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MACROALGAE BIODIVERSITY IN GILI MATRA CONSERVATION AREA

Biodiversitas Makroalga di Kawasan Konservasi Gili Matra

Disa Aulia Rahmi[1], Edwin Jefri[1], Nurliah Buhari[1*], Hotmariyah[2]

[1] Marine Science Study Program University of Mataram, [2]Kupang National Marine Conservation Area Center

Pendidikan Street No.37, Dasan Agung Baru, Selaparang, Mataram City, West Nusa Tenggara

*Corresponding Author: nurliah.buhari@unram.ac.id

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ABSTRACT

Macroalgae are a group of lower marine plants commonly referred to as thalloid plants. The diversity of macroalgae in tropical regions, particularly in eastern Indonesia, is very high due to the area being part of the Wallacea region. This study aims to determine the level of diversity and distribution of macroalgae in these waters. The method used is the line transect method, with data analysis including ecological indices and distribution patterns. The results show that the diversity index ranges from 2.45 to 2.80, which falls into the medium category. The evenness index ranges from 0.80 to 0.81, classified as high, while the dominance index ranges from 0.09 to 0.11, which is considered low. The distribution pattern of macroalgae at stations 1, 2, and 3 ranges from 1.37 to 1.49, indicating a clustered distribution pattern. This suggests that the environmental conditions in the waters of Gili Air are stable and conducive to the growth of macroalgae, with no species dominating the ecosystem.

Key words: Diversity, chlorophyta, phaeophyta, rhodophyta, Gili Air

ABSTRAK

Makroalga merupakan tumbuhan laut tingkat rendah atau yang lebih dikenal dengan tumbuhan berthallus. Keanekaragaman spesies makroalga di wilayah tropis, khususnya Indonesia bagian timur, sangatlah tinggi karena wilayah tersebut berada di Kawasan Wallacea, yang dikenal sebagai hotspot biodiversitas. Tujuan dari penelitian ini untuk mengetahui tingkat keanekaragaman dan mengetahui distribusi makroalga. Metode yang digunakan yaitu metode *line transect* dengan analisis data menggunakan Indeks ekologi dan Pola sebaran. Indeks keanekaragaman berkisar antara 2,45-2,80 dengan kategori ‘sedang’. Indeks keseragaman 0,80-0,81 dengan kategori ‘tinggi’ dan indeks dominansi berkisar 0,09- 0,11 dengan kategori ‘rendah’. Nilai pola sebaran jenis makroalga pada stasiun 1, 2 dan 3 didapatkan berkisar antara 1,37-1,49 menunjukkan kategori pola sebaran mengelompok. Hal ini menandakan bahwa kondisi lingkungan di perairan Gili Air stabil dan baik untuk pertumbuhan makroalga dan tidak adanya spesies yang mendominansi.

Kata Kunci: Keanekaragaman, alga hijau, alga coklat, alga merah, Gili Air

INTRODUCTION

Gili Air, Gili Meno, and Gili Trawangan Islands are located in Pemenang District, North Lombok Regency, West Nusa Tenggara Province. Based on the decree of the Minister of Fisheries and Marine Affairs number KEP. 34/MEN/2022, this area is designated as a Conservation Area. This area is managed as a Park in the Waters of Gili Air, Gili Meno, and Gili Trawangan, which covers a total area of 2,268.59 hectares.

Macroalgae are low-level marine plants also known as thallus plants. Although macroalgae have roots, stems, and leaves that resemble higher plants, macroalgae do not have a clear structure. According to Kepel *et al.* (2018), macroalgae are low-level plants that only have a thallus shape and have parts such as stipe (stem), holdfast (root), and blade (leaf).

Macroalgae play an important role in marine ecosystems, functioning as producers that support the lives of other organisms, especially herbivores and habitats for small marine animals such as crustaceans, molluscs, and echinoderms (Ira *et al*., 2018; Handayani, 2017). From an economic perspective, macroalgae are widely used as food, cosmetics, medicines, paints, toys, and even as a trading commodity (Ramdhan & Ratnasari, 2021).

