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Macroalgae Ecology Index in Leuweung Sancang Nature Reserve Area

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ABSTRACT

One of the many marine organisms in Indonesia is macroalgae. Macroalgae has many benefits as a raw material for industries such as food, textile, and cosmetic industries. Macroalgae also provide a habitat for several types of marine life, such as crustaceans, mollusks, echinoderms, and fish. This study aims to determine the diversity, dominance, and evenness in the Leuweung Sancang Nature Reserve Area. This study uses a survey method with data collection using the quadrant transect method. The results of the study showed that there were 11 species of macroalgae found in the Leuweung Sancang Nature Reserve, including *Turbinaria ornate*, *Padina australis*, *Sargasum aquifolium*, *Sargasum polycystum*, *Ulva reticulate*, *Chaetomorpha crassa*, *Ulva lactuca*, *Boodlea composite*, *Amphiroa rigida*, *Amphiroa fragilissima*, and *Glacilaria coronopifolia*. The value of the macroalgae diversity index in the Leuweung Sancang Nature Reserve is included in the medium category with an average value of 1.0573, the dominance index value is included in the low category with an average value of 0.4004, and the evenness index value is included in the low category with an average value of 0.2671. This research contributes to determining the density, frequency of occurrence, and diversity of macroalgae species.

Indeks Ekologi Makroalga di Kawasan Cagar Alam Leuweung Sancang

ABSTRAK: *Organisme laut yang banyak di Indonesia salah satunya adalah makroalga. Makroalga memiliki banyak manfaat sebagai bahan baku industri seperti industri makanan, tekstil dan kosmetik. Makroalga juga menyediakan habitat untuk beberapa jenis biota laut seperti krustasea, moluska, echinodermata dan ikan. Penelitian ini bertujuan untuk mengetahui keanekaragaman, dominansi, dan kemerataan yang terdapat di Kawasan Cagar Alam Leuweung Sancang. Penelitian ini menggunakan metode survei dengan pengembilan data menggunakan metode transek kuadran. Hasil penelitian menunjukkan spesies makroalga yang ditemukan di Kawasan Cagar Alam Leuweung Sancang berjumlah 11 spesies diantaranya Turbinaria ornate, Padina australis, Sargasum aquifolium, Sargasum polycystum, Ulva reticulate, Chaetomorpha crassa, Ulva lactuca, Boodlea composite, Amphiroa rigida, Amphiroa fragilissima, dan Glacilaria coronopifolia. Nilai indeks keanekaragaman makroalga di Kawasan Cagar Alam Leuweung Sancang termasuk ke dalam kategori sedang dengan nilai rata-rata yaitu 1.0573, nilai indeks dominansi termasuk ke dalam kategori rendah dengan nilai rata-rata sebesar 0.4004 dan nilai indeks kemerataan termasuk ke dalam kategori rendah dengan nilai rata-rata sebesar 0.2671. Penelitian ini memberikan kontribusi dalam mengetahui kepadatan, frekuensi kemunculan dan keragaman jenis makroalga.*

INTRODUCTION

Macroalgae are algae that have large sizes, from several centimeters to meters (Tell et al., 2024). Most macroalgae live in marine waters by sticking to substrates. This substrate can be rocks, corals, sand, sandy soil, and epiphytes in plants or other macroalgae (D'Archino & Piazzi, 2021);(Jung et al., 2022).

Macroalgae are divided into three divisions based on the dominating pigment content, namely Rhodophyta (red algae), Phaeophyta (brown algae), and Chlorophyta (green algae) (Olmedo-Masat et al., 2020). The species diversity of macroalgae in the tropics is very high, but it is very susceptible to environmental changes. Macroalgae germplasm resources in Indonesian waters amounted to 6.42% of the world's total macroalgae biodiversity (Handayani et al., 2023). Macroalgae are one of the competitors for coral animals in fighting for space resources in the form of sunlight. For this reason, the presence of macroalgae is very important for life (Komala et al., 2024).

Generally, macroalgae live in intertidal areas that have a fairly high variation in environmental factors compared to other parts of the marine ecosystem (Sangaji, 2022). Different environmental characteristics have an impact on the diversity of macroalgae species in an aquatic environment (Saha et al., 2024). Macroalgae in the tropics have high species diversity, but these organisms are very vulnerable to environmental changes or ecological pressures that can affect their existence. Environmental conditions such as substrate, water movement, temperature, salinity, light, pH, nutrients, and water quality must be maintained and maintained so that they do not degrade and cause damage and even extinction of species (Lebrun et al., 2022);(Zarzyczny et al., 2024).

