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Abstract. Karang Bolong Beach is a beach located at the eastern tip of the island of Nusakambangan Cilacap. Karang Bolong Beach has a substrate type in the coral and composite substrate (fragment coral, rock, and sand). Therefore, a lot of seaweed grows there. This research aims to determine the macroalgae community on different substrates at Karang Bolong Beach, Cilacap. This is done to explore and use seaweed as a source of bioethanol. The research method used was a survey method - sampling using transects with a random process. The research variables included the macroalgae community in terms of species diversity and abundance on different substrates. The main parameters observed were the number of species and the number of individuals for each species. Supporting parameters consist of current velocity, nitrate content, turbidity, depth, tides, salinity, temperature, and pH. The data obtained were analyzed using Primer-7 to determine the diversity and density of each macroalgae species. The results showed 11 species of macroalgae consisting of *Amnasia glomerata*, *Caulerpa mexiana*, *Chaetomorpha crasa*, *Dictyota ciliolata*, *Eucheuma serna*, *Gracilaria arcuata*. *Gracilaria gigas*, *Laurencia subopposita*, *Padina australis*, *Rhodymenia* sp., and *Ulva rigida*. On the coral substrate, there were eight species, and on the composite substrate, six species. Four of these species are found in both substrate types. The diversity of species on the coral substrate varies from low to moderate. The highest abundance on composite substrates dominated by *Padina australis* biomass with a weight of 431 $g.m^{-2}$. On coral substrate dominated by *Gracilaria gigas* with a value of 275.33 $g.m^{-2}$. The community is in an unstable condition due to ecological pressures.

1. Introduction

Community structure is a collection of populations living in a particular area and is broadly organized with specific characteristics and functions as a metabolic transformation unit. Community studies can be carried out functionally and structurally. Functionally, looking at an organism's role and position in the food chain and food pyramid can be seen. Structurally, a community can be defined by species diversity, abundance, distribution, and dominance [1].

The diversity of macroalgae is divided into three main divisions based on the dominant pigment content in the macroalgae, namely Rhodophyta (red algae), Phaeophyta (brown algae), and Chlorophyta (green algae) [2][3]. Factors that influence species diversity in seaweed communities in nature are oceanographic, topographical, and biological factors. Oceanographic conditions temperature, light intensity, depth, salinity, pH, currents, and waves. Topographical factors include bottom substrate conditions, a biological factors include herbivores and competition between macroalgae species themselves [1].

There are two main substrate types used as a habitat for macroalgae, namely soft substrate, which includes mud, sand, or a mixture of sand and dirt, and rigid substrate, which consists of dead coral, live coral, and rock. According to [4] [2], soft substrate waters are inhabited by *Halimeda, Caulerpa, Gracilaria*, and *Hypnea*. In waters with a rigid substrate are settled many species of *Enteromorpha, Ulva, Sargassum,* and *Turbinaria,*

Karang Bolong Beach is a beach on the eastern tip of the island of Nusakambangan Cilacap. Karang Bolong Beach has the primary type of substrate in corals and composite, many overgrown with macroalgae. Various coastal substrates have the potential to take the wealth of the macroalgae. Based on the coastal substrate, the Nusakambangan area has a reasonably large species diversity. The raw data of the number of macroalgae and biomass species is needed in various substrates in these waters. The variety, dominance, evenness, and similarity index can be studied.

Information about species diversity and density of a resource and environmental conditions is necessary information indispensable in aquaculture application, considering that marine resources' life and growth have different living conditions [5]. Changes in the coastline are due to natural factors, such as wind, waves, and currents, which are also factors that trigger changes in hábitat, especially in coastal areas. This condition is also exacerbated by the speed of development in coastal areas, such as sand mining, jetty construction, tourism, and transportation, causing the ecosystem to function. The coastal regions to decline and the carrying capacity for marine resources' existence and potential is also increasingly depressed.

This study aims to determine the diversity and distribution patterns of macroalgae on the coast of Karang Bolongto to explore sustainable bioethanol resources' potency. According to [6], macroalgae have broader industrial applications from conventional food, feed, and hydrocolloid to recently explored polysaccharide sources as potential renewable biomass for bioethanol production on top of terrestrial resources. The potential of macroalgae as a renewable raw material for bioethanol production depends on the biomass macroalgae and the growing environment.