Macroalgae can grow on various types of substrates, both soft and hard, such as sand, mud, coral, dead coral, coral fragments, rocks, and bivalve shells (Ferawati *et al*., 2014). In addition, macroalgae are also often found attached to other macroalgae (Lokollo, 2019). Macroalgae growth occurs by attaching or placing their holdfasts on a stable substrate to protect themselves from wave and current pressure (Perisha *et al*., 2022).

The diversity of macroalgae species in tropical regions, especially in eastern Indonesia, is very high (Dwimayasanti & Kurnianto, 2018). This is because eastern Indonesia is located in the Wallacea Region, which is known to have extraordinary biodiversity. Lombok Island, which is part of the Wallacea Region, also contributes to the diversity of marine ecosystems (Bisjoe, 2015). In Indonesian waters, there are around 782 species of macroalgae recorded, consisting of 196 species of green algae, 134 species of brown algae, and 452 species of red algae (Manggay & Meiyasa, 2023).

Macroalgae usually grow side by side with seagrass plants in the intertidal zone and form interactions. Handayani's (2021) research shows that seagrass cover has a negative correlation with macroalgae abundance, but a positive correlation with macroalgae diversity. However, the abundance and diversity of macroalgae are difficult to determine because they are also influenced by water quality (Handayani, 2021). The variation of macroalgae species is also influenced by the type of substrate, so the more diverse the substrate, the more macroalgae species can be found (Melsasail *et al*., 2018).

Several studies on macroalgae on Lombok Island have been conducted; in the waters of Gili Sulat, 11 species were found (Ariani *et al*., 2020), in Tawun Beach, 25 species were found (Kharismawati *et al*., 2019), and in the southern part of Lombok Island, namely in the Kaliantan area (East Lombok), Serinting Bay (Central Lombok), and Batukijuk Bay (West Lombok) 22 species of macroalgae were recorded (Karnan et al., 2018). However, until now there has been no research on macroalgae in the Gili Matra conservation area. Therefore, research on the diversity of macroalgae in the Gili Matra conservation area needs to be conducted.

RESEARCH METHOD

This research was conducted on January 16-18, 2024 on Gili Air Island, Gili Indah Village. There were 3 data collection stations (Figure 1).

