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# COMMUNITY STRUCTURE OF MACROALGAE IN LEMUKUTAN ISLAND WATERS, WEST KALIMANTAN

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## ABSTRACT

Macroalgae or known as seaweed is one of the potential resources and is responsible for primary productivity in marine waters. Macroalgae plays an important role in marine ecosystems, provides food, oxygen, and habitat for several types of marine biota. Moreover, macroalgae have been reported as renewable resources in marine environment and widely used in various fields. The biodiversity and abundance of macroalgae are strongly influenced by aquatic environmental factors. Lemukutan Island is the largest inhabited island located in Bengkayang Regency, West Kalimantan and has the potential natural resources, including macroalgae. This Island can become a center for producing macroalgae that can be used to meet food needs both locally and domestically. The main objective of this study were to determine the community structure of macroalgae and the condition of the environmental physico-chemical parameters. The sampling locations were carried out in-situ at three stations and the determination of the sampling site was done by purposive random sampling method, by selecting an area based on the presence of macroalgae. The sampling of macroalgae was carried out using a quadratic transect with size of 10x10 m2 and the water quality parameters were measured using the AZ 8603 of WQC instrument. The study found 6 genera of macroalgae, such as Caulerpa, Halimeda, Padina, Turbinaria, Sargassum, and Gracillaria. Among the identified macroalgae, Phaeophyceae have the highest per cent contribution (50%), and Padina had the highest abundance (29.84 ind/m2). Lemukutan Island waters had a moderate level of diversity, high macroalgae uniformity, and dominance index in the low category. The aquaatic environmental factors influenced the abundance of macroalgae in Lemukutan Island waters.

Keywords: community structure, macroalgae, Lemukutan Island

## INTRODUCTION

Macroalgae or known as seaweed is one of the potential resources and is responsible for primary productivity in marine waters (Sudhakar *et al*., 2018). Macroalgae is a low-level plant, which is relatively difficult to distinguish between the roots, stems and leaves (Setyobudiandi *et al*., 2009). Macroalgae grows from intertidal to shallow coastal water and attaches to the substrate (Anggadiredja *et al*., 2006) at the bottom up to 180 meter depth (Sahayaraj and Sathiyamoorthy, 2014). Furthermore, macroalgae need to be exposed to sunlight, so they are easy to examine. This organism contains chlorophyll for photosynthesis process (Simatupang *et al*., 2018), other pigments that give different colors. Based on the pigment content, macroalgae is divided into three classes, namely green macroalgae (Chlorophyceae), red macroalgae (Rhodophyceae), and brown macroalgae (Phaeophyceae) (Anggadiredja *et al*., 2006; Koch *et al*., 2013).

Macroalgae is widespread in tropical waters, including Indonesia, which has a potential of ±6.42% of the total world macroalgae biodiversity (Surono, 2004). Macroalgae plays an important role in marine ecosystems (John and Al-Thani, 2014). Ecologically, macroalgae provides food, oxygen, and habitat for several types of marine biota, especially at the juvenile stage (Niamaimandi, 2006), such as crustaceans, molluscs, echinoderms, fish and other small algae. This phenomenon can increase the existing level of diversity (Veiga *et al*., 2014; Veiga *et al*., 2016). Its lush shape is able to provide protection against waves (Marianingsih *et al*., 2013). In addition, macroalgae has important economic value (Irwandi *et al*., 2017) and the bioactive compounds contained in it are widely used in various industrial fields such as the food, beverage, pharmaceutical, cosmetic, paint, and photography industries (Anggadiredja *et al*., 2006).

Marine macroalgae have been reported as renewable sources in marine environment, and widely used in various fields. As a source of nutrition, macroalgae contains carbohydrates, proteins, fats, vitamins, and minerals. They are able to produce different kinds of secondary metabolites (Vimala *et al*., 2015) with several biological activities (Wijesekara and Kim, 2010; Wijesekara *et al*., 2010; Wijesekara *et al*., 2011) including antibacterial (Devi *et al*., 2012), antiviral (Sivagnanavelmurugan *et al*., 2012), biofuels

(Lenstra *et al*., 2011), biofertilizer (Sridhar and Rengasamy, 2010), and cosmetics (Yoon *et al*., 2009). According to previous study, species of *Eucheuma spinosum* from Lemukutan Island has the antioxidant activity (Sofiana *et al*., 2020).