The existence of macroalgae is very important in marine waters, namely as producer organisms that are beneficial for the survival of organisms, especially herbivorous organisms (Menaa et al., 2020). Biologically, macroalgae have a role in increasing primary productivity, absorbing pollutants, producing organic matter, and producing oxygen for other aquatic biota (Jalilian et al., 2020). Ecologically, macroalgae have a function as a spawning place, protection as well as a place to find food for surrounding organisms (García-Poza et al., 2020). Economically, macroalgae are commonly used as industrial and pharmaceutical ingredients (Akbar & Hasan, 2024);(Wijayanto et al., 2022).

The role of macroalgae as part of coastal ecosystems contributes greatly to the balance and health of coastal ecosystems (Muthmainnah et al., 2023). Macroalgae are found on the coast of Java, especially on beaches in the Leuweung Sancang Nature Reserve Area. For this reason, the presence of macroalgae species in coastal waters is very important, namely participating in the formation of new coral reef ecosystems and as a control in shallow sea water pollution (Paulus et al., 2023);(Torres-Pérez et al., 2021);(Mustafa et al., 2022).

The distribution of macroalgae in various Indonesian waters has different habitats, namely grassy, sandy, and coral substrates. Beach Leuweung Sancang Nature Reserve Area, located in South Garut Regency, West Java, is a beach that has different characteristics, so these differences result in different organisms living in it. The biodiversity found in the Leuweung Sancang Nature Reserve Area is abundant. However, minimal research related to macroalgae has been carried out regarding the type and number of macroalgae in each block of the Leuweung Sancang Beach Nature Reserve Area. So, this research was carried out as a source of information and database to determine the diversity, dominance, and equality found in the Leuweung Sancang Beach Nature Reserve Area.

METHOD

The study was conducted from November 2022 to January 2023. It included

literature studies, site surveys, data collection in the field, sample identification, and data analysis. Samples were taken in the Leuweung Sancang Marine Nature Reserve Area, South Garut Regency, West Java, and sample identification was done using the World Register of Marine Species website. Figure 1 presents a map of the research location.

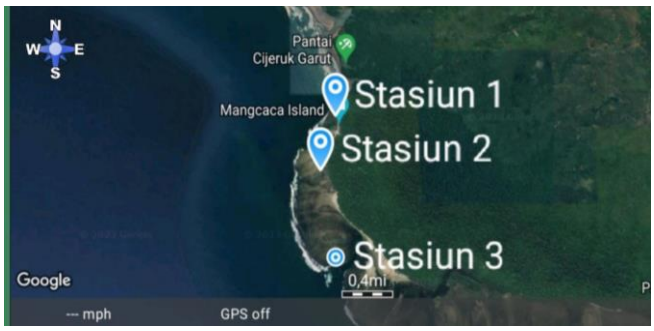

Figure 1. Map of the Research Location

The tools used in this study include GPS, quadrant transects, roll meters, water quality testers, mobile phones, plastic samples, LCD writing tablets, labels, pencils, gloves, plastic cups, plastic bottles, and rapid ropes. The materials used in this study were macroalgae, tissues, and equates.

This research was conducted using a survey method, namely data collection using the quadrant transect method. Sampling is done by placing transects at each point at each station. This study amounted to 3 observation stations, where station 1 was located in the Cipanikis block with coordinates 7°43'01.2''S, 107°50'09''E, station 2 was located in the Cikabodasan block with coordinates 7°43'24.1''S, 107°50'02''E, and station 3 was located in Cetut with coordinates 7°43'59.9''S, 107°50'09''E. The choice of this location was based on the presence of scattered macroalgae. The characteristics of the Cipanikis block are sandy and coral beaches, the characteristics of the Cikabodasan block are coral beaches, while the Cetut block has sandy beach characteristics. Each station is divided into 2 location points, where the location point is determined based on the presence of macroalgae.

Macroalgae sampling is carried out using the quadrant transect method measuring 5x5 meters, which is carried out at the lowest low tide. At the time of sampling, quadrant transects are placed at each point randomly at each station. The samples contained in each transect are identified and then photographed, and then several samples are taken.

Water quality parameter data were taken to describe the environmental conditions at the study site where macroalgae lived (Sulistiawati et al., 2020). Water quality data was taken prior to sampling at each observation station (Aditya et al., 2022). Water sampling is carried out in situ using plastic cups, and then parameters of temperature, pH, salt content, and electrical conductivity are measured. In addition, measurements of the speed of ocean currents are carried out using buoys (bottles) measured in meters per second.

