Jurnal Ilmu Kelautan
SPERMONDE (2021) 7(1): 16-26

P-ISSN: 2460-0156
E-ISSN: 2614-5049

DIVERSITY AND DISTRIBUTION OF MACROALGAE TO ENVIRONMENTAL CONDITIONS OF MAKASSAR CITY

Hidayah Mushlihah[1], Khairul Amri[2], Ahmad Faizal[2]*

Submitted: July 29, 2021   Accapted: August 16, 2021

[1]Student at Department of Marine Science, Faculty of Marine Science and Fisheries, University of Hasanuddin
[2]Department of Marine Science, Faculty of Marine Science and Fisheries, University of Hasanuddin
Corresponding Author:
*Ahmad Faizal
E-mail: ahmad.faizal@unhas.ac.id

ABSTRACT

The distribution of macroalgae in the waters is influenced by various environmental factors ranging from anthropogenic pressures such as the activities of local communities and tourists to the Physico-chemical effects of the waters. This study aims to examine the effect of environmental parameters on the distribution of macroalgae and to map the spatial distribution of macroalgae on Lae-lae Island and Gusung Lae-lae Caddi. Data collection for macroalgae was carried out using a 1 × 1 m transect method and environmental parameters were surveyed using in situ measurements and further analysis in the laboratory. The status and diversity of macroalgae were calculated using ecological indices, distribution of macroalgae using Mapping Techniques, and the interrelationships between parameters were tested using Principal Component Analysis (PCA). The results showed that the largest macroalgae cover was found in Gusung Lae-Lae Caddi by 55% with the average distribution of macroalgae cover respectively; Lae-laen Island East Station 9%, Lae-lae Island West Station 36%, Gusung Lae-lae Caddi East Station 21%, and Gusung Lae-lae Cadii West Station 55%. The high macroalgae cover in Gusung Lae-Lae Caddi is influenced by nutrients and the low level of turbidity. Based on the calculation of the ecological index, it was found that the ecological status was dominated by the late-successional group.

Keywords: Macroalgae, diversity, distribution, environmental condition

INTRODUCTION

Indonesia is known as a country with high biodiversity, including marine biodiversity. Macroalgae is one of the marine organisms that can be found in almost all coastal areas of Indonesia. Macroalgae live as macrobenthos by attaching their holdfast to various substrates (such as rock, sandstone, sand, wood, mollusk shells, and epiphytes) on other plants or other types of macroalgae (Sambamurty, 2005).

Macroalgae play a very important role in ecology and the economy. The advantage of macroalgae in the field of ecology is to provide habitat for several marine organisms, such as crustaceans, molluscs, echinoderms, small fish, and other small algae (Marianingsih et al., 2013). In the field of economics, macroalgae may be used as food, industrial raw materials, and as materials in laboratory practicums such as wet preservation, media for the proliferation of bacteria and fungi to produce antibiotics, as well as macroalgae that function as medicinal ingredients (Rarasari, 2019).

Macroalgae may be found in littoral and sublittoral areas where there is still sufficient sunlight for their survival. Macroalgae have diverse habitats such as sand substrate, rocks, shell fragments, and even macroalgae can also live as epiphytes for other marine plants. The distribution of macroalgae in the waters is influenced by various environmental factors ranging from anthropogenic pressures such as the activities of local communities and tourists to the physicochemical effects of the waters.

Lae-lae and Lae-lae Caddi are the closest islands to coast of the Makassar City where the waters have great potential for marine resources. The various potentials in these two islands cannot be separated from the quality of the waters about the presence of macroalgae. Around the waters of the island is a route in and out of ships because the location of the island is close to the port so that all activities, sea transportation, ports, and tourism are found in these islands.

The high level of human activity in the waters around the island may potentially lead to a decrease in water quality, especially in the ecosystems in these waters. Such conditions can be identified from changes in physical, chemical, and biological components in the surrounding waters. Changes in physical and chemical components in addition to causing a decrease in water quality, also cause the bottom of the water to decrease which can affect the life of various marine biota and plants, especially macroalgae. Water quality affects the macroalgae community structure which includes diversity, evenness, abundance, dominance, and biomass (Arfah & Patty, 2016). According to Silvia (2019), the distribution of macroalgae on Lae-Lae Island found 8 species of the Chlorophyta division, 8 species of the Phaeophyta division, and 3 species of the Rhodophyta division. Macroalgae cover in Lae-Lae Island is quite high, the average cover obtained in the previous study was 40%. This is due to the high availability of nutrients and the lack of competition on Lae-Lae Island so that macroalgae can take advantage of these conditions to grow. Meanwhile, another study, research by Rizal (2012) found that seagrass cover on

Lae-Lae Island was in a disturbed condition. The low density of seagrass on Lae Lae Island is due to high turbidity, nitrate, and the substrate is dominated by fine sand or mud which causes seagrass to not thrive in these conditions. Supriharyono (2000) in Rizal (2012) also mentions that in addition to suspended solids, high nitrate triggers the rapid growth of algae and phytoplankton effluents, and domestic waste or organic waste is also the cause of turbidity. Dense population activities on Lae-Lae Island and its proximity to the mainland are the cause of the turbidity which eventually disrupts the condition of the seagrass beds. This condition is favorable for macroalgae in terms of occupying space and utilizing nutrients in the waters.

The quality of a suitable aquatic environment is a determining factor for the growth and development of macroalgae. This study can provide information about the species and distribution of macroalgae found in the waters of Lae-lae and Lae-lae Caddi Islands. In addition, to determine the distribution of macroalgae in these waters, a spatial analysis will be carried out. Spatial analysis was used to map the distribution of macroalgae on Lae-lae and Lae-lae Caddi Islands.