The biodiversity and abundance of macroalgae are strongly influenced by aquatic environmental factors such as temperature and current speed (Campbell *et al*., 2008), salinity, pH, brightness, nutrients (Marianingsih *et al*., 2013), as well as the type of base substrate (Mouritsen, 2013). The current speed affects the characteristics of the macroalgae that lives in these waters (Neish, 2003). In general, there are two main types of substrate as habitats, namely soft and hard substrates. Soft substrates such as mud, sand or a mixture of sand and silt (Rachello-Dolmen and Cleary, 2007) are commonly found of genera *Caulerpa*, *Gracillaria*, *Halimeda*, and *Hypnea*. Meanwhile, hard substrate types such as dead coral, live coral and rock (Ferawati *et al*., 2014) are mostly inhabited by *Sargassum*, *Ulva*, *Turbinaria*, and *Enteromorpha* species (Kadi and Atmadja, 1988).

Administratively, Lemukutan Island is the largest inhabited island located in Bengkayang Regency, West Kalimantan with an area of 1,235 Ha (BPS Bangkayang Regency, 2020). Lemukutan Island is one of the underwater tourist destinations because it has the potential natural resources. In addition, many macroalgae are found in these waters (Sofiana *et a*l., 2018) which play an important role in the economy of local communities. Macroalgae is also economically very potential as a leading commodity in the sea waters of West Kalimantan.

Lemukutan Island, as waters with high potential biodiversity, can become a center for producing macroalgae that can be used to meet food needs both locally and domestically. However, tourism activities that are not environmentally can reduce water quality and damage existing natural resources, including macroalgae. A part in the management of biodiversity in coastal waters is understanding the community of macroalgae by observation and monitoring of local species, existence, and distribution (Trono 2003; Raffo *et al.,* 2014). Additionally, studies on the diversity and abundance of macroalgae in Lemukutan Island waters have not been widely carried out. Therefore, the main objective of this study were to determine the community structure of macroalgae and the condition of the environmental physico-chemical parameters.

This study provides valuable information on marine macroalgae biodiversity particularly in West Kalimantan region, Indonesia.

## MATERIALS AND METHODS

This research was conducted in Lemukutan Island waters, Bengkayang Regency, West Kalimantan (Fig. 1). The sampling location of macroalgae and measurement of physico-chemical parameters were carried out *in-situ* at three stations. Determination of the sampling location was done by purposive random sampling method, by selecting an area based on the presence of macroalgae.

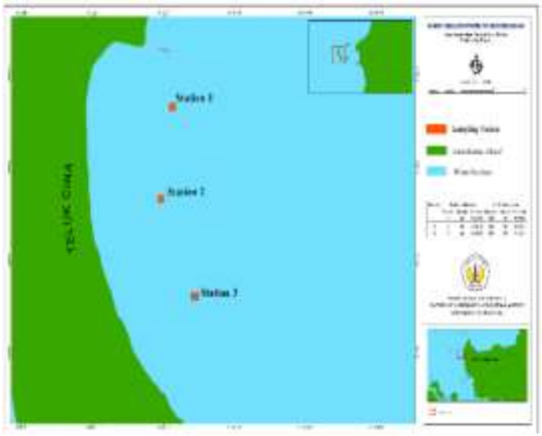

Figure 1. Sampling locations in Lemukutan Island waters

### Sampling of Macroalgae

The sampling of macroalgae was carried out in the intertidal zone. At each sampling station, a line transect is drawn vertically straight coastline, and each line transect consists of a quadratic transect with size of 10x10 $m^2$ (Fig. 2). The macroalgae samples were collected, put into a clean specimen bag and added with seawater for further identification work. The taxonomic group of macroalgae were reviewed and morphological characteristics were explained through www.algaebase.org.

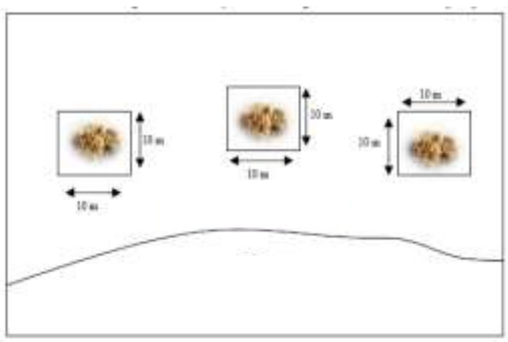

Figure 2. Quadratic transect for sampling of macroalgae

### Measurement of Water Quality Parameters

Measurement of water samples was conducted together with the collection of macroalgae in all sampling locations that had been determined. Water quality parameters such as temperature, salinity, pH, and Dissolved Oxygen (DO) were measured using the AZ 8603 of WQC instrument. All environmental parameters were measured in three replications. Water depth was measured using an tidal palm, current speed was using a current meter.