2. Method

This study used a survey method. Samples were taken by a random line transect method. Research variables included species diversity and distribution patterns of macroalgae. The main parameters observed were the number of species and the number of individuals of each species. Supporting parameters consisted of current velocity, nitrate content, brightness, depth, tides, salinity, temperature, and pH.

The materials used in this study were macroalgae obtained from Karang Bolong Beach. The tools in this research including identification book, GPS, thermometer, depth sounder, pH meter, litmus paper, hand refractometer, Secchi disk, sample bottles, stopwatch, Erlenmeyer flask, measuring pipette, reduction column, Dual-beam UV-vis spectrophotometer, 0.45 filter paper, camera, and cool box.

Macroalgae samples were identified by observing the type of branching, the shape and size of the thallus, and the holdfast shape; then, they were determined by matching with the morphological and the descriptions in the identification book [3][7][8][9][10] and Algaebase. The data obtained were analyzed using the Shannon-Wiener diversity index (H') and the Simpson dominance index (D). The Shanon-winner diversity index uses the following formula ([11][12].

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

$$pi = \frac{ni}{N}$$

where H' = Shannon-Wiener diversity index, pi = proportion of the ith species in the total sample, ni = The number of individuals in plot i, N = The total number of individuals of all species.

The dominance of each substrate using the Simpson dominance index formula [1] and [13] is as follows:

$$D = \Sigma \left(\frac{ni}{N}\right)^2$$

where D = dominance index, ni = the amount of biomass per species, and N = total biomass value.

The values of the Shannon-Wiener diversity index (H') and the Simpson dominance index (D) were compared between substrates and interpreted according to [14]; [15]; [16], if the value of H' <1 diversity is low, $1 < H' < 3$ is moderate diversity, and $H' > 3$ high diversity. Dominance 0 means nothing is dominant, and one means some species dominate other species, or the community is in an unstable condition due to ecological pressure.

3. Results and discussion

The diversity of macroalgae species that grow on composited and corals substrate at Karang Bolong Beach Nusakambangan Cilacap were 11 species, namely *Amnesia glomerata*, *Caulerpa Mexicana*, *Chaetomorpha crasa*, and *Dictyota ciliolata*, *Eucheuma Serna*, *Gracilaria arcuata*. *Gracilaria gigas*, *Laurencia subopposita*, *Padina australis*, *Rhodymenia palmata*, and *Ulva rigida* (Figure 1).

The number of macroalgae found on the coral substrate was ten species and 5 species in the composited substrate. However, four species found in coral and composite were: *Padina australis*, *Gracilaria gigas*, *Chaetomorpha crasa*, and *Ulva rigida*. The diversity of species on coral and composited substrates is low to moderate. The community structure is in an unstable condition due to ecological pressures. The highest abundance in the composite substrate was dominated by *Padina australis* biomass with a weight of 431 g.m^{-2}. The lowest was from *Ulva rigida*, with a value of 1.63 g.m^{-2}. The coral substrate was dominated by *Gracilaria Giga*s biomass with a weight of 275.33 g.m^{-2}, and the lowest was biomass from *Rhodymenia palmata* weighing 0.67 g.m^{-2}.

The number of seaweed species obtained on the coral substrate was higher than in the composited substrate. The coral substrate was more stable so that the seaweed could be firmly attached to the substrate and was not easily knocked over during big waves. [17] and [13] stated that a stable substrate condition was the right place for seaweed growth. The process of absorption of nutrients is better with large wave water movements. Seaweed is also clean from dirt so that it can grow better [12].