Diversity Index

The diversity index is calculated using Shannon Wiener's formula (Konopiński, 2020).

$$H' = - \Sigma(pi) (\ln pi)$$

Description:
H' = diversity index
pi = proportion of each species of i

Table 1. Diversity Index Category

No.	Diversity (H)	Category
1	H' ≤1	Low
2	1 < H' < 3	Moderate
3	H' > 3	High

Dominance Index

The dominance index is calculated using Simpson's formula (C. Wang et al., 2021).

$$C = \Sigma(ni/N)^2$$

Description:
C = Dominance index
ni = Number of i-th individuals
N = Total number of individuals

Table 2. Dominance Index Category

No.	Dominance (C)	Category
1	0,00 < C ≤ 0,50	Low
2	0,50 < C ≤ 0,75	Moderate
3	0,75 < C ≤ 1,00	High

Evenness Index

The evenness index is calculated using the Everness formula (Kurniawati et al., 2024).

$E = H'/H'max$

Description:
E = evenness index
H' = Diversity Index
H'max = Maximum diversity index

Table 3. Everness index criteria

No.	Everness (E)	Category
1	E ≤0,4	Low
2	0,4 < E ≤ 0,6	Moderate
3	E > 0,6	High

RESULTS AND DISCUSSION

Macroalgae are benthic biota that require substrates to attach (Handayani, 2020). The beach of the Leuweung Sancang Nature Reserve area has a variety of substrates in each block. The Cipanikis block has a sandy coral substrate, the Cikabodasan block has a coral substrate, and the Cetut block has a sandy substrate. The results of water quality measurements on the coast of the Leuweung Sancang Nature Reserve Area are presented in Table 1.

Table 4. Water Quality Measurement Results

Parameters	Unit	St 1	St 2	St 3
pH	-	6,90	6,88	7,04
Temperature	℃	29,1	28,2	28,8
Salinity	ppm	31,8	31,8	32,4
Electrical Conductivity	μS/cm	52,2	52,5	52,7
Current Speed	m/s	0,35	0,32	0,37

The pH at all three stations was in the range of 6.88 – 7.04. Gao (2021) said that macroalgae growth can take place continuously in the pH range of 7-8. The pH range < 6.5 will suppress the growth rate; even pH < 9 is the optimal range in water (Mustafa et al., 2022). The temperature of the three stations at the time of observation was in the range of 28.2 – 29.1 °C. This is in accordance with Chiaramonte et al. (2023) statement that the normal temperature range for macroalgae life is between 25–35ºC. The temperature obtained from the sun's heat is useful for macroalgae respiration and breaks down nutrients obtained from seawater content. Salinity is in the range of 31.8 – 32.4 ppm. The salinity value is still suitable for macroalgae growth. According to Medina-ruiz et al. (2024), algae can grow in waters with a salinity of 13-37 ppm. Salinity provides a positive correlation to the abundance and diversity of macroalgae (Abougabal et al., 2021). If the salinity is too low, the growth will be inhibited from the color of the thallus to pale brown (Aris et al., 2021). Electrical conductivity is in the range of 52.2 – 52.7 µS/cm.

The current speed is in the range of 0.32 – 0.37 m/s. According to Sidabutar (2020), the existence of certain algae species can be caused by current movements. Calm waters can cause spores to stick well to the substrate (Enamul & Johannes, 2023). This is in accordance with the statement of Moreira et al. (2022) that good water movement for macroalgae growth is 0.033-0.066 m/s. The speed of the current causes nutrients in the waters to be carried by the current so that nutrients in the waters can be dispersed, and the movement of water affects the attachment of macroalgae to the substrate (Hui et al., 2020).

Macroalgae found in the Reserve Area were 11 species. The findings of macroalgae on the coast of the Nature Reserve Area are presented in Table 2.

Table 5. Macroalgae Findings

No	Species	St 1	St 2	St 3	Tot. Ind.
1	*Turbinaria ornata*	35	172	170	377
2	*Padina*	180	10	131	321

No	Species	St 1	St 2	St 3	Tot. Ind.
	australis				
3	*Sargasum aquifolium*	809	9	0	818
4	*Sargasum polycystum*	0	0	317	317
5	*Ulva reticulata*	465	159	0	624
6	*Chaetomorpha crassa*	0	1	0	1
7	*Ulva lactuca*	7	0	0	7
8	*Boodlea composita*	0	0	1	1
9	*Amphiroa rigida*	1	11	0	12
10	*Amphiroa fragilissima*	0	0	1	1
11	*Glacilaria coronopifolia*	0	2	0	2
		1497	**364**	**620**	**2481**

The 11 species of macroalgae found are divided into three groups of macroalgae, namely brown algae, green algae, and red algae. Brown algae include Turbinaria ornata, with 377 individuals; Padina australis, with 321 individuals; Sargassum aquifolium, with 818 individuals; and Sargassum polycystum, with 317 individuals.

Green algae include Chaetomorpha crassa, which has one individual; Ulva lactuca, which has seven individuals; and Boodlea composita, which has one individual.