MATERIAL AND METHODS

This research was carried out from December 2020 to July 2021 which included literature studies, field surveys, field data collection, identification of macroalgae species, data analysis, and preparation of research reports. Field data collection in the waters of Lae-Lae and Lae-lae Caddi Islands, Makassar City, South Sulawesi Province in June 2021, (Figure1) W. Sample identification was carried out at the Marine Biology Laboratory, Faculty of Marine Science and Fisheries, Hasanuddin University.

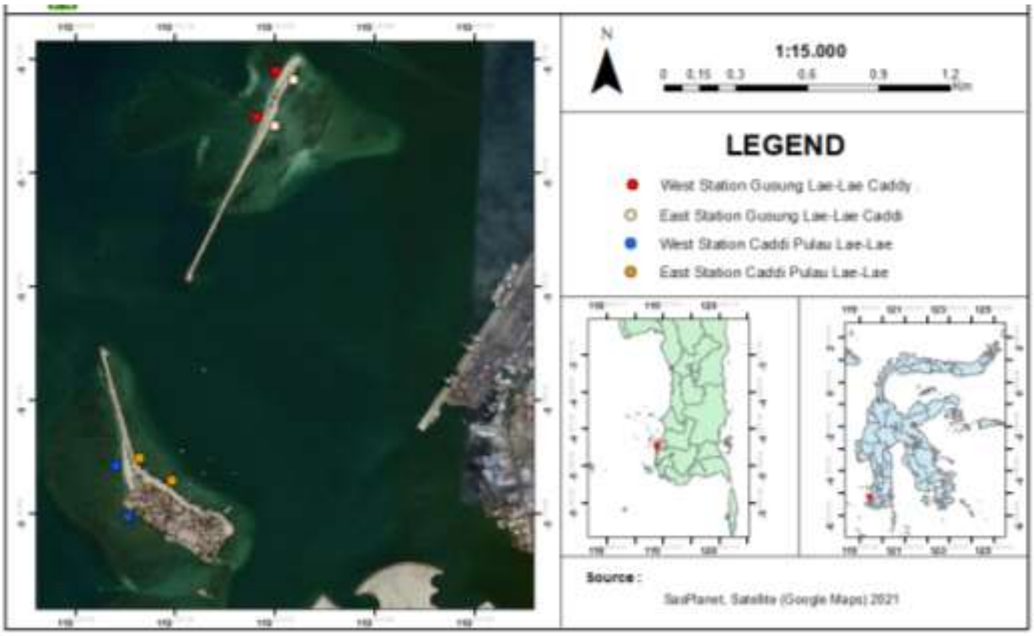

Figure1. Map of the Study Location

Data Collection of Macroalgae and Water Quality

Data collection and macroalgae samples were collected using the Line Transect method following the observation procedure of McKenzie et al. (2001). For each sampling station, 3 line transects were laid out along 50 m perpendicular to the coast with a distance of 50 m between the transects. The first observation was carried out by placing a 1 m x 1 m quadrant transect (with a 25 cm x 25 cm grid) at a distance of 5 m from the shoreline. Placement of the next quadrant transect at a distance of 10 m from the first laying, and so on until 50 m. Macroalgae type, substrate type, and percent cover were calculated and recorded in the table, macroalgae samples were taken and put into plastic samples for identification. The estimation of the percent cover of macroalgae used the estimation developed by Amri, & Yasir (2015) which is an adaptation of McKenzie et al. (2001). Furthermore, macroalgae samples that are put in plastic are stored or preserved for identification purposes. Identification of

macroalgae was carried out according to Reyes (1978), Hatta & Reine (1991), Hatta (1993), Verheij & Reine (1993), Atmadja et al. (1996), Reine & Trono (2002), and Jha et.al (2009).

Water samples were collected using a dark bottle with three replications and then labeled. Seawater samples were taken using dark bottles to prevent the proliferation of organisms that could affect turbidity, phosphate, and nitrate levels before and after sampling. The water sample that has been taken is put into the coolbox. At each station in the two locations, measurements of the parameters of Temperature, Salinity, Current Speed, Depth, and pH were carried out in situ. Other parameters Turbidity, Nitrate (NO3), and Phosphate (PO4) were further analyzed in the laboratory.

Data Processing

Similarity Index (SI)

The Sorensen Similarity Index or also known as the Czekanowski index is used to determine the level of similarity of the vegetation in all sample units (Ludwig & Reynolds 1988; Clarke & Warwick 1994; Krebs 1999; Krebs 2002; Bakus 2007).

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

where:
S = Sorensen Similarity Index
A = Number of the same species within-sample unit I and II
B = Number of species found within sample unit I only
C = Number of species found within sample unit II only

The Sorensen similarity index uses binary data (presence and absence) of a species in a sampling unit and the values range from 0 (no similarity) to 1 (highest similarity) (Clarke & Warwick 1994; Krebs 1999; Bakus 2007).

The results of IS calculations for all sampling stations are arranged in the form of a Similarity Index (SI) and Dissimilarity Index (DI) matrix, where DI = 100-SI (Clarke & Warwick 1994). The level of similarity between observation stations can be determined based on the criteria in **Table 1** below:

Table 1. Determination of Similarity level of Vegetation among Stations

Similarity Index (%)	Level of Similarity
>75	Very High
50-75	High
25-50	Low
<25	Very Low

Source: Krebs (2002)

Ecological Status Group (ESG)

The Ecological Evaluation Index (IEE) is designed to estimate the ecological status of transitional and coastal waters where benthic macrophytes (macroalgae) are used as bioindicators of ecosystem shifts (ecosystem shifts) due to anthropogenic stress, from a natural state with species of late succession to a degraded state with opportunistic species (Orfanidis). et al., 2003).

Changes in the structure and function of marine ecosystems are evaluated by classifying benthic marine macrophytes into two ecological status groups (ESG) which represent different ecological status groups, for example in natural or polluted (degraded) areas. Group I consists of all macroalgae species with thick or calcareous thallus, slow growth rate, and consists of perennial species with a long life cycle (late-successional), while group II includes macroalgae species with a sheet and filamentous thallus with a fast growth rate. and consists of annual species with short life cycles (opportunistic) and ruderal (Orfanidis et al., 2001; 2003).

