Macroalgae on the Rocky Shore of the Southern Coast of Garut, West Java, Indonesia

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Abstract. The rocky shore of the southern coast of Garut, which is directly adjacent to the Indian Ocean, is strongly influenced by large energy waves. This condition has an impact on marine biota, especially macroalgae. Macroalgae that grow in these waters are macroalgae with high adaptation. The aims of this study were to determine the diversity, adaptation and potency of macroalgae on the rocky shore of the southern coast of Garut, West Java. Observation of macroalgae on the southern coast of Garut was conducted on May 2016. The study was conducted in nine locations, namely Bubujung, Karang Paranje, Santolo Indah, Karang Papak, Taman Manalusu, Cicalobak, Karang Wangi, Ranca Buaya 1 dan Ranca Buaya 2. Macroalgae samples were collected by the transect quadrate method. Parameters measured were species, standing crops biomass and substrates of macroalgae. A total of 44 species (21 genera) of macroalgae have been successfully collected from the southern coast of Garut, West Java. The adaptation of macroalgae on the large energy waves was by morphological changes. There are 13 of 21 genera of macroalgae that were collected which were the economically potential. *Hormophysa*, *Padina*, *Sargassum* and *Turbinaria* are alginate producers, whereas, *Gelidiella* and *Gracilaria* are agarose producers.

Keywords: adaptation, diversity, macroalgae, rocky shore, West Java

1. Introduction

Garut Regency is one of the regions in West Java that is directly adjacent to the Indian Ocean. The south coast of Garut is a rocky shore that is strongly influenced by large energy waves. Large energy waves affect marine biota, for example macroalgae. Macroalgae on rocky shores have a high adaptation to large energy waves and hard substrates.

Macroalga is the biota of the coastal ecosystem that has a role both ecologically and economically. Macroalgae ecological roles include: as a primary producer in the food chain, a habitat for other small marine organisms (crustaceans, mollusks and echinoderms) and food sources for marine organisms [1-3]. Economic macroalgae benefits include sources of alginate, carrageenan and agar [4, 5], as a source of bioactive polysaccharides [5].

Research of macroalgae on rocky shores had been carried out in several regions in Indonesia: Malang, East Java [6], Gunung Kidul, Yogyakarta [7], Ujung Genteng, West Java (personal data 2010, 2017), Simeulue, Nangroe Aceh Darusalam (personal data 2017). Macroalgae in the rocky shore had different adaptation from low wave waters. Macroalgae communities on the rocky shore had different adaptations depending on the conditions of the study site, for example: wave strength, tidal, substrate, nutrient, and water quality [7, 8].

Research related to diversity, adaptation and potency of macroalgae on rocky shores was very important as a basis for coastal area management and development policies. Until now, in the rocky shores of the Southern Coast of Garut there was still little information of macroalgae communities. The purposes of this study were to determine the diversity, adaptation and potency of macroalgae that can survive in large energy wave waters.

2. Materials and Methods

2.1. Study site

The research was conducted in May 2016 at nine locations, namely Bubujung (S 07º43' 955', E 107º55'380'), Karang Paranje (S 07º41'012', E 107º47'687'), Santolo Indah (S 07º39'775', E : 107º41'072'), Karang Papak (S 07º38'473', E 107º41'013'), Taman Manalusu (S 07º35'445', E 107º37'434'), Cicalobak (S 07º32'811', E 107º31'759'), Karang Wangi (S 07º32'650', E 107º31'415'), Ranca Buaya 1(S 07º32'664', E 107º28'675') and Ranca Buaya 2 (S 07º31'928', E 107º28'790') (figure 1). The choice of study site was based on the possible location routes for sampling of macroalgae. The location of the study included 5 sub-districts in Garut Regency, namely Cibalong, Pameungpeuk, Cikelet, Caringin and Mekarmukti. An additional sub-district Cipatujah (Tasikmalaya Regency) is also as study site.

