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Diversity of Macroalgae in the Intertidal Zone of Gili Ketapang Beach, Probolinggo, Jawa Timur, Indonesia

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ABSTRACT
Indonesia is a country that has high potential in biodiversity, especially in the marine areas. As the primary producer of marine ecosystems, macroalgae provide food for many species. Macroalgae have very varied structures but are generally divided into three groups based on their color of thallus i.e. Chlorophyceae, Ochrophyceae, and Rhodophyceae. This research aims to study the diversity of macroalgae in the intertidal zone of Gili Ketapang Beach, Probolinggo, Jawa Timur. This study was conducted on May, 22 2021 during low tide. Samples were collected using a purposive random sampling method. Data analysis was performed by identifying and classification of samples of macroalgae that were found. The result showed that macroalgae were found five species consisting two species of Ochrophyta, two species of Rhodophyta, and one species of Chlorophyta. The substrate of Gili Ketapang Beach is more suitable for Rhodophyta and Ochrophyta growth.

Keywords: *Diversity, Gili Ketapang Beach, Macroalgae*

1. INTRODUCTION

Indonesia is a country that has high potential in biodiversity, especially in the marine areas. Biodiversity in marine areas spread from tidal until deep zone. The intertidal zone is the interface between terrestrial and sea environments. The substrates in this zone determine the presence of macroalgae e.g. sandy or rocky [1]. Moreover, this zone has a unique ecosystem, including in Gili Ketapang Beach, Probolinggo, Jawa Timur. Gili Ketapang located in the north of Probolinggo. This island is coral island at the coordinates of 113°15'21" East Longitude and 7°40'48" South Latitude [2]. This site is dominated by the sandy substrate. There are many tourism activities like snorkeling, fishing, and other water sports in the beach area. The activities in Gili Ketapang Beach have the potential to increase water pollution that can disturb the marine ecosystem, especially in intertidal zone. The pollution can damage the habitat and place of the macroalgae attached [3]. Macroalgae is important for the marine ecosystem that plays as primer producer, can degrade heavy metals, and reduce pollutants. Indonesia has high diversity of macroalgae about 88 species because there are many suitable habitat areas for macroalgae [4]. Diversity of macroalga in Gili Ketapang beach is divided into three groups: Chlorophyta, Ochrophyta, and Rhodophyta [1].

Chlorophyta is green macroalgae known to contain chlorophyll a and b adominantan pigments. Chlorophyta also has carotene and xanthophyll pigments. This alga is one of the algae group with the largest vegetation in the intertidal zone. Chlorophyta is commonly found in freshwater, seawater, and semi-aquatic environments [5]. This group is divided into four orders; Ulvales, Siphonocladales, Bryopsidales, and Dasycladales [6]. Ochrophyta is brown macroalgae known to contain chlorophylls a and c and carotenoids. Brownish color occurs because of fucoxanthin predominance [7]. This group is divided into three orders; Dictyotales, Scyrosiphonales, and Fucales [6].

Rhodophyta is known as red macroalga that has chlorophyll a, phycobilins, and some carotenoids as photosynthetic pigments [7]. This group is divided into seven orders Nemaliales, Bonnemaisoniales, Gelidiales, Cyptonemiales, Corallinales, Gigartinales, and Ceramiales [6].

This research aims to study the diversity of macroalgae in the intertidal zone of Gili Ketapang Beach. Diversity of macroalgae has more important gaps for each area than others. Macroalgal diversity is very important because it can provide information about the current condition of macroalgae and the ecosystem in Gili Ketapang Beach. Long-term study of diversity from year to year can detect the ecological changes of diversity through global changes [8]. The result of this study can be preliminary data for further research about conservation.

2. METHODOLOGY

This research was conducted on May 22, 2021 at intertidal zone of Gili Ketapang Beach, Probolinggo, Jawa Timur.

Figure 1. Study site: Gili Ketapang Beach, Probolinggo, Jawa Timur

Macroalgae specimens were collected by the purposive random sampling method. The tools and materials used in this research were a zip-lock plastic bag for storage, a digital camera, millimeter blocks for documentation, and FAO Species Identification Guide for Fishery Purpose for identification. The macroalgae specimens were collected using bare hands then placed in a zip-lock plastic bag and filled with seawater. For documentation, macroalgae were cleaned with running water and placed in millimeter block then photographed.

Identification of macroalgae using the FAO Species Identification Guide for Fishery Purposes 1998. The Identification result shows the macroalgae diversity.

3. RESULT

The result (Table 1) showed that in Gili Ketapang Beach were found five macroalgae species consist of two Ochrophyta, two Rhodophyta, and one Chlorophyta.

Table 1. Macroalgae species found in intertidal zone Gili Ketapang Beach, Probolinggo, Jawa Timur

No	Families	No	Species
1	Ochrophyceae	1	*Padina minor* Yamada
		2	*Sargassum crassifolium* J.Agardh
2	Rhodophyceae	3	*Gracilaria edulis* S.G.Gmelin
		4	*Gracilaria gracilis* (Stackhouse) Steentoft, L.M.Irvine & Farnham
3.	Chlorophyceae	5	*Caulerpa racemose* (Forsskål) J.Agardh