Relationship between Physicochemical Parameters and Macroalgae Community

Water physicochemical parameters were analyzed using Principal Component Analysis (PCA) (Legendre & Legendre, 1983; Ludwig & Reynolds, 1988; Bengen, 2000). Bengen (2000), stated that PCA can be used to obtain the relationship between biophysical parameters as well as determine the grouping of stations based on biophysical parameters.

Macroalgae Spatial Distribution

According to Faizal et al. (2012), the spatial distribution of macroalgae can be mapped using a mapping technique by entering coordinates and macroalgae cover data. The coordinates and cover of macroalgae are described using points of distribution so that local mapping of macroalgae cover is formed. The base map uses the Earth Map from the Geospatial Information Agency.

RESULTS AND DISCUSSION

Lae-Lae Island is a densely populated island with a population of ±1,951 people (Yahya, 2016). Most of the island communities have incomes from fishermen and some provide transportation from Makassar to Lae-Lae or vice versa. This island is also used as a tourist destination for Makassar City. A large number of island residents and also close to the mainland makes this island get higher anthropogenic pressure so that it can affect the condition of the waters of Lae-Lae Island. One of the things that can be seen is the waste of island communities that are simply thrown into the sea because they do not have adequate disposal sites, this can affect the biota in the sea.

Lae-Lae Caddi Island is the closest island to the mainland and is also an easily accessible tourist attraction and this island is only inhabited by a few fishermen who live on this island. Not only as a tourist attraction, but some fishermen from other islands also look for fish in the waters of Lae-Lae Caddi Island.

Diversity, percent cover, and ecological index

Macroalgae are marine plants that are commonly found in Makassar waters, including Lae-Lae Island and Gusung Lae-Lae Caddi. Based on the results of research that has been done there are 41 species (Appendix.1). Lae-Lae Island was found as many as 28 species of macroalgae consisting of 12 species of Chlorophyta, 8 species of Phaeophyta, and 8 species of Rhodophyta. Meanwhile, in Gusung Lae-Lae Caddi found 34 species of macroalgae consisting of 12 species of Chlorophyta, 11 species of Phaeophyta, and 11 species of Rhodophyta. Macroalgae cover on Lae-Lae Island obtained 9% Station LLT, 36% Station LLB, 10%. Meanwhile, Gusung Lae-Lae Caddi macroalgae cover obtained 21% Station LCT, and 55% Station LCB. Based on the results of the identification and classification of macroalgae at both locations, it was found that the composition of macroalgae species was almost the same. This is possible because the two locations are close together and have water conditions that are not much different. Macroalgae found on Lae-Lae Island consisted of 12 species of Chlorophyta, 8 species of Phaeophyta, and Rhodophyta. While in Gusung Lae-Lae Caddi there are 12 species of Chlorophyta, 11 species of Phaeophyta, and Rhodophyta. The most common species found in Lae-Lae Caddi with 34 species and followed by Lae-Lae Island with 28 species. The locations that found the most species were Station LLB on Lae-Lae Island with 21 species and Station LCB on Gusung Lae-Lae Caddi with 20 species of macroalgae.

In contrast to the species composition found on several other islands in Spermonde, such as on Barrang Caddi Island, 7 species of Chlorophyta were found, 5 species of Phaeophyta and 8 species of Rhodophyta (Silvia, 2019), Bonebatang Island found 4 species of Chlorophyta, 10 species of Phaeophyta and 6 species of Rhodophyta (Amri, 2012), on Barrang Caddi Island 8 species of Chlorophyta, 3 species of Phaeophyta and 8 species of Rhodophyta (Ali, 2019). The three islands are far from the mainland so that the species composition is smaller than Lae-Lae and Lae-Lae Caddi Islands. Based on the comparison of the species composition of several islands, it is known that the farther the distance of the island from the mainland affects the composition of macroalgae species where the species composition is getting smaller. This is by the statement of Faizal, et al., 2011 that the closer to the mainland the greater the macroalgae cover, which means that the species composition is also higher. Based on the results of grouping the ecological status of macroalgae on Lae-Lae Island, 13 species of ESG I and 15 species of ESG II were found. Meanwhile, in Lae-Lae Caddi, 18 ESG I and 16 ESG II were found. The number of ESG II species found on Lae-Lae Island was more than ESG I species (**Appendix 2),** which means that the opportunistic species on Lae-Lae Island indicate that environmental conditions have been polluted due to high anthropogenic pressure increasing nutrient levels and also in Lae-Lae Island community competition. less so that it provides opportunities for opportunistic macroalgae species to increase. This has been emphasized in previous studies that Lae-Lae Island has conditions that do not support the growth of seagrass, which is one of the communities that can become competitors for macroalgae, thus causing a small possibility of competition. This is beneficial for opportunistic macroalgae to absorb all nutrients in the waters (Silvia, 2019).

In contrast to the condition of the Lae-Lae Caddi's Ecological Status Group, the number of ESG I species was found to be more than that of ESG II species, this is because this location does not have too many inhabitants and in this location is only used as a beach tourist attraction and fishermen also use the waters as a place of livelihood so that the anthropogenic pressure is lower than Lae-Lae Island which makes the opportunist species lower than the late-successional species.

Macroalgae can be used as an indicator of environmental quality because it has a fast response to environmental changes. Similarly, in some studies, changes in species abundance are used as an indication of anthropogenic effects. Polluted water conditions due to increased nutrient levels and lack of competition will be followed by an increase in the number of opportunistic species because opportunistic species take advantage of these conditions (Wells, et al., 2007)

Similarity index values between research stations ranged from 29-75%. The highest similarity of 75% was found between stations LLB-LCB , while the lowest similarity value of 29 % was between stations LLB-LCT This similarity index value indicates that the similarity value between islands is high (Table 2), Similarity index (Sorensen index) is one index that consistently has a high ranking and linear correlation. However, this index only uses binary data (presence and absence) of species and does not calculate species. abundance. Therefore, this index does not inform the true ecological pattern in the data (Balmer 2002).