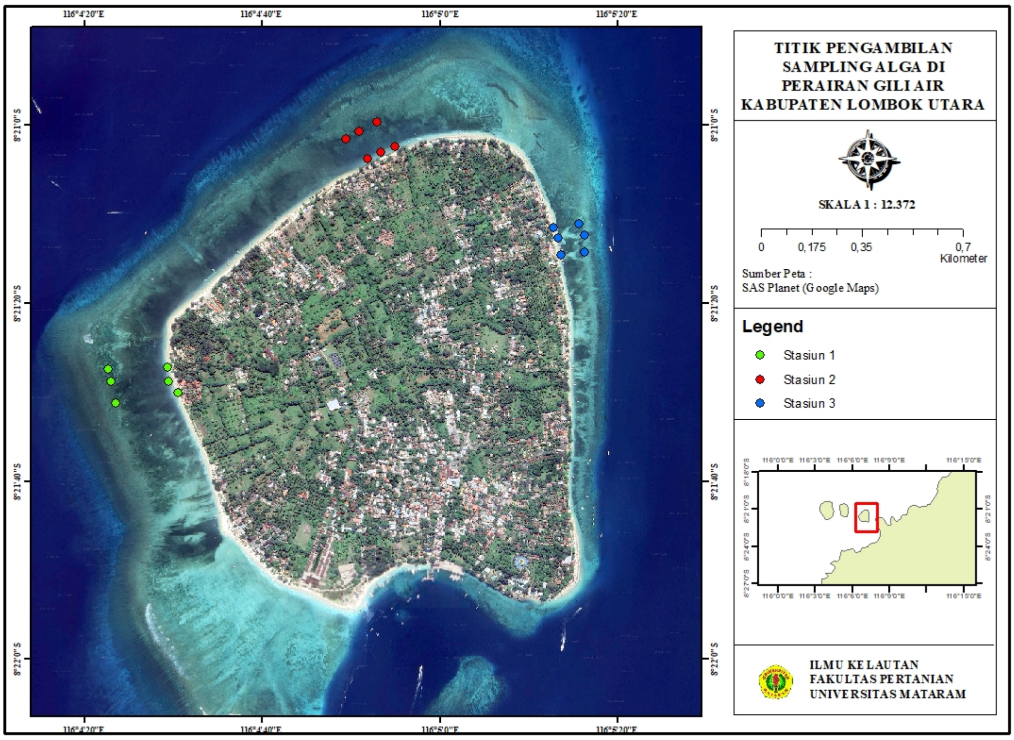

Figure 1. Research Location Map

The collection of macroalgae diversity data refers to the line transect method from Kirana *et al*., (2021). At the research location, it was carried out at three stations with three repetitions at each station. At each research location point, the length of the line transect will adjust to the length of the existing intertidal zone, with a distance between transects of 100 meters. Quadrants measuring 1x1 meter are placed along the transect with a distance between quadrants of 20% of the length of the transect (Figure 2). The diversity data taken is each type of macroalgae found in each quadrant plot. Each macroalgae found in the quadrant will be recorded as a species on the existing data sheet.

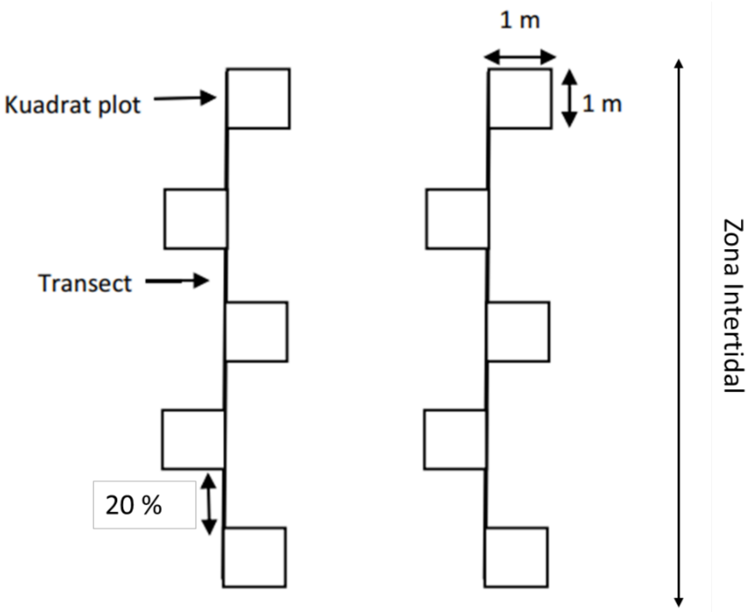

Figure 2. Data Collection Method

Research Variables

The research variables used include the ecological index from Shannon Wiener and distribution patterns according to Browner *et al.* (1990).

1. Diversity Index

$$H' = - \Sigma [(ni/N)/\ln (ni/N)]$$

Information:
H' = Diversity Index
Ni = Number of individuals of species
N = Total of all individuals
With the criteria:
H′ < 1 = Low diversity
1 < H′ < 3 = Moderate diversity
H′ > 3 = High diversity.

2. Uniformity Index

$$E = H'/\ln S$$

Information:

3. E = Uniformity Index
H'= Diversity Index
S = Number of Species
With the criteria:
E < 0,4 = The community is stressed and has low uniformity.
0,4 < E < 0,6 = The community is less stable and has moderate uniformity.
E > 0,6 = The community is stable and has high uniformity.

4. Dominance Index

$$C = \Sigma[ni/N]2$$

Information:
C = Dominance Index
ni = Number of individuals in species-i
N = Total of all individuals
With the criteria:
Low category (0,00 < C ≤ 0,50)
Moderate category (0,50 < C ≤ 0,75)
High category (0,75 < C ≤ 1,00).