Red algae include Amphiroa rigida, with 12 individuals; Amphiroa fragilissima, with one individual; and Gracilaria coronopifolia, with two individuals.

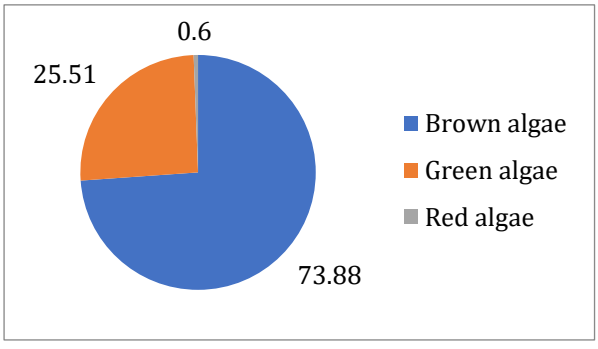

Figure 2. The Composition of Macroalgae Types

The total number of macroalgae individuals in the Leuweung Sancang Nature Reserve Area is 2,481 individuals. Proportion of brown algae is greater compared to green algae and red algae. Brown algae groups are the most common group found in the Leuweung Sancang Marine Reserve Area, with a total of 73.88% of the total individuals found. Another 25.51% percent were green algae groups, and only 0.6% of red algae groups were found. Brown algae are found compared to green and red algae because brown algae are more resistant to higher temperatures. The growth needs of brown algae are resistant to temperatures up to 30-32 °C, which is relatively higher than those of green and red algae (Bringloe et al., 2020). The high group of brown algae found indicates that the study site is a suitable place for brown algae growth. The most common species of brown algae is the species Sargasum aquifolium. The most commonly found species of green algae is the species Ulva reticulata. High levels of nutrients such as microalgae, phytoplankton, and aquatic plants can support the growth of aquatic biota (Lobus & Kulikovskiy, 2023). The most commonly found species of red algae is the species Amphiroa rigida.

The value of the diversity index, dominance index, and evenness index in three stations, namely Cipangikis, Cikabodasan, and Cetut. The ecological indices of all three stations are presented in the following table.

Table 6. Macroalgae Ecology Index

No	Ecology Index	St 1	St 2	St 3	Average
1	Diversity Index	1.0682	1.0568	1.0470	1.0573
2	Dominance Index	0.4036	0.4164	0.3812	0.4004
3	Evenness Index	0.2674	0.2655	0.2683	0.2671

The diversity index of each station in the Leuweung Sancang Nature Reserve Area has a different value. Station 1 has a diversity index of 1.0682, station 2 has a

diversity index of 1.0568, and station 3 has a diversity index of 1.0470. The highest diversity index in the Leuweung Sancang Nature Reserve Area is at station 1. The average diversity index in the Leuweung Sancang Nature Reserve Area is 1.0573 and falls into the fair category. High macroalgae diversity will affect high biological productivity in the ecosystem (Duarte et al., 2022). The higher the number of species, the higher the diversity. A small diversity value describes the small number of macroalgae present in the waters and indicates the presence of dominating species. When an area has high species diversity with an even density, the area can be categorized as good because it can be a habitat for many types of organisms, and the number is balanced (Johnson et al., 2020). According to Dahar et al. (2022), macroalgae are seasonal, so at certain times, they can be found in abundance, while in other seasons, they are found in small or no amounts. The combination of substrate structures determines the variation of macroalgae species (Smale et al., 2020).

The dominance index of the three stations in the Leuweung Sancang Nature Reserve Area has different values. Station 1 has a dominance index value of 0.4036. Station 2 has a dominance index of 0.4164. Station 3 has a dominance index value of 0.3812. The average dominance index value in the Leuweung Sancang Nature Reserve Area is 0.4004 and falls into the low category. The low dominance index indicates that macroalgae have different attachment abilities according to their substrate type (Besterman et al., 2020);(Lloyd et al., 2020).

The evenness index of the three stations in the Leuweung Sancang Nature Reserve Area has different values. Station 1 has an even value of 0.2655, Station 2 has an even value of 0.2655, and Station 3 has an equitable index value of 0.2683. The average equitable index value in the Leuweung Sancang Nature Reserve Area is 0.2671 and is included in the low category.

CONCLUSIONS AND SUGGESTIONS

Macroalgae species found in the Leuweung Sancang Nature Reserve Area were 11 species, including Turbinaria ornate, Padina australis, Sargasum aquifolium, Sargasum polycystum, Ulva reticulate, Chaetomorpha crassa, Ulva lactuca, Boodlea composite, Amphiroa rigida, Amphiroa fragilissima, and Glacilaria coronopifolia. The macroalgae diversity index value in the Leuweung Sancang Nature Reserve Area is included in the medium category, the dominance index value is included in the low category and the evenness index value is included in the low category.

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