The proportion of living species dominating the composited substrate was *Padina australis*, reaching 91%, and the coral substrate *Gracilaria gigas* reaching 72%. The propotiom of each species that dominate the compositeed substrate (with a value of less or equal to 5%) was *Gracilaria gigas*, *Chaetomorpha crasa*, *Laurencia subopposita*, and *Ulva rigida*. The proportion of each species that dominate the coral substrate (with a value of less than or equal to 11%) were *Gracilaria arcuata*, *Caulerpa Mexicana*, *Eucheuma Serna*, *Padina australis*, *Dictyota ciliolate*, *Chaetomorpha crasa*, *Amnesia glomerata*, *Ulva rigida*, and *Rhodymenia palmata* (Figure 2). A stable substrate is the right place for seaweed growth [12]. The composited substrate consists of coral and coral fragments composited with sand so that it was less stable. It resulted in easily knocked over by a big wave. Macroalgae were not found on the sand substrate because waves or currents quickly carried it away. This condition also due to the holdfast might not be strong enough to stick on and the thallus. [13] stated that water currents and the marine organisms easily carried away the sand substrate to become in an irregular pattern.

Macroalgae can be found in somewhat sheltered areas in the littoral and sublittoral zones. The measurement of the waters' physicochemical factors in the deeper part of water showed that the Karang Bolong Beach waters' condition was quite suitable for macroalgae growth. This was supported by [1] and [18]'s research that macroalgae could be found in somewhat protected areas in the littoral and sublittoral zones. Macroalgae species grew on rigid substrates consisting of rocks and corals to be firmly attached to the substrate. [13] stated that a stable substrate condition was the right place for macroalgae growth. The composited substrate consists of coral or coral fragments composited with sand, which was less stable so that it was easily knocked over during big and strong waves. In the soft substrate in the form of sand, no macroalgae species was found because sand was a substrate that was quickly washed away by waves or currents.

Amnasia glomerata	*Caulerpa mexiana*	*Chaetomorpha crasa*	*Dictyota ciliolata*
Eucheuma serna	*Gracilaria arcuata*	*Gracilaria gigas*	*Laurencia subopposita*
Padina australis	*Rhodymenia palmata*	*Ulva rigida*	

Figure 1. A voucher specimen of macroalgae found in Karang Bolong Beach, Nusakambangan Cilacap

The Shannon-Wiener diversity index (H') of macroalgae in Karang Bolong Beach (H') in the composited was 0.2092–0.5660 while the H' value in the coral substrate was 0.6422–1.4480, which meant low to moderate diversity (Table 1). Interpretation according to [14] and [16], if the value of H' <1 diversity is low, $1 < H' < 3$ is medium diversity, and $H' > 3$ is high diversity. According to [5] the variety of macroalgae species was influenced by the type of substrate, stability, surface hardness, and porosity of the bottom substrate.

The low level of diversity in the composite substrate was less stable, so waves easily carried away macroalgae. Macroalgae are vulnerable to changes or ecological stresses that affect their growth. Diversity in the coral substrate was higher than the composite substrate. Macroalgae are growing in a stable substrate, and their holdfast was stronger gripping the substrate. Poor water conditions indicate low diversity [19][17].
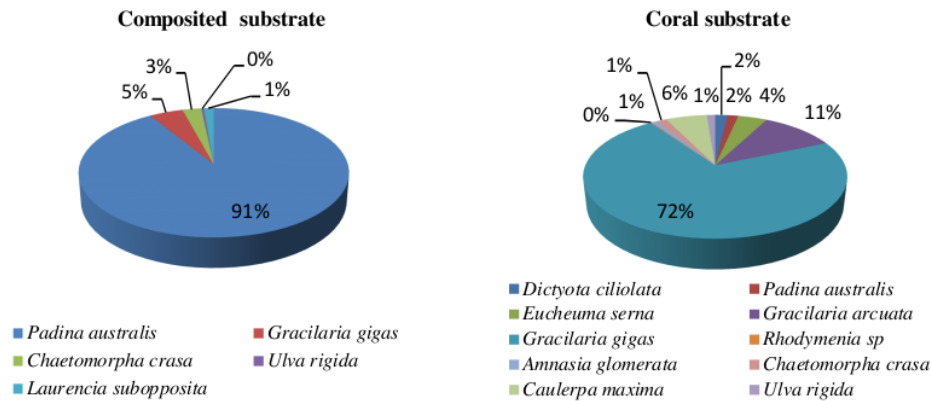
Figure 2. Macroalgae species composition in Karang Bolong Beach, Nusakambangan Cilacap

The dominance index ranged from 0.1639–1.0630, which means that other species dominated than the other species. The high dominance index indicated that there was a very tight competition among members of the community. The community was in unstable condition due to ecological pressures. Organisms that live in nature have minimum and maximum ecological limits for survival; There were three things in competition between species: competition in gaining space for interference competition, epiphytic, and allelopathy exploitation [11]. A population can survive if it is within the limits of the tolerance range for specific conditions of abiotic factors and resource availability. The waters' physicochemical parameters measured were quite right to support macroalgae growth (Table 2).

