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.

Macroalgae 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 07°43’ 955”, E 107°55’ 380”), Karang Paranje (S 07°41’ 012”, E 107°47’ 687”), Santolo Indah (S 07°39’ 775”, E 107°41’ 013”), Karang Papak (S 07°38’ 473”, E 107°41’ 013”), Taman Manalusu (S 07°35’ 445”, E 107°37’ 434”), Cicalobak (S 07°32’ 811”, E 107°31’ 759”), Karang Wangi (S 07°32’ 650”, E 107°31’ 415”), Ranca Buaya 1 (S 07°32’ 664”, E 107°28’ 675”) and Ranca Buaya 2 (S 07°31’ 928”, E 107°28’ 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.](image)

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 m²) 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-Wiener 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 from 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 Shannon-Wiener 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].

| No | Species                  | St | St | St | St | St | St | St | St |
|----|--------------------------|----|----|----|----|----|----|----|----|
| 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          | -  | -  | +  | -  | -  | -  | +  | -  |

| No | Species                  | St | St | St | St | St | St | St | St |
|----|--------------------------|----|----|----|----|----|----|----|----|
| 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. | - | - | - | + | - | - | - | - | - |
23 | Acanthophora dendroides | - | + | + | - | + | + | + | + |
24 | Acanthophora muscoides | - | - | - | - | - | - | + | + |
25 | Acanthophora spicifera | - | - | + | - | - | - | - | + |
26 | Acrocystis nana | - | - | + | + | - | - | - | - |
27 | Amphipora 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](image_url)

**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/m² (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.

| No | Macroalga                  | Average of biomass (g/m²) |
|----|----------------------------|--------------------------|
| 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        | Average biomass (%) |
|------------------|---------------------|
| 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 example: *Gracilaria salicornia* on large wave waters has slimmer thallus 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](image)

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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References

[1] Williams S L and Smith J E 2007 A global review of the distribution, taxonomy and impacts of introduced seaweeds *Annual Review of Ecology, Evolution and Systematics* **38** 327-359
[2] Prathep A, S Pongparadon, A Darakrai, B Wichachucherd and S Sinutok 2011 Diversity and distribution of seaweed at Khanom-Mu Ko Thale Tai National Park, Nakhon Si Thammarat Province, Thailand Songklanakarin Journal of Science and Technology 33 6 633-640

[3] Satheesh S and Wesley S G 2012 Diversity and distribution of seaweeds in the Kudankulam coastal waters South-Eastern coast of India Biodiversity Journal 3 1 79-84

[4] Rasmussen R S and Morrissey M T 2007 Marine biotechnology for production of food ingredients Advances in food and nutrition research 52 237–292

[5] Holdt S L and Kraan S 2011 Bioactive compounds in seaweed: functional food applications and legislation J. Appl. Phycol. 23 543-597.

[6] Irawan S and Luthfi O M 2017 Identification of Macroalgae on Micro Atoll of Porites in Kondang Merak, Malang J. Ilmiah Rinjani 5 1 40-46.

[7] Pratama W, Dewi S C, Sari I Z R, Hardiyati A and Wajong A E 2015 Distribution and abundance of macroalgae in intertidal zone of Drini Beach, Gunung Kidul, DIY KnE Life Sciences 2 514-517

[8] Dawes C J 1998 Marine botany, 2nd ed (New York: John Wiley & Sons)

[9] Rigby P R, Iken K and Shirayama Y 2007 Sampling Biodiversity in Coastal Communities: NaGISA Protocols for Seagrass and Macroalgal Habitats (Kyoto: Kyoto University Press)

[10] Dhargalkar V K and Kavlekar D 2004 Seaweeds–a field manual (Goa: National Institute of Oceanography)

[11] Copejans E, Beeckman Hand M De Wit 1992 The Seagrass and Associated Macroalgal vegetation of Gazi Bay (Kenya). In: Jaccarini V and EM Kluwer (Eds) The Ecology of Mangrove and the Related of Ecosystems (Belgium: Springer)