Table 2. Similarity and Dissimilarity Indices of Macroalgae among Stations in Lae-Lae and Lae-Lae Caddi Islands. LL = Lae-Lae, LC = Lae-Lae Caddi, B= West Station and T = East Station

SIMILARITY INDEX				
Sta	LLB	LLT	LCB	LCT
LLB		0,389	0,755	0,293
LLT	0,611		0,400	0,417
LCB	0,245	0,600		0,341
LCT	0,707	0,583	0,659	
DISIMILARITY INDEX				

Environmental Condition

The presence of macroalgae is influenced by water conditions, both physical and chemical. The results of measurements of several water parameters including temperature, salinity, current, pH, turbidity, nitrate, and phosphate (Table 3) each provide an important role in the presence of macroalgae in water.

Table 3 Environmental Parameters; among stations in Lae-Lae and Lae-Lae Caddi Islands. LL = Lae-Lae, LC = Lae-Lae Caddi, B= West Station and T = East Station

Environmeter Parameters	Station			
	LLB	LLT	LCB	LCT
Temperature (^{0}C)	28	29	29	30
Salinity (ppt)	34	33	35	36
Current Velocity (m/s)	0,04	0,05	0,04	0,05
pH	7,70	7,69	7,77	7,73
Turbidity (NTU)	3,024	4,157	2,258	2,672
Nitrate (mg/l)	0,276	0,242	0,267	0,243
Phosphate (mg/l)	0,078	0,071	0,064	0,085

Temperature is one of the most important factors in regulating the metabolism and distribution of organisms. Most marine organisms such as macroalgae have adapted to live and reproduce in a narrow temperature range of 0-40 ^{0}C (Nyabakken, 1992). The temperature range in the waters of Lae-Lae Island and Gusung Lae-Lae Caddi is still included in the growth temperature criteria, which is 28-30 ^{0}C. The high water temperature can have an unfavorable impact on the growth of macroalgae. The threshold temperature for the growth of green, brown, and red algae is 34.5 ^{0}C (Hutagalung, 1988).

Salinity in waters is influenced by many factors, including evaporation, rainfall, water circulation patterns, and the content of freshwater that enters the waters. The results of the salinity measurement show a range of 32-36 ppt. This salinity range can be categorized as quite high but still at a good level for macroalgae growth. Good salinity for macroalgae growth is in the range of 30-34 ppt (Kadi & Atmadja, 1988).

Current is a supporting factor for macroalgae growth because currents play a role in nutrient transport and water agitation (Ayhuan et.al, 2017). Current measurement results in both locations ranged from 0.02-0.06 m/s. Widyastuti (2008) states that the range of good current velocity values for macroalgae growth is 0.10 - 0.50 m/s. The role of the current is to avoid sediment accumulation and attachment of epiphytes attached to the thallus which can hinder the growth of macroalgae (Ayhuan et.al, 2017).

Based on the results of the study at all locations the pH value range was still in the good category for macroalgae growth and development, namely 7.69-7.78. Luning (1990) stated that good macroalgae growth grew in the pH range of 6.8–9.6. Changes in the pH value will affect the balance of carbon dioxide (CO_2) content which in general can endanger the life of marine biota from the level of primary productivity of the waters.

Turbidity is a limiting factor for photosynthesis and primary production because it affects light penetration (Boyd 1988). The turbidity value obtained ranged from 2,250-4,457 NTU which was still below the quality standard for biota growth, which was <5 (KEPMEN LH, 2004).

Phosphate is one of the nutrients needed and influences the growth and development of living organisms in the sea. High and low levels of phosphate in water are one indicator to determine the fertility of water. The measurement results showed that phosphate levels ranged from 0.063-0.094 mg/l. According to Joshimura in Wardoyo, 1982 phosphate levels in fertile waters ranged from 0.0021-0.05 mg/l and fertile waters ranged from 0.051-0.1 mg/l. The range of phosphate levels is still within safe limits for marine life. KMLH (2004) sets the quality standard for phosphate compounds for marine biota at 0.015 mg/l. Referring to the fertility category above, these waters are categorized as quite fertile and still good for macroalgae growth.

Nitrate is also a chemical compound that functions as a nutrient in seawater. Nitrate levels in these waters ranged from 0.238-0.303 mg/l. Normal nitrate content in marine waters generally ranges from 0.001-0.007 mg/l (Brotowidjoyo et al, 1995). KMLH (2004) sets the standard quality standard for nitrate compounds for marine biota at 0.008 mg/l. The threshold value of water set by the US-EPA (1973) for nitrate is 0.07 mg/l. Meanwhile, the Chu in Wardoyo (1981) suggested that the range of nitrate levels of 0.3-0.9 mg/l is sufficient for the growth of organisms and > 3.5 mg/l can harm the waters. Thus the range of nitrate content in these waters is still within the safe limits of the fertility of water.

Distribution of Macroalgae

Based on research conducted by Faizal et al 2011, Macroalgae Cover in the Spermonde Islands has a high distribution of cover on islands closer to the mainland. The high macroalgae cover in zone 1 is made possible by the large supply of nutrients, land as a supplier of organic matter that increases water fertility (McCook, 2001; Edinger, et al 1998). The high average macroalgae cover in zone 4 far from the mainland is also probably due to the high nutrient content, which is the source of upwelling (Faizal et al, 2011).