### Macroalgae Sample Analysis

Macroalgae identification was conducted by taxonomist using identification book guide. The abundance was calculated according to the following formula (APHA, 2009) :

$$K = \frac{ni}{A}$$

where, K is the abundance of macroalgae (ind/m$^2$), and A is the sampling area

Macroalgae species diversity index (H') was determined following Shannon-Wienner (1969) formula :

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

where, H' is diversity index, pi is proportional abundance of each species, is given pi = ni/N; ni is number of individuals species-i; and N is total abundance of individuals species in a community. Macroalgae diversity was classified into three criteria (Odum, 1993), such as H'<1 indicates a low level, 1<H'<3 indicates a moderate level, and H'>3 indicates a high level of diversity, respectively.

The Evenness index (E) was utilized to determine the distribution of macroalgae in a community. This index was calculated following the formula (Odum, 1993) :

$$E = \frac{H'}{Hmax}$$

where, E is Evenness index, H' is species diversity index, and $H_{max}$ is maximum possible value of species diversity, is expressed $H_{max}$ = ln S; and S is total number of species in a community. The value of Evenness index ranges from 0-1, where the value near to 0 determines the distribution of individuals for each genus is not the same and there is a tendency for a genus to dominate the population. Otherwise, if the value is close to 1, indicating the individual number of each genus is not much different and there is no tendency for a genus to dominate in the population (Krebs, 1985).

The dominance index Simpson was used to determine the existence of a certain type of microalgae species dominance and was calculated following the formula (Odum, 1993):

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

where, C is dominance index, ni is number of indivial species-i; and N is total number of individual species in the community. The value of dominance index was classified into three criteria, namely C<0.50 exhibits low dominance, 0.50<C>0.75 indicates moderate dominance, and C>0.75 shows high dominance, respectively (Odum, 1993).

## RESULTS AND DISCUSSION

### Composition and Abundance of Macroalgae

During the study period, macroalgae in Lemukutan Island were classified to 4 ordo, 5 families, 3 classes, and 6 genera, respectively (Table 1). Among the identified microalgae, Phaeophyceae have the highest percent contribution (50%), compared to Chlorophyceae (40%) and Rhodophyceae (10%) of the total genera.

Table 1. Macroalgae composition in Lemukutan Island waters

| Ordo | Family | Class | Genus |
|---|---|---|---|
| Bryopsidales | Caulerpaceae<br>Halimedaceae | Chlorophyceae | Caulerpa<br>Halimeda |
| Dictyotales | Dictyotaceae | Phaeophyceae | Padina |
| Fucales | Sargassaceae | | Turbinaria<br>Sargassum |
| Gracilariales | Gracilariaceae | Rhodophyceae | Gracilaria |

It can be seen that all of the genera have different abundances ranging from 1.06 to 29.84 ind/m$^2$. Among the identified macroalgae, *Padina* had the highest value (Figure 3). This genus was the most common class discovered in aquatic environment, including Lemukutan Island. Furthermore, *Padina* was generally found to be an annual dominant species (Kokabi *et al*., 2016; Srimariana *et al*., 2020). The environmental conditions could be linked to the emergence of macroalgae species (Sukiman *et al*., 2014), such as season (Bruckner and Dempsey, 2015; Shoubaky and Kaiser, 2014), depth (Kang *et al*., 2011), temperature (Campbell *et al*., 2008), and the characteristic of base substrate (Mouritsen, 2013). Moreover, macroalgae are known to be vulnerable to the changing of physical and chemical parameters in the marine environment (Harley *et al.*, 2012).Water temperature is a key factor for the geographical distribution of seaweed (John and Al-Thani, 2014), and can negatively affect macroalgae survival, as well as their diversity. Moreover, as sessile organisms, seaweed cannot move after attachment on the substrate (Mikami *et al.*, 2006). Characteristics of substrat can affect as well the growth and population of macroalgae (Zhao *et al.*, 2016) and impacts the species diversity (Handayani, 2017) in this location.