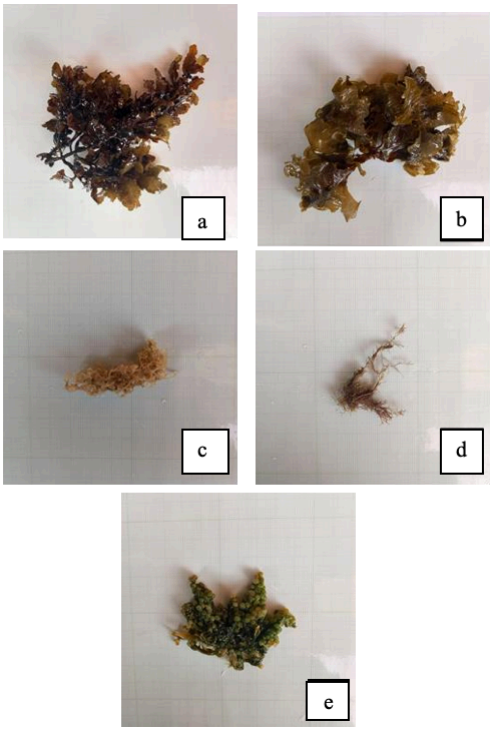

Figure 2. (a) S. crassifolium, (b) P. minor, (c) G. edulis, (d) G. gracilis, (e) C. racemosa.

3.1. Ochrophyta

Ochrophyceae or yellow-green macroalgae are a group that is only found in Tropical regions. Besides that, Ochrophyta is widely distributed in coastal areas and is highly abundant. These groups are commonly found in temperate regions [9]. *S. crassifolium* and *P. minor* are two species that are found in Gili Ketapang Beach.

Sargassum (*Sargassaceae)* is a genus that has diverse species with lots of potential uses in industry. *S. crassifolium* has a cylindrical cauloid with alternate regularly branched. The filoid has an oval shape with serrated edges. The color of the thallus is pale green to brown with vesicles (air bubbles) in their thalli. These species clearly midrib from base to the tip of filoid, but the cryptostomata are still unclear [10]. *Sargassum* can grow in various substrates (rocky-sandy, sandy, and rocky-muddy substrate) in shallow water or exposure areas.

P. minor (Dictyotaceae, Ochrophyta) has an "ear-like" blade with whitish brown colour [11]. *P. minor* is one of calcified brown algae with thallus that is divided into several flabellate. These species are also widely distributed in tropical coastal areas from intertidal to subtidal zones. *P. minor* grows in a solid substrate including rocky or sandy bottom and sometimes live epiphytically with another large blade algae like *Sargassum* spp. These species are usually more abundant during the dry season. Not only do they play a role as primary producers, but *Padina minor* also has an important role in their ecosystem as adsorbing pollutants and can be considered as biological indicators when contamination occurs [12].

3.2. Rhodophyta

This study also found two species that consist of family Rhodophyceae or red algae there are *G. edulis* and *G. gracilis*. Red algae or Rhodophyta are the major group of macroalgae in the world that consist of more than 4000 species described [8]. Genus *Gracilaria* is a majority genus that is used in the agar industry also known as Agarophyte. Agarophyte is economically important macroalgae for large scale industrial especially agar production. Nowadays, *Gracilaria* is cultivated based on the spores [13].

G. edulis (Gracilariaceae) has erect thallus that sub dichotomously branched. The branches terete to be flattened with a small holdfast [6]. These species are usually found attached on sandy or rocky substrate in protected areas and naturally the thallus immersed in the sand [13]. *G. edulis* has worldwide distribution from tropical to subtropical regions [14]. *G.gracilis* has cylindrical cartilaginous thallus with irregular branches. The color of this species is red to purple and usually grows on sandy shores [14]. The growth of this species depends on water sea parameters like temperature, salinity, and availability of other species. The optimal water temperature to grow in the range 19-23 ^{o}C [15].

3.3. Chlorophyta

The third Family that was found in Gili ketapang was Chlorophyta. Chlorophyta is widely distributed in intertidal zones that are nearest to the mainland. These groups need a lot of penetration of sunlight so usually found in the exposure area. Only one species of Chlorophyta that is found in Gili Ketapang there is *C. racemosa* (Caulerpaceae). This species has dark green to pale green thallus color. These species have stolons with erect "grape like" thallus that tightly adheres to the substrate. The substrate that supports *C. racemosa* growing are dead coral with sandy and sandy-muddy bottom. Besides that, these species are usually colonized with live coral or associated with other algae like red algae [16]. These species are also widely distributed in tropical and subtropical regions [17].

4. DISCUSSION

The substrate in the intertidal zone of Gili Ketapang was dominated by sandy substrate with high activity of tourism. The five species macroalgae that was found suggests that in the Intertidal zone of Gili Ketapang Beach the diversity of macroalgae is influenced by substrate and exposure conditions. Substrates are one of many important factors for the growth and presence of macroalgae. Sandy substrate only supports few macroalgae, especially Rhodophyta and Ochrophyta that mostly grow in the sandy bottom. Tourism activity also plays a crucial role in the ecological process in the intertidal zone of Gili Ketapang Beach because it can inhibit the growth of macroalgae. In the end, until now there is still no recent research that mentions the diversity of macroalgae in Gili Ketapang.

Macroalgae species found in the intertidal zone Gili Ketapang Beach were five species, consisting three Families. Macroalgae that were found classified to two species are Ochrophyceae (*Sargassum crassifolium* and *Padina minor*), two species are Rhodophyceae (*Gracilaria edulis* and *Gracilaria gracilis*), and one species is Chlorophyceae (*Caulerpa racemosa*). Sandy substrate is more suitable for Rhodophyta and Ochrophyta growth than Chlorophyta growth.

AUTHORS' CONTRIBUTIONS

NMA was designing this study and collecting samples. Then, FF was analyzing data and conducts manuscript proofreading before submission. All authors write, read, and approved the final version of the manuscript.

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