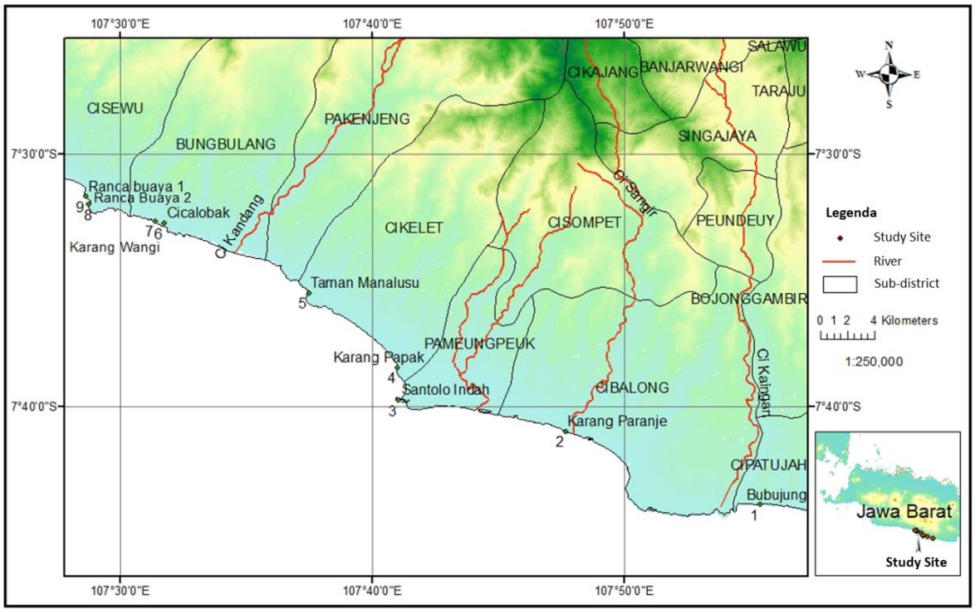

Figure 1. Study site of macroalgae in the Southern Coast of Garut, West Java: Bubujung, Karang Paranje, Santolo Indah, Karang Papak, Taman Manalusu, Cicalobak, Karang Wangi, Ranca Buaya 1 and Ranca Buaya 2.

2.2. Sampling of macroalgae

Macroalgae was collected by the quadrat transect method. Quadrat transects were carried perpendicular to the coastline toward to edge. Macroalgae in the frame (1 m^2) was taken to examine biomass and species macroalgae [9, 10]. In addition, collections were also done outside the transect frame. Macroalgae collections outside transects were carried out to identify macroalgae that grow in the study site but are not found in the transect frame. Macroalgae samples were weighed and sorted based on their species. Observation of substrate was carried out visually in the transect frame. Examination of samples was carried out by means of wet weighing and sorting of seaweed by species to be identified. The grouping of macroalgae life forms was based on substrate. Diversity of species has been calculated using the Shannon-Wienner diversity index [11, 12].

2.3. Identification and sample preparation of macroalgae

Macroalgae were identified according to the guide for identification of macroalgae [13-20]. The nomenclature of macroalgae was matched by the World Register of Marine Species [21]. For collection of macroalgae, samples of macroalgae were preserved in 70% alcohol. Samples were stored in the Reference Collection of Research Center for Oceanography-Indonesian Institute of Sciences in Jakarta.

3. Result and Discussion

3.1. Diversity of macroalgae

A total of 44 species of macroalgae were collected form the Southern Coast of Garut, West Java. The macroalgae consists of three Divisions: Chlorophyta (13 species and seven genera), Ochrophyta (nine species and 4 genera) and Rhodophyta (22 species and 10 genera) (table 1 and figure 2). The most common macroalgae were *Gracilaria* (six species) and *Sargassum* (four species). The two genera were founded more often than others, but it did not mean dominant.

Based on the Sannon-Wienner diversity index, macroalgae on the rocky shore of Garut had low index diversity. Large energy waves less-affected macroalgae on hard substrates which was capable to growing. Karang Papak and Manalusu have a higher number of macroalgae than other areas, respectively 28 species and 23 species. The reef flat of Karang Papak and Manalusu had many moats which were areas for macroalgae growth. Cicalobak has the lowest number of macroalgae. Macroalgae at each location have varied diversity and macroalgae dominance is not found. Macroalgae found were macroalgae which are only able to grow on hard substrates.

The number of macroalgae species on the rocky shore of Southern Coast of Garut is lower than on the rocky shore of Ujung Genteng, Sukabumi, West java (56 species; personal data at 2017), but higher than on the rocky shore of Simelue, Nangroe Aceh Darusalam (34 species, personal data at 2017). The total species of macroalgae in an area was influenced by several factors including geographic location, coastal topography, substrate and seasonal of macroalgae [22, 23].