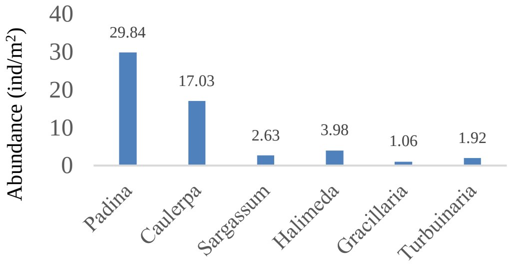


Figure 3. Abundance of macroalgae in Lemukutan Island waters

In this study, Caulerpa had as well a high abundance value of 17.03 ind/m$^2$. Several studies had observed that *Caulerpa* belonging to Chlorophyceae was also a potential macroalgae commonly found in Indonesian waters (Nofiani *et al*., 2018; Srimariana *et al*., 2020; Zulpikar *et al*., 2020) and this genus was to be cosmoplite (Draisma *et al*., 2018). In general, Chlorophyceae has a wide habitat distribution so they easy to find in coastal waters (Odum, 1993). Furthermore, they have high adaptability to the environmental condition, such as easily attached to various types of bottom substrate so that it can defend itself from water currents (Irwandi *et al*., 2017)

## Biological Index of Macroalgae

The biological index such as Diversity index (H’), Evenness index (E), and Dominance index (C) can express the stability of macroalgae community in the waters. The diversity index was determined by the number of species, number of individuals, and the distribution pattern (Krebs, 1985).

Table 2. Diversity, Evenness, and Dominance Index of Macroalgae in Lemukutan Island

| Index | Value | Criteria |
|---|---|---|
| H’ | 1.22 | Moderate |
| E | 0.68 | High |
| C | 0.38 | Low |

In this study, the diversity index (H’) of macroalgae was 1.22 and according to the diversity level criteria (Odum, 1993), the waters of Lemukutan Island had a moderate level of macroalgae diversity. The physico-chemical factors was presumably to influence the diversity resulting in only certain types of macroalgae were able to adapt to the conditions. According to the value of Evenness index (E), this condition indicates that the waters of Lemukutan Island had high macroalgae uniformity. This index showed that the distribution of individuals for each genus was equally distributed and there was no tendency for a genus to dominate the population. The value of the dominance index (C) showed the waters have low dominance category. This indicates that there were no certain types of macroalgae that dominate the population.

## Water Quality Parameters

Table 3. Physico-chemical Parameters of Lemukutan Island waters

| Index | Station I | Station II | Station III |
|---|---|---|---|
| Temperature (°C) | 32 | 32 | 32 |
| Salinity (‰) | 31 | 29 | 29 |
| pH | 8.61 | 8.43 | 8.39 |
| Depth (m) | 0.71 | 0.72 | 1 |
| Current speed (m/s) | 0.064 | 0.022 | 0.025 |

The waters condition of Lemukutan Island could be observed based on physico-chemical parameters. In the present investigation, water temperature was 32 °C. Water temperature plays an important role, as well as affect the the growth of spesies (Kusumaningtyas *et al*., 2014). The presence and distribution of aquatic organisms, as well as the life of the existing biota were also influenced by the water temperature (Odum, 1993; Effendi, 2003; Nontji, 2005; Brahmana, 2014). Lemukutan Island has the water salinity ranging from 29-31‰. Previous study conducted at the same location, the water salinity ranged 31- 32.3‰ (Nurcahyanto *et al*., 2021). Salinity will determine the distribution and productivity of macroalgae. Furthermore, the low level of salinity affect the growth and the photosynthesis process (Wisudyawati, 2014). Sudradjat (2009) suggested that the optimum salinity for the growth of macroalgae was ranged from 28-35 ‰. pH is one of the important chemical parameters in monitoring the stability of the waters (Simanjuntak, 2009). The measurement of pH value in Lemukutan Island waters showed alkaline conditions, in the range from 8.39 to 8.61. the variation of pH value greatly influence the community structure of aquatic organisms (plants, animals, and microorganisms) (Rangkuti *et al*., 2017). The majority of aquatic biota prefered around 7-8.5 and were sensitive to the change of pH value (Effendi, 2003; KepMen LH No. 51 year 2004).

In this study, the depth in Lemukutan Island where macroalgae found ranged from 0.71 to 1 m. Water depth was a physical parameter related to the the intensity of light and affects the level of penetration (Effendi, 2003). Macroalgae need the light intensity entering to the water coloum for the photosynthesis process (Effendi, 2003; Rosada, 2017). The value of current speed in this research was 0.022 - 0.064 m/s and was classified as a slow category. Current was linked to the distribution of aquatic organisms, as well as the spread of dissolved gases and nutrients (Barus, 2004; Kordi and Tancung, 2010).

## CONCLUSION

The study found 6 genera of macroalgae, such as *Caulerpa*, *Halimeda*, *Padina*, *Turbinaria*, *Sargassum*, and *Gracillaria*. Among the identified macroalgae, Phaeophyceae have the highest per cent contribution (50%), and Padina had the highest abundance (29.84 ind/$m^2$). Lemukutan Island waters had a moderate level of diversity, high macroalgae uniformity, and dominance index in the low category. The aquaatic environmental factors influenced the abundance of macroalgae in Lemukutan Island waters.

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