Lae-Lae Island and Gusung Lae-Lae Caddi are two locations that are close to the mainland so that the macroalgae cover obtained at the two locations is not too much different. The lowest average cover is at each station in the western part of the island. The average macroalgae cover on Lae-Lae Island was 9% at East Station and 36% at West Station. Meanwhile, the average macroalgae cover of Gusung Lae-Lae Caddi; East Station 21% and West Station 55%. (Figure2)

Coverage data shows a significant difference between the west and east stations of the island. On Lae-Lae Island, the East Station has higher coverage than the West Station. Differences in macroalgae cover at the west and east stations at each location were caused by

P-ISSN: 2460-0156
E-ISSN: 2614-5049

several factors; the average turbidity at the east station is higher than the west station, nutrient concentrations are higher at the west station, associations with other benthic groups such as coral reefs and seagrass.

Figure 2. Macroalgae Cover Distribution Map

The distribution of macroalgae cover tends to be uniform where Gusung Lae-lae Caddi shows distinctive characteristics. This is due to the high average macroalgae cover, and this further strengthens (Littler et al, 2006) that the closer to the mainland the greater the macroalgae cover.

Relationship between Environmental Condition and Distribution Macroalgal Coverage

Based on field observations, it can be seen that the average macroalgae cover in Gusung Lae-Lae Caddi is higher than Lae-Lae Island. The highest average macroalgae cover at Gusung Lae-Lae Caddi was at LLB station 55% and LLC station 20%. The cause of the low macroalgae cover at station 4 was presumably because at this station the current was higher than the other side of the island. This is consistent with the statement that most organisms prefer a calm environment where the movement of water caused by waves and currents is relatively small (Nyabakken, 1992). In addition, the cause of macroalgae growing well in Gusung Lae-Lae Caddi is that the substrate types at stations LCB are sand and coral which are suitable habitats for macroalgae growth as well as at station LCT has a sandy substrate. The turbidity parameter also affects the three stations, although for all stations in Gusung Lae-Lae Caddi the turbidity value is still below the quality standard, which is <5 NTU, the turbidity value for station LCB is indeed higher than the other stations, which is 2.672 NTU.

While on Lae-Lae Caddi Island the highest cover was found at station LLB with an average closure of 36% and the lowest cover was found in the station LLT with an average closure of 9%. The cause of the low macroalgae cover at the LLT station is thought to be caused by the high level of turbidity and the speed of the current. Meanwhile, the cause of the high macroalgae cover at the LLB station was influenced by the high supply and type of substrate in the form of coral and sand

The presence of macroalgae is influenced by water conditions, both physical and chemical. Several factors measured in the field showed a large enough variation at each observation point. Based on the results of PCA analysis using three characterizing roots (each axis F1 = 55.68%; F2 = 29.36%, and F1-F2 = 85.04%) in Figure 3, it shows that there are 3 groups of station similarities with their preferences. ; Group 1= LCT with a preference for temperature, salinity, phosphate, and current velocity; Group 2 = LCB with a preference for pH and nitrate and Group 3 = LLT and LLB with a preference for turbidity The main factor suspected to be the cause of higher macroalgae cover in Gusung Lae-Lae Caddi compared to Lae-Lae Island is the anthropogenic pressure obtained in Gusung Lae-Lae Caddi is lower than Lae-Lae Island because Gusung Lae-Lae Caddi is an island that has the population is still lacking so that the existing anthropogenic pressure is not too high so that it does not affect the condition of the aquatic ecosystem too much. In addition, in both locations macroalgae benefited from damaged seagrass conditions resulting in high macroalgae cover. According to the results of research by Rizal (2012) found that the seagrass cover on Lae-lae Island was in a disturbed condition, it was almost the same as the macroalgae conditions in Gusung Lae-Lae Caddi. The low density of macroalgae in both locations was due to high turbidity due to suspended sediment, nitrate, and a substrate dominated by fine sand which resulted in seagrass being unable to thrive in these conditions (Faizal et al, 2011).

.

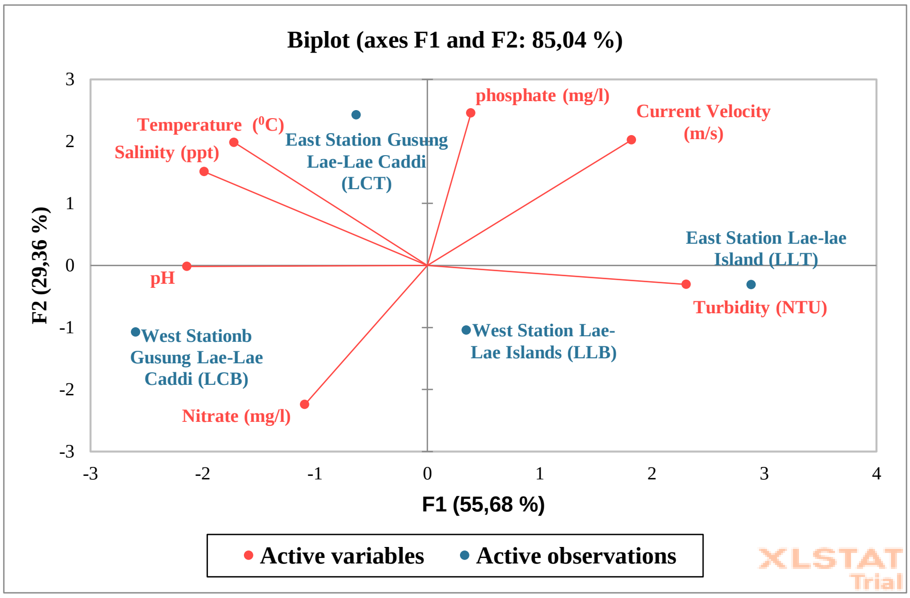

Figure3. The relationship between macroalgae cover and environmental conditions at each station

CONCLUSION

Based on the results of the study, the largest macroalgae cover was found in Gusung Lae-Lae Caddi with a cover percentage of 55%. The high macroalgae cover in Gusung Lae-Lae Caddi was influenced by the high nutrient concentration, low turbidity, and low anthropogenic activity. Distribution of macroalgae cover on Lae-Lae Island obtained an average of 9% East Station (LLT) and West Station (LLB) 36% and in Gusung Lae-Lae Caddi obtained East Station (LCT) 21% and West Station (LCB) 55%

REFERENCES

Ali, S. 2019. Hubungan Kelimpahan Makroalgae Dengan Kondisi Padang Lamun Di Pulau Barrang Caddi dan Pulau Bonebatang, Kota Makassar, Sulawesi Selatan. Skripsi. Program Sarjana, Program Studi Ilmu Kelautan, Faukultas Ilmu Kelautan dan Perikanan Universitas Hasanuddin.