5. Distribution Pattern

$$Id = n\frac{\Sigma x^2 - N}{N(N-1)}$$

Information:
Id = Morisita dispersion index
n = Number of plots taken
N = Total number of individuals in the plot
x^2 = Number of individuals in each plot
With the criteria:
Id < 1,0 = Even distribution pattern
Id = 1,0 = Random distribution pattern
Id > 1,0 = Clustered distribution pattern

6. Water Quality Measurement

The water quality parameters measured were temperature, salinity, pH and current speed. Measurements of temperature, salinity and pH were carried out at point 0m and the end point of the transect using a water quality tester. While the current speed was measured using a current kite and stopwatch.

Data Analysis

The collected data were analyzed descriptively including the general condition of the location, algae morphology, number of species and Ecological Index. Meanwhile, to determine the relationship between seagrass cover and the number of macroalgae species, a simple linear regression analysis was carried out using the excel program.

RESULT

Macroalgae Composition

The results of data collection at 3 research location stations found 47 species grouped into 3 large groups, 10 orders, 15 families, and 19 genera. However, 12 species from the red algae group (Rhodophyta) have not been identified (Table 1). The species found consisted of 20 species of Chlorophyta, 4 species of Phaeophyta, and 23 species of Rhodophyta (Table 1).

Table 1. Macroalgae species found in Gili Air

Devisi/Ordo/Famili/Genus/Spesies	Station		
	1	2	3
Chlorophyta			
Dasycladales			
Polyphysaceae			
Acetabularia			
Acetabularia major	+	+	+
Bornetellaceae			
Bornetella			
Bornetella nitida		+	+
Dasycladaceae			
Neomeris			
Neomeris sp	+	+	
Cladophorales			
Siphonocladaceae			
Boergesenia			
Boergesenia forbesii	+		+
Dictyospaeria			
Dictyosphaeria sp	+	+	+
Cladophoraceae			
Chaetomorpha			
Chaetomorpha sp	+	+	+
Bryopsidales			
Caulerpaceae			
Caulerpa			
Caulerpa racemosa		+	
Caulerpa serrulata		+	
Caulerpa sertularioides		+	

Caulerpa taxifolia	+		
Halimedaceae			
Halimeda			
Halimeda macroloba	+	+	+
Halimeda gracilis	+		
Halimeda opuntia	+	+	+
Halimeda gigas		+	+
Halimeda tuna			+
Halimeda sp	+		+
Udotea			
Udotea sp	+	+	+
Ulvales			
Ulvaceae			
Ulva			
Ulva sp	+		
Green filament (*unidentified*)	+		
Phaeophyta			
Dictyotales			
Dictyotaceae			
Padina			
Padina sp	+	+	+
Dictyota			
Dictyota dichotoma	+	+	+
Fucales			
Sargassaceae			
Turbinaria			
Turbinaria decurrens		+	
Turbinaria ornata			+
Rhodophyta			
Ceramiles			
Rhodomelaceae			
Palisada			
Palisada perforata	+	+	+
Palisada poiteaui	+	+	+
Palisada sp	+	+	
Gigartinales			
Cystocloniaceae			
Hypnea			
Hypnea valentiae	+		
Hypnea sp	+	+	
Solieriaceae			
Eucheuma			
Eucheuma arnoldii	+	+	
Eucheuma sp	+	+	+
Kappaphycus			
Kappaphycus sp	+		
Corallinales			
Lithopjyllaceae			

Amphiroa			
Amphiroa sp		+	
Gracilarales			
Gracilariaceae			
Gracilaria			
Gracilaria salicornia	+		
Gracilaria sp		+	
Sp 1	+	+	+
Sp 2	+	+	
Sp 3		+	
Sp 4		+	
Sp 5		+	
Sp 6		+	
Sp 7		+	
Sp 8		+	
Sp 9		+	
Sp 10		+	
Sp 11			+
Sp 12			+
Total	**26**	**33**	**20**

Ecological Index

The highest macroalgae diversity analysis results were obtained at station II with a value of H'=2.80, and the lowest diversity value was at station III with a value of H'=2.45. The highest uniformity index was at stations I & III with a value of E=0.81, and the lowest uniformity value was at station II with a value of E=0.80. Then, the highest dominance value was obtained at station III with a value of C=0.11, and the lowest dominance value was at station II with C=0.09 (Table 2).

