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Diversity and distribution pattern of bioactive compound potential seaweed in Menganti Beach, Central Java, Indonesia

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Abstract. *Widyartini DS, Hidayah HA, Insan AI. 2023. Diversity and distribution pattern of bioactive compound potential seaweed in Menganti Beach, Central Java, Indonesia. Biodiversitas 24: 1125-1135.* Seaweed has great potential in the pharmaceutical industry. This study aims to obtain data on the diversity and distribution of bioactive compound potential seaweeds collected from Menganti Beach. The research applied the survey and random transect sampling in each substrate type. The variables were species diversity, distribution pattern, and bioactive compound potential. The main parameters were the number of species and the number of individuals of each species of seaweed. The supporting parameters were depth, salinity, temperature, and pH. The data were analyzed by calculating the Shannon-Wiener diversity, Simpson dominance, and Morisita indices using Primer 7 software. The results showed that 21 species have bioactive compound potential. There were seven species (33 %) of Chlorophyta, including *Caulerpa leltilifera, C. racemosa, C. taxifolia, Ulva lactuca, U. intestinalis, Valonopsis pacynema,* and *Codium tomentosum.* Twelve species (57%) of Rhodophyta, including *Callophyllis crispata*, *Chondrus crispus, Eucheuma spinosum, Halymenia harveyana, Gigartina stellata, Gracilaria gigas, G. canaliculata*, *G. lichenoides*, *G. verrucosa*, *Palmaria palmata*, *Portieria hornemannii*, and *Rhodymenia palmata;* and two species (10%) of Phaeophyta, including *Padina australis* and *Sargassum crassifolium*. The diversity of seaweed was moderate (0.903-1.153). The dominance index (0.559-0.68) indicates no dominance, and the seaweed distribution pattern is grouping.

Keywords: Distribution pattern, diversity, Menganti Beach, seaweed