American Public Health Association. 2012. Standard Methods for the Examination of Water and Wastewater, 22nd Edition. Editor E.W., Rice R.B., Baird A.D., Eaton L.S. (eds). Clesceri.American Public Health Association, Virginia.

Amri, K. 2012. Sinekologi Padang Lamun Akibat Tekanan Antropogenik: Studi Kasus Pulau Barranglompo dan Bonebatang Kepulauan Spermonde Sulawesi Selatan.Disertasi. Institu Pertanian Bogor. Bogor.

Amri, K. & I. Yasir. 2015. 'Makroalgae" dalam A. Bahar (Editor). Pedoman Survei Laut. Masagena Press. Makassar. 175 p.Arfah, H., & Patty, S.I. 2016. Kualitas Air dan Komunitas Makroalga di Perairan Pantai Jikumerasa, Pulau Buru. Jurnal Ilmiah Platax. Vol 4, No.2: 109-119.

Atmadja, W. S., Kadi, A., Sulistijo & Sutari, R. 1996. Pengenalan Jenis Rumput Laut di Indonesia. Jakarta: Puslit Oseanologi-LIPI.

Atmajaya, W.S., 1999. Sebaran dan Beberapa Aspek Vegetasi Rumput Laut (Makro Alga) Di Perairan Terumbu Karang Indonesia. Puslitbang Oseanologi –LIPI. Jakarta.

Ayhuan, H. V., Zamani, N. P. dan Soedharma, D. 2017. Analisis Struktur Komunitas Makroalga Ekonomis Penting di Perairan Intertidal Manokwari, Papua Barat. Jurnal Teknologi Perikanan dan Kelautan. Vol 8, No.1: 19-38.

Balmer O. 2002. Species lists in ecology and conservation: abundance matter. Conser Biol 16: 1160-1161.

Bakus GJ. 2007. Quantitative Analysis of Marine Biological Communities, Field Biology and Environment. John Wiley and Sons, Inc. New Jersey. 434 p.

Belliveau, S. A. dan V. J. Paul. 2002. Effects of herbivory and nutrients on the early colonization of crustose coralline and fleshy algae Marina Ecology Progress Series. Vol. 232: 105 - 114.

Bengen, D. G. 2000. Teknik Pengambilan Contoh dan Analisis Data Biofisik Sumberdaya Pesisir. PKSPLFPIK Institut Pertanian Bogor. Bogor.

Boyd CE. 1988. Water Quality in Pond for Aquaculture. Agricultural Experiment Station Auburn University. USA

Brotowidjoyo, D.M., D. Tribowo, Eko. M., 1995. Pengantar Lingkungan Perairan dan Budidaya Air. Liberty. Yogyakarta.

Clarke KR, Warwick RM. 1994. Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. Natural Environment Research Council. Plymouth. 144 p.

Edinger, E. N., J. Jompa, et al (1998). "Reef degradation and coral biodiversity in Indonesia: Effects of land-based pollution, destructive fishing practices and changes over time." Marine Pollution Bulletin 36(8): 617-630.

Fachrul, M.F. 2007. Metode Sampling Bioekologi. Bumi Aksara. Jakarta. 198 p.

Faizal, A., Jompa, J., & Nessa, N. 2012. Pemetaan Spasio-Temporal Ikan-Ikan Herbivora Di Kepulauan Spermonde, Sulawesi Selatan. Jurnal Iktiologi Indonesia, Vol.12, No.2: 121–133.

Faizal, A., J. Jompa & N. Nessa. 2011. Pemetaan Sebaran Tutupan Makroalga Kaitannya dengan Kualitas Lingkungan Di Kepulauan Spermonde, Sulawesi Selatan. Seminar Nasional Tahunan VIII Hasil Penelitian Perikanan dan Kelautan. UGM. Yogyakarta.

Hatta, A.M. 1993. Sistematik dan Ekologi Makroalga Hijau (Chlorophyta) di Perairan Maluku dan Sekitarnya. Balitbang Sumberdaya Laut. Puslitbang Oseanologi LIPI. Ambon.

Hatta, A. M., & Reine W. F. P. V. 1991. A Taxonomic Revision of Indonesian Gelidiales (Rhodophyta). Blumea, Vol.35, No.2: 347-380.

Hutagalung, H.P., 1988. Pengaruh Suhu Terhadap Kehidupan Organisme Laut. Pewarta Oseana. LON-LIPI, Jakarta (13):153-163.

Jha, B., Reddy, C. R. K., C. Thakur, M., & Rao, M. U. 2009. Seaweeds of India : The Diversity and Distribution of Seaweeds of The Gujarat Coast. Springer. Dordrecht.

Kadi A. 2007. Komunitas Makro Alga di Pulau Buton dan Sekitarnya. Biosfera. Vol 24, No. 3.

Kadi, A & Atmajaya, W. S., 1988. Rumput Laut (Alga), Jenis, Reproduksi, Produksi, Budidaya dan Pasca Panen. LIPI. Jakarta.