Table 2. Results of Ecological Index Analysis

Ecological Index	Station			Average	Informaation
	I	II	III		
Diversity	2,67	2,80	2,45	2,64	Moderate
Uniformity	0,81	0,80	0,81	0,81	High
Dominance	0,10	0,09	0,11	0,10	Low

Distribution Pattern

Based on the morisita index value, the distribution pattern of macroalgae at each station is included in the grouped category (Table 3). The index value ranges from 1.37 to 1.49.

Table 3. Results of Macroalgae Distribution Pattern Analysis

Station	Morisita Index	Category
1.	1,49	Grouping
2.	1,43	Grouping
3.	1,37	Grouping

Water Quality Parameters

Macroalgae growth is influenced by environmental factors, both chemical and physical. The measurement results are shown in Table 4.

Table 4. Water Quality Parameters

Water Quality Parameters	**Station**			**Quality Standards[1]**
	I	**II**	**III**	
Temperature (^{0}C)	31,4	32,9	31,2	28-30^{0}C
Salinity (‰)	33	33	32	33-34
pH	7,8	7,9	7,8	7-8,5
Current Speed (m/s)	0	0,87	0,36	-

[1] Government Regulation of the Republic of Indonesia Number 22 of 2021 Concerning the Implementation of Environmental Protection and Management

Correlation of Seagrass Cover with Macroalgae Abundance

The results of a simple linear regression analysis between the number of species and seagrass cover in Gili Air Waters showed a negative relationship (Figure 3). However, the R2 value was less than 0.5, indicating a weak relationship.