Table 1. The diversity of macroalgae on the rocky shore of the Southern Coast Garut, West Java.

No	Species	St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9
	CHLOROPHYTA									
1	*Boegesenia forbesii*	-	-	+	+	+	-	-	-	+
2	*Boodlea composita*	-	-	+	-	+	-	-	-	-
3	*Caulerpa cupressoides*	-	-	-	+	-	-	-	-	-
4	*Caulerpa sertularioides*	-	-	-	+	+	-	-	-	-
5	*Chaetomorpha antennina*	-	-	-	-	-	-	+	-	-
6	*Chaetomorpha crassa*	-	+	+	+	+	-	-	+	+
7	*Chaetomorpha* sp.	-	+	-	-	-	-	-	-	-
8	*Chlorodesmis* sp.	-	-	-	+	+	-	-	-	+
9	*Halimeda macroloba*	-	-	+	-	-	-	-	-	-
10	*Halimeda micronesica*	-	-	+	+	-	-	-	-	-
11	*Ulva intestinalis*	-	-	-	+	+	-	-	-	+
12	*Ulva lactuca*	-	-	+	+	+	-	+	+	+
13	*Ulva reticulata*	-	-	-	+	+	-	-	+	+
	OCHROPHYTA									
14	*Hormophysa cuneiformis*	-	-	-	-	+	-	-	-	-
15	*Padina australis*	-	-	+	+	+	-	-	+	+
16	*Sargassum cinereum*	-	-	+	-	+	-	-	-	-
17	*Sargassum ilicifolium*	-	-	-	+	-	-	-	-	-
18	*Sargassum polycystum*	+	-	-	+	+	-	+	+	-
19	*Sargassum* sp. 1	-	-	-	+	-	-	-	-	+
20	*Sargassum* sp. 2	-	-	-	-	-	-	-	+	-

No	Species	St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9
21	*Turbinaria ornata*	-	-	-	-	+	-	-	-	+
22	*Turbinaria* sp.	-	-	-	+	-	-	-	-	-
	RHODOPHYTA									
23	*Acanthophora dendroides*	-	+	+	-	+	-	+	+	+
24	*Acanthophora muscoides*	-	-	-	-	-	-	-	+	-
25	*Acanthophora spicifera*	-	-	-	+	-	-	-	-	+
26	*Acrocystis nana*	-	-	-	+	+	-	-	-	+
27	*Amphiroa fragilissima*	-	-	-	+	-	-	-	-	+
28	*Galaxaura rugosa*	-	-	-	+	-	-	-	-	-
29	*Galaxaura* sp.	-	-	-	-	+	-	-	-	+
30	*Gelidiella acerosa*	-	+	-	-	+	-	-	-	-
31	*Gigartina* sp.	-	-	+	-	-	-	-	-	-
32	*Gracilaria bangmeiana*	-	-	-	+	+	-	-	-	-
33	*Gracilaria edulis*	-	-	-	-	+	-	-	-	+
34	*Gracilaria salicornia*	-	-	+	+	+	-	-	+	+
35	*Gracilaria gigas*	-	-	-	+	-	-	-	-	-
36	*Gracilaria* sp. 1	-	-	+	+	+	-	-	+	-
37	*Gracilaria* sp. 2	-	-	-	+	+	-	-	-	-
38	*Hypnea spinella*	-	-	-	+	+	-	-	-	+
39	*Hypnea* sp.	-	-	+	-	-	-	-	-	-
40	*Laurencia intricata*	-	-	-	+	-	-	-	-	-
41	*Laurencia nidifica*	-	-	-	+	-	-	-	-	-
42	*Laurencia obtusa*	-	-	-	+	-	-	-	-	-
43	*Laurencia* sp.	-	-	-	+	-	-	-	-	-
44	*Rhodymenia* sp.	-	-	-	-	-	-	-	-	+
	Total of Species	1	4	13	28	23	0	4	10	18

Note: + is found, – is not found, St 1. Bubujung, St 2. Karang Paranje, St 3. Santolo Indah, St 4. Karang Papak, St 5. Taman Manalusu, St 6. Cicalobak, St 7. Karang Wangi, St 8. Ranca Buaya 1, St 9. Ranca Buaya 2.