Kementerian Negara Lingkungan Hidup. 2004. Keputusan Menteri Negara Lingkungan Hidup Tentang Baku Mutu Biota Air Laut. KEP. No-51/MNLH/2004. Jakarta.

Khouw, A. S. 2009. Metode dan Analisa Kuantitatif Dalam Bioekologi Laut. Pusat Pembelajaran dan Pengembangan Pesisir dan Laut (P4L). Jakarta.

Krebs CJ. 1999. Ecological Methodology, Second Edition. Addison Wesley Educational Publishers, Inc. California.

Krebs CJ. 2002. Ecology; The Experimental Analysis of Distribution and Abundance. Harper & Row Publisher. New York.

Legendre, L. & Legendre, P. 1983. Numerical Ecology. Developments in Environmental Modelling, 3. Elsevier Scientific Publishing Company. Amsterdam. 419 pp.

Littler, M. M., D. S. Littler. (2006). "Harmful algae on tropical coral reefs: Bottom-up eutrophication and top-down herbivory." Harmful Algae 5(5): 565-585.

Ludwig, J. A. & Reynold, J. F. 1988. Statistical Ecology. A Primer on Methods and Computing. John Wiley & Sons, Inc. New York. 337 pp.

Luning. 1990. Seaweeds, Their Environment, Biogeography, And Ecophysiology. John Wiley And Sons. New York.

Marianingsih, P., Amelia, E., & Suroto, T. 2013. Inventarisasi dan Identifikasi Makroalga di Perairan Pulau Untung Jawa. Prosiding SEMIRATA. Program Studi Pendidikan Biologi, FKIP - UNTIRTA, Vo. 1, No.1: 219–223.

Meriam, W.P., Kepel, R.C., Lumingas, L. J. 2016. Inventarisasi Makroalga di Perairan Pesisir Pulau Manteghe Kecamatan Wori, Kabupaten Minahasa Utara, Provinsi Sulawesi Utara. Jurnal Ilmiah Platax, Vol.4, No,2 : 84–108.

McCook L.J., 2001. Competition between corals and algal turfs along a gradient of terrestrial influence in the nearshore central Great Barrier Reef. Coral Reefs, 19: 419-425.

Mckenzie, LJ., Campbell, S. J. dan Roder, C. A. 2001. Seagrass-Watch: Manual for Mapping and Monitoring Seagrass Resources by Community (Citizen). Volunteers. Queensland Fisheries Service, NFC, Cairns.

Nybakken, J. W. 1992. Biologi Laut Suatu Pendekatan Ekologis. Gramedia Pustaka Utama. Jakarta.

Orfanidis, S., Panayatidis, P., & Stamatis, N. 2001. Ecological Evaluation Of Transitional And Coastal Waters: A Marine Benthic Macrophytes-Based Model. Mediterranean Marine Science, Vol.2, No.2: 45–66.

Orfanidis, S., Panayotidis, P., & Stamatis, N. 2003. An Insight to The Ecological Evaluation Index (EEI). Ecological Indicators, Vol. 3, No.1: 27–33.

Rani, C., Nessa, M. N., Jompa, J., Toaha, S., & Faizal, A. 2013. Dinamika Spasio-Temporal dan

Keterkaitan Nutrien, Makroalga dan Ikan Karang Herbivora di Kepulauan Spermonde Sulawesi Selatan. Seminar Nasional Tahunan X Hasil Penelitian Kelautan Dan Perikanan, 1–18.

Rarasari, D. A. 2019. Inventarisasi dan Distribusi Makroalga pada Substrat Pasir di Pantai Kukup Gunung Kidul Yogyakarta. Skripsi. Universitas Muhammadiyah. Surakarta.

Reine, W. F. P. V., & Trono, G. C. 2002. Plant Resources of South-East Asia. Bibliography 15. Cryptogams: Algae, Bagian ke-1. Prosea Foundation. Bogor.

Reyes, A. Y. 1978. The Litoral Benthic Algae of Siquijor Province II. Phaeophyta and Rhodophyta. The Philippine Journal of Science, 107,117-173.

Rizal, M. 2012. Analisis Kondisi dan Keragaman Lamun pada Beberapa Pulau di Kota Makassar. Makassar: Universitas Hasanuddin.

Sambamurty, A. V. S. S. 2005. A Text-Book of Algae. In I.K. International Pvt. Ltd. New Delhi. 261 p.

Silvia, A. 2019. Analisis Kelimpahan Makroalga di Wilayah Perairan Pulau Lae-lae dan Pulau Barrangcaddi Kota Makassar. Skrips. Program Sarjana, Program Studi Ilmu Kelautan, Fakultas Ilmu Kelautan dan Perikanan Universitas Hasanuddin.

Soegianto, Agoes. 1994. Ekologi Kuantitatif. Metode Analisis Populasi dan Komunitas. Usaha Nasional. Surabaya.

Sulaeman. 2005. Analisis Kimia Tanah, Tanaman, Air, dan Pupuk. Balai Penilitian Tanah dan Pengembangan Paertanian, Deprtemen Pertanian. Bogor.

Verheij, E., & Reine, W. F. P. V. 1993. Seaweeds of the Spermonde Archipelago SW Sulawesi Indonesia. Blumea, 37: 385-510.

Wardoyo S. 1981. Pengelolaan Kualitas Air. Proyek Peningkatan Mutu Perguruan Tinggi. Bogor (ID): Institut Pertanian Bogor.

Wells, E., Wilkinson, M., Wood, P. & Scanlan, C. 2007. The use of macroalgal species richness and composition on intertidal rocky seashores in the assessment of ecological quality under the European Water Framework Directive. Marine Pollution Bulletin, 55 (1-6): 151-161.

Widyastuti, S., 2008.Pengolahan Pasca Panen Alga Merah Strain Lokal Lombok Menjadi Agar-agar Menggunakan Dua Metode Ekstraksi. Jurnal Penelitian UNRAM. 14(2): 7-63.