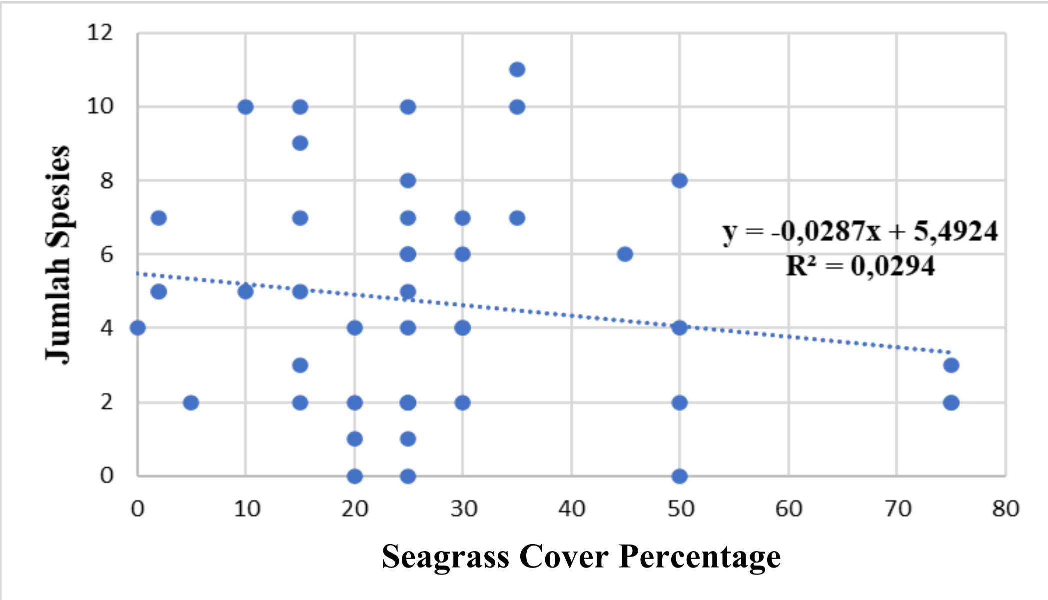

Figure 3. Linear Regression Analysis Results

DISCUSSION

Macroalgae Composition

At station 1, macroalgae from the Chlorophyta group (green algae) were found the most (Table 1). This is because station 1 has various types of substrates, namely sandy substrates, coral rubble and sand-rubble. Macroalgae from the Chlorophyta group (green algae) have good adaptability to the surrounding environmental conditions. This is in line with the opinion of Irwandi *et al*. (2017), who explained that one example of green algae adaptation is its ability to easily attach to various types of substrates at the bottom of the waters, so that it can survive water currents. In addition, green macroalgae can absorb long-wave light, especially red light, which can only be reached in shallow waters. Aslan (1998) also stated that green algae thrive in areas that have high light intensity and are rich in red light. The green macroalgae found in the waters of Gili Air are more numerous than those found in research by Destikawati (2024), who found a total of 13 species in Pandanan Hamlet, West Sekotong Village.

The Rhodophyta group was found more at station 2, which has characteristics of sandy, sand-rubber, and coral-sandy and coral substrates. Samman & Achmad (2023) stated that red algae grow in clear waters with substrates such as coral rocks, dead coral, volcanic rocks, and hard objects. Station 2 also has a fairly high ebb, almost up to a human waist. According to Kharismawati *et al.* (2019), macroalgae from the Rhodophyta group can photosynthesize and can live at deeper depths compared to other macroalgae.

Phaeophyta were found at all stations, each with 3 species except at Station 1 (Table 1). At station 1, only Dictyota sp. and Padina sp. were found, while *Turbinaria* sp. were not found. Station 1 is located in a sloping water location and at the lowest ebb it will be exposed to the sun. In addition, the substrate at station 1 is more sand and rubble so that it is less supportive of the growth of the Phaeophyta group (brown algae). This is in accordance with the statement of Widyartini et al., (2017) that Phaeophyta can grow on coral substrates consisting of stable rocks and corals so that macroalgae can attach and are not easily carried away by waves.

Ecologycal Index

According to the Shannon-Winner criteria, the diversity value in Gili Air waters ranges from 2.45-2.80, which is included in the "moderate" category because the value is in the range of $1<H'<3$. Differences in the diversity index of macroalgae species found at various stations can be influenced by the physical and biological conditions of the waters. Stations I and II show a high level of diversity compared to station III, because both stations have little boat mooring activity and human interaction. Conversely, station III has a lower level of diversity due to the high human activity around the location.

The evenness index at each station is included in the high category because $E> 0.6$, indicating a stable community with high evenness. Ariani *et al*. (2020), stated that the evenness index value is related to the diversity index value obtained. In this study, it was found that the evenness index value was directly proportional to the diversity index value. Guiri *et al.* (2021), argue that species uniformity is influenced by several factors, such as the availability of nutrients in the waters, balanced competition between species for nutrients, and even distribution of species.

The dominance index indicates the presence of species that dominate a community. Rosdiana *et al.* (2017), explained that the diversity of a community is closely related to the level of dominance of its species. In this study, the dominance index values obtained were Station I 0.1 (low), Station II 0.09 (low), and Station III 0.11 (low). A dominance index value that does not reach 1 indicates that no species dominates at the three stations. This is in line with the opinion of Ira (2018), who stated that if the value is close to 1, there is a species that dominates the area, while if it is close to 0, no species dominates.

Distribution Pattern

The distribution pattern of macroalgae at stations 1, 2, and 3 showed values ranging from 1.37-1.49, indicating a clustered distribution pattern. This phenomenon is related to the ability of macroalgae species to choose a suitable substrate for growth. The clustered distribution pattern allows for closer interactions between individuals, increasing nutrient exchange and reproductive efficiency.