Table 1. Dominance index, diversity index, and criteria for the value of macroalgae species diversity obtained at Karang Bolong Beach using Primer-7

Substrate	Dominance index	Diversity index	Diversity value criteria
Composite 1	0.1687	0.5660	Low
Composite 2	0.6067	0.2865	Low
Composite 3	0.1639	0.2092	Low
Coral 1	0.8471	1.4480	Moderate
Coral 2	0.5684	0.7687	Low
Coral 3	1.0630	0.6422	Low

Table 2. Observations of average the physicochemical properties of the water at Karang Bolong Beach

Substrate	Temperature (˚C)	Salinity (‰)	pH	Depth (cm)
Composite 1	30	25	6	80
Composite 2	30	25	6	90
Composite 3	31	24	6	70
Coral 1	30	27	6	75
Coral 2	31	27	6	70
Coral 3	30	26	6	80

The waters' physicochemical parameters' measurement showed that the Karang Beach conditions, Nusakambangan Cilacap were quite reasonable according to the reference in supporting macroalgae growth, except for the depth parameters, which are classified as relatively low because the sampling is carried out during the lowest tide. Macroalgae can live well in the optimal temperature range of 26–33°C [17]. Water temperature plays an essential role in helping the metabolic processes and photosynthesis of macroalgae. Right salinity for macroalgae growth ranged from 28–35‰ so that the process of nutrient absorption by diffusion run well [20][21]. The degree of acidity (pH) was a chemical, environmental factor determining whether growth was good or bad. [20] stated that a fair and optimal pH for macroalgae growth ranged from 6.8 to 8.2.

The depth measurement ranged from 70–90cm, which relatively low because the sampling was done during the lowest tide [22]; the optimum water depth conditions for macroalgae ranged from 60–120 cm. Tidal parameters measured using the WXTide32 software ranged from 0.1–2.1 m with a wave height range of 1.9 m. This condition was optimal for macroalgae growth. According to [19], the optimal tides for macroalgae growth were 1–3 m.

The measurement of this current velocity obtained 0.5–0.8 m.s^{-1}, which was classified as vital, so it requires strong holdfast to stick to the substrate. Macroalgae that attach to the coral substrate and composite can withstand high current and strong waves [15] and [23], the optimum flow velocity for macroalgae growth ranged from 0.2–0.3 m.s^{-1}. Water transparency ranged from 10.2–23 cm. This condition would support the level of sunlight reflection to get optimum light intensity. This optimum light will facilitate nutrient elements to be absorbed by macroalgae.

Nitrate measurement results ranged from 0.205–0.537 ppm, while phosphate measurements ranged from 10,745–20,061 ppm. Nitrate in natural waters is the primary nutrient source for macroalgae [24]. The optimal range for macroalgae growth was 0.9–3.5 ppm [25]. Nitrate levels exceeding five ppm indicate the pollution caused by human and animal activities [26][27].

4. Conclusion

There were 11 species of macroalgae found in the coastal waters of Karang Bolong Nusakambangan Cilacap, namely *Amnesia glomerata, Caulerpa Mexicana, Chaetomorpha crasa, Dictyota ciliolata, Eucheuma Serna, Gracilaria arcuata. Gracilaria gigas, Laurencia subopposita, Padina australis, Rhodymenia palmata,* and *Ulva rigida*. The highest abundance in the composited substrate was dominated by *Padina australis* biomass with a weight of 431 g.m^{-2} and on coral substrate dominated by *Gracilaria gigas* of 275.33 g.m^{-2}. The species diversity index was low to moderate, and some species were dominating the others. The community was in an unstable condition due to ecological pressures.

Acknowledgments

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