Yahya, M. 2016. Evaluasi dan Analisis Potensi Infrastruktur Permukiman Kumuh Masyarakat di Pulau Lae-Lae Kota Makassar. Prosiding Temu Ilmiah IPLBI. Makassar.

P-ISSN: 2460-0156
E-ISSN: 2614-5049

Appendix 1. Classification of Macroalgae found in Lae-Lae and Lae-Lae Caddi Islands

Division	Class	Order	Family	Genus and Species	Station Found	
					Lae-Lae	Lae-Lae Caddi
Chlorophyta	Bryopsidophyceae	Bryopsidales	Halimedaceae	*Halimeda macrophysa*	+	+
	Bryopsidophyceae	Bryopsidales	Halimedaceae	*Halimeda macroloba*	+	+
	Bryopsidophyceae	Bryopsidales	Halimedaceae	*Halimeda opuntia*	+	+
	Bryopsidophyceae	Bryopsidales	Udoteaceae	*Chlorodesmis fastigiate*	+	+
	Bryopsidophyceae	Bryopsidales	Udoteaceae	*Udotea indica*	+	+
	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa serrulata*	+	-
	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa sertullaroides*	+	+
	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa racemosa*	+	+
	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa verticillate*	+	-
	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa lentillifera*	+	+
	Ulvophyceae	Bryopsidales	Dichotomosiphonaceae	*Avrainvillea erecta*	-	+
	Ulvophyceae	Bryopsidales	Codiaceae	*Codium geppiorum*	-	+
	Ulvophyceae	Dasycladales	Dasycladaceae	*Bornetella nitida*	+	+
	Ulvophyceae	Dasycladales	Dasycladaceae	*Noemeris annulata*	-	+
	Ulvophyceae	Cladophorales	Boodleaceae	*Boodlea composita*	+	-
Phaeophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Padina tetrastromatica*	-	+
	Phaeophyceae	Dictyotales	Dictyotaceae	*Padina australis*	+	+
	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyota dichotoma*	+	+
	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyota bartayresiana*	-	+
	Phaeophyceae	Fucales	Saegasseae	*Sargassum polycystum*	+	+
	Phaeophyceae	Fucales	Saegasseae	*Sargassum duplicatum*	+	+
	Phaeophyceae	Fucales	Saegasseae	*Sargassum sp.*	+	+
	Phaeophyceae	Fucales	Saegasseae	*Sargassum cristaefolium*	+	+
	Phaeophyceae	Fucales	Saegasseae	*Sargassum siliquosum*	+	-
	Phaeophyceae	Fucales	Saegasseae	*Sargassum crassifolium*	-	+
	Phaeophyceae	Fucales	Saegasseae	*Turbinaria ornata*	-	+
	Phaeophyceae	Ectocarpales	Chordariaceae	*Levringia boergesenii*	-	+
	Phaeophyceae	Ectocarpales	Scytosiphonaceae	*Rosenvingea intricate*	+	-
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Acanthophora spicifera*	+	+
	Florideophyceae	Ceramiales	Delesseriaceae	*Platysiphonia delicata*	+	-
	Florideophyceae	Corallinales	Corallinaceae	*Amphiroa fragilissima*	+	+
	Florideophyceae	Corallinales	Corallinaceae	*Amphiroa anceps*	+	+
	Florideophyceae	Corallinales	Corallinaceae	*Jania rubens*	-	+
	Florideophyceae	Corallinales	Corallinaceae	*Mastophora rosea*	+	-
	Florideophyceae	Gigartinales	Cystocloniaceae	*Hypnea spinella*	+	+
	Florideophyceae	Nemaliales	Galaxauraceae	*Galaxaura sp*	-	+
	Florideophyceae	Gracilariales	Gracilariaceae	*Gracilaria salicornia*	-	+
	Florideophyceae	Gracilariales	Gracilariaceae	*Gracilaria debilis*	-	+
	Florideophyceae	Gelidiales	Gelidiellaceae	*Gelidiella acerosa*	+	+
	Florideophyceae	Halymeniales	Halymeniaceae	*Halymenia maculata*	-	+
	Florideophyceae	Halymeniales	Halymeniaceae	*Halymenia durvillaei*	+	+

Apeendix 2. Grouping of the Ecological Status Groups of Macroalgae in Lae-Lae and Lae-Lae Caddi Islands

Macroalgae Species	ESG	
	Lae-Lae	Lae-Lae Caddi
Halimeda macrophysa	I	I
Halimeda macroloba	I	I
Halimeda opuntia	I	I
Chlorodesmis fastigiata	II	II
Udotea indica	II	II
Caulerpa serulata	I	-
Caulerpa sertullaroides	II	II
Caulerpa racemosa	II	II
Caulerpa verticillata	II	-
Caulerpa lentilifera	II	II
Avrainvillea erecta	-	I
Codium geppiorum	-	I
Boernetella nitida	I	I
Noemeris annulata	-	I
Boodlea composita	II	-
Padina tertrastromatica	-	I
Padina australis	I	I
Dictyota dichotoma	II	II
Dictyota bartayresiana	-	II
Sargassum polycystum	I	I
Sargassum duplicatum	I	I
Sargassum sp.	I	I
Sargassum cristaefolium	I	I
Sargassum siliquosum	I	-
Sargassum crassifolium	-	I
Turbinaria ornata	-	I
Levringia boergesenii	-	II
Rosenvingea intricata	II	-
Achanthophora spicifera	II	II
Platysiphonia delicata	II	-
Amphiroa fragilissima	I	I
Amphiroa anceps	I	I
Jania rubens	-	I
Mastophora rosea	I	-
Hypnea spinella	II	II
Galaxaura sp	-	I
Gracilaria salicornia	-	II
Gracilaria debilis	-	II
Gelidiella acerosa	II	II
Halymenia maculata	-	II
Halymenia durvillaei	II	II