According to Rosdiana *et al*. (2017), this distribution pattern is influenced by ecological factors and biological characteristics of macroalgae. Ariani *et al.* (2017), added that environmental factors, such as substrate type, water depth, and seagrass bed area and the presence of dead coral, play an important role in determining macroalgae habitat. Macroalgae that grow in a clustered distribution pattern are usually found in waters that are rich in nutrients and have adequate light for their growth.

Water Quality Parameters

Macroalgae growth can be influenced by environmental factors, both chemical and physical. The measurement results shown in Table 4 show that the average water temperature at the three stations had a value between 31.2°C and 32.9°C. This temperature is still within the normal range for macroalgae, which can generally survive at temperatures of 0-40°C. Station 2 recorded the highest temperature, which was 32.9°C, but the waist-deep water and relatively high seagrass cover helped protect the macroalgae from direct exposure to sunlight during low tide.

Salinity in this study ranged from 32-33‰, with the highest values at stations 1 and 2. Salinity at the research location is in accordance with the seawater quality standards (PP No. 22 of 2021) for biota except at station 3, which is 32 ppm. Station 3 is located in front of a crowded resort and hotel so it is likely that the low salinity at station 3 is due to the flow of fresh water entering the waters. This can also be seen from the slightly muddy substrate at station 3, indicating a higher amount of organic matter (Taqwa *et al*., 2014). However, a salinity of 32 ppm is still within the optimal range for several types of macroalgae (Arfah & Patty, 2014).

The average pH value obtained has a value ranging from 7.8 to 7.9, with the highest value found at station 2. This pH range is also safe for macroalgae growth. Regarding current speed, station 1 shows a value of 0 because it is in a dry ebb state, while station 2 has a faster current than station 3. This is due to the location of station 2 which is not blocked by an island, while station 3 is near Sire Beach, North Lombok.

According to Hairati *et al*. (2016), a good current speed for macroalgae is between 20-40 m/s; if it exceeds 40 m/s, it can damage macroalgae. According to Ira (2018), calm waters are actually less supportive of macroalgae habitats, because this condition tends to cause mud accumulation which can inhibit their growth. Sunarernanda *et al*. (2014), explained that currents play an important role as limiting factors in the process of spore spread, attachment, and seaweed growth. Meanwhile, according to Wulandari *et al.* (2015), water currents help spread nutrients in the waters, thus supporting nutrient distribution and influencing the process of spore attachment to macroalgae.

Correlation of Seagrass Cover with Macroalgae Abundance

The results of a simple linear regression analysis show that the relationship between the number of macroalgae species and seagrass cover in Gili Air Waters is relatively low. The correlation value obtained is negative, which means there is an opposite effect between the two variables. According to Siregar (2014), if the correlation value is positive, then the two variables are related in the same direction, while a negative value indicates an opposite relationship. This indicates that an increase in seagrass abundance or cover can cause a decrease in the number of macroalgae species, and vice versa.

This phenomenon can be explained by the competition between seagrass and macroalgae for nutrients, as expressed by Mocenni & Vicino (2006). Alexandre *et al*. (2017), also noted that there is competition for nutrients between these two organisms. On the other hand, Handayani (2021) argues that seagrass cover can have a positive impact on macroalgae diversity. Despite the competition, seagrass also functions as a habitat or substrate for macroalgae, which allows increased seagrass cover to contribute to increased macroalgae diversity. This condition shows the complexity of the interaction between seagrass and macroalgae, where both can compete and support each other in the ecosystem.

CONCLUSION

Macroalgae found in Gili Air amounted to 47 species grouped into 3 large groups, 10 orders, 15 families, and 19 genera. The species found consisted of 20 species of Chlorophyta, 4 species of Phaeophyta, and 23 species of Rhodophyta. The diversity index ranged from 2.45-2.80 with the category of 'moderate'. The uniformity index was 0.80-0.81 with the category of 'high' and the dominance index ranged from 0.09-0.11 with the category of 'low'. The distribution pattern of macroalgae was clustered.

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