[12] Zakaria M H, Bujang J S, Amit R, Awing S A and Ogawa H 2006 Marine macrophytes: macroalgae species and life forms from Golden Beach, Similajau National Park, Bintulu, Sarawak, Malaysia Coastal Marine Science 30 1 243-246

[13] Atmadja W S, Kadi A, Sulistijo dan Rachmaniar 1996 Pengenalan jenis-jenis rumput laut di Indonesia (Jakarta: Pusat Penelitian dan Pengembangan Oseanologi-LIPI)

[14] Cordero J R 1981 Studies on Philippine marine red algae. Smithsonian Inst. Univ. Stat. Nat. Museum 4 258

[15] Criib A B 1983 Marine algae of the southern great barrier reef-Rhodophyta (Brisbane: Watson Ferguson & Co)

[16] Lewmanomont K and H Ogawa 1995 Common seaweeds and seagrasses of Thailand (Bangkok: Kasetsart University)

[17] Magruder W H and Hunt J W 1979 Seaweeds of Hawaii: a photographic identification guide (Hawaii: Oriental Publishing Company)

[18] Misra J N 1966 Phaeophyceae in India (New Delhi: Indian Council of Agricultural Research)

[19] Trono J R C C and Ganzonfortes E T 1988 Philippine seaweed Technology ND Livelihood Recourse Centre, Net. (Manila: Book store Inc. Metro)

[20] Wei T L and Chin W Y 1983 Seaweeds of Singapore (Singaphore: Singapore University Press)

[21] Guiry M D and Guiry G M 2018 AlgaeBase World-wide electronic publication, National University of Ireland, Galway (taxonomic information republished from AlgaeBase with permission of MD Guiry) Accessed through: World Register of Marine Species at http://www.marinespecies.org

[22] Kang J C, Choi H G and Kim M S 2011 Macroalgal species composition and seasonal variation in biomass on Udo, Jeju Island, Korea Algae 26 4 333–342

[23] Norashikin A, Harah Z M and Sidik B J 2013 Intertidal seaweeds and their multi-life forms J. Fish. Aqua. Sci. 8 3 451–461

[24] Imchen T 2015 Substrate deposit effect on the characteristic of an intertidal macroalgal community Indian Journal of Geo-Marine Science 44 3 1–6

[25] Chevolot L, Foucault A, Chaubet F, Kervarec N, Sinquin C, Fisher A M and Boisson-Vidal C 1999 Further data on the structure of brown seaweed fucans: relationships with anticoagulant activity Carbohydr Res. 319 154-165
[26] Ellouali M, Boissonvidal C, Durand P and Jozefonvicz J 1993 Antitumor-activity of low-molecular-weight fucans extracted from brown seaweed Ascophyllum nodosum Anticancer Res. 13 2011–2019

[27] Mandal P, Mateu C G, Chattopadhyay K, Pujol C A, Damonte E B and Ray B 2007 Structural features and antiviral activity of sulphatedfucan s from the brown seaweed Cystoseira indica. Antiviral Chem Chemother. 18 153–162

[28] Miao H Q, Elkin M, Aingorn E, Ishai-Michaeli R, Stein C A and Vlodavsky I 1999 Inhibition of heparanase activity and tumor metastasis by laminarin sulfate and synthetic phosphorothioate oligodeoxynucleotides Int. J. Cancer 83 424–431

[29] Wang J, Zhang Q B, Zhang Z S and Li Z 2008 Antioxidant activity of sulfated polysaccharide fractions extracted from Laminaria japonica Int. J. Biol Macromol. 42 127–132

[30] Zhang Q B, Li N, Zhou G F, Lu X L, Xu Z H and Li Z 2003 In vivo antioxidant activity of polysaccharide fraction from Porphyra haitanesis (Rhodophyta) in aging mice Pharmacol Res. 48 151–155

[31] Zhuang C, Itoh H, Mizuno T, and Ito H 1995 Antitumor active fucoidan from the brown seaweed, Umitoranoo (Sargassum thunbergii) Biosci Biotechnol Biochem. 59 563–567