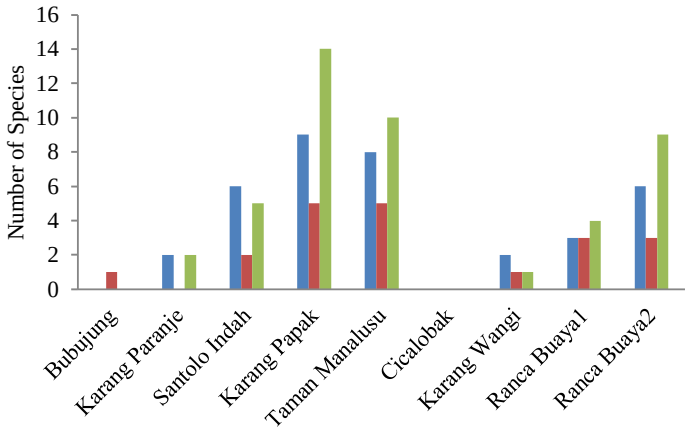

Figure 2. Number of macroalgae based on division on the rocky shore of the Southern Coast Garut, West Java, ■ Chlorophyta; ■ Ochrophyta; ■ Rhodophyta.

3.2. Life form of macroalgae

There are four life form types of macroalgae, namely: epilithic, rhizophitic, epiphytic and epizoic (figure 3). One species of macroalgae can have more than one type of life form, for example *Padina australis* which has three types of life forms, namely epilithic, epiphytic and epizoic. The dominant life form was epilithic (82%). Epilithic is a type of macroalgae life form that lives strongly on hard substrate, for

example: rocks, coral fragments, and dead coral. The rocky shore of the Southern Coast of Garut was dominated by hard substrate, so only macroalgae that adapt to waves are able to survive. Macroalgae can adapt well to hard substrates, for examples: *Gracilaria*, *Turbinaria*, *Sargassum* and *Hypnea* [24]. Hard substrate on rocky shores affect the dominance of macroalgae, especially the epilithic macroalgae [11].

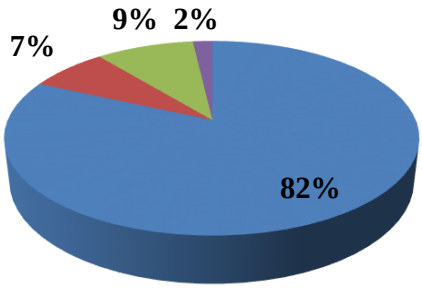

Figure 3. Life form of macroalgae on the rocky shore of the Southern Coast Garut, West Java, ■ Epilithic; ■ Rhizophitic; ■ Epiphytic; ■ Epizoic.

3.3. Biomass and Potency of Macroalgae

The southern coast of Garut is an area that has a short beach, very steep topography and high energy waves. These conditions causes not all research locations to allow transect activities. Based on the waters' condition, Santolo Indah was the only possible location for transect activities. The average macroalgae biomass in Santolo Indah Beach waters was 130 g /m^2 (table 2).

Santolo Indah Beach was the only research location that was protected from large wave energy, however Santolo Indah was still founded with macroalgae growing on sand substrate. Santolo Indah was also the only one of possible location routes for transect kwadrat of macroalgae. In addition, Santolo Indah had seagrass by the highest cover (36.1%). Santolo indah was dominated by sand substrate (69.55%). However, these waters have high biomass compared to other locations. Santolo indah was dominated by sand substrate (69.55%). However, these waters have high biomass compared to other locations. The high biomass of macroalgae was likely to be influenced by location of water that was more protected from waves than other research locations. In addition, the presence of seagrass becomes a substrate stabilizer, so the unstable substrate such as the sand substrate becomes more compact by the presence of seagrass. The association between macroalgae and seagrass protects the substrate from energy waves.

Table 2. The biomass and substrate of macroalgae on Santolo Indah, Garut, West Java.

No	Macroalgae	Average of biomasa (g/m^2)
1	*Acanthophora dendroides*	85
2	*Padina australis*	5
3	*Gracilaria* sp.	10
4	*Gracilaria salicornia*	25
5	*Boergesenia forbesii*	5
6	*Chaetomorpha crassa*	5
	Total of biomass	130
	Substrate	
	Dead coral	25.90 %
	Sand	69.55 %
	Sandy mud	4.55 %
	Average depth	17.20 cm
	Seagrass cover	36.10 %

Macroalga is one of the marine biota that has economic value. A total of 13 of 21 genera of macroalgae are potentially economic macroalgae, including: *Caulerpa*, *Chaetomorpha*, *Halimeda*, *Ulva*, *Hormophysa*, *Padina*, *Sargassum*, *Turbinaria*, *Acanthophora*, *Gelidiella*, *Gracilaria*, *Hypnea* and

Laurencia. Some genera of seaweed are producing phycocolloid such as agar and alginate. *Hormophysa*, *Padina*, *Sargassum* and *Turbinaria* are producing alginate. *Gelidiella* and *Gracilaria* are producing agar. *Caulerpa*, *Chaetomorpha*, *Halimeda*, *Ulva*, *Acanthophora*, *Hypnea* and *Laurencia* are used as a food source.

Macroalgae has bioactive polysaccharides. Bioactive polysaccharides are materials or additives for the pharmaceutical and cosmetic industries. Bioactive polysaccharides have activities: anti-oxidants, anti-cancer, anti-diabetic, anti-infective, anti-obesity, anti-coagulant, anti-virus, anti-bacterial [5, 25-31].

3.4. Adaptation of macroalgae

Macroalgae was able to grow on various substrates, among other: soft substrate (mud and sand) dan hard substrate (dead coral, ruble, coral and rock). In addition, macroalgae was also able to grow in the large waves waters. There are differences in macroalgae morphology as adaptation to large wave waters, for exampel: *Gracilaria salicornia* on large wave waters has slimmer thalus than on low wave waters (figure 4).

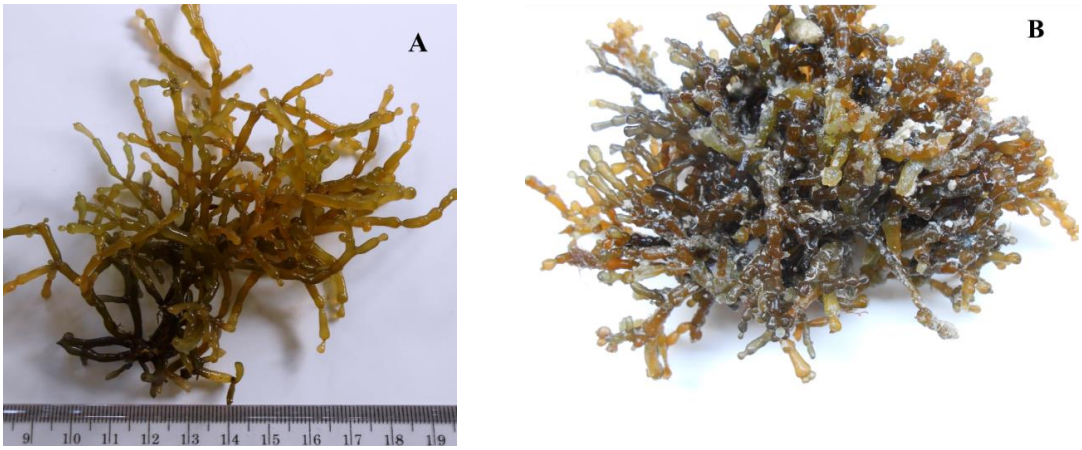

Figure 4. Morphology of macroalgae thallus, (A) on the rocky shore of Southern Coast of Garut and (B) on Pari Islands

4. Conclusion

A total of 44 species of macroalgae have been collected from the rocky shore of the southern coast of Garut, West Java. The adaptation of macroalgae on the large energy waves was by morphological changes. Thirteen genera of macroalgae have economic value including: *Caulerpa*, *Chaetomorpha*, *Halimeda*, *Ulva*, *Hormophysa*, *Padina*, *Sargassum*, *Turbinaria*, *Acanthophora*, *Gelidiella*, *Gracilaria*, *Hypnea* and *Laurencia*. *Hormophysa*, *Padina*, *Sargassum* and *Turbinaria* are producing alginates. *Gelidiella* and *Gracilaria* are producing agar.

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