makroalga Di Pantai Selatan Gunungkidul." *Juvenil:Jurnal Ilmiah Kelautan Dan Perikanan* 1 (3): 325–30. https://doi.org/10.21107/JUVENIL.V1I3.8560.

Sofiyana, Marinda Sari. 2011. "Lumut Hati Di Taman Nasional Gunung Halimun Salak, Jawa Barat." Bogor: IPB University. http://repository.ipb.ac.id/handle/123456789/104227.

———. 2022. "Diversity of Liverworts (Marchantiophyta) in the Bromo Tengger Semeru National Park Area." *Indonesian Journal of Biology Education* 5 (1): 47–52. https://doi.org/10.31002/IJOBE.V5I1.6081.

———. 2023. "Tree Species Diversity at Kebon Rojo, Blitar City." *Bioma : Jurnal Ilmiah Biologi* 12 (1): 1–8. https://doi.org/10.26877/BIOMA.V12I1.11992.

Srimariana, Endang Sunarwati, Mujizat Kawaroe, Dea Fauzia Lestari, and Aditya Hikmat Nugraha. 2020. "Keanekaragaman Dan Potensi Pemanfaatan Makroalga Di Pesisir Pulau Tunda." *Jurnal Ilmu Pertanian Indonesia* 25 (1): 138–44. https://doi.org/10.18343/jipi.25.1.138.

Sriwajungningsih, Dewi Hernawati, and Crisya Monetha Raharjo. 2022. "Analisis Keanekaragaman Dan Kelimpahan Makroalga Di Kawasan Pantai Rancabuaya Desa Purbayani Kabupaten Garus." *Journal Scientific of Mandalika (JSM)* 3 (3 (Maret)): 117–26. https://doi.org/10.36312/jomla.v3i3 (maret).581.

Ulfah, Soraya, Elita Agustina, and Muslich Hidayat. 2018. "Struktur Komunitas Makroalga Ekosistem Terumbu Karang Perairan Pantai Air Berudang Kabupaten Aceh Selatan." *Prosiding Seminar Nasional Biotik* 5 (1): 237–44. https://doi.org/10.22373/pbio.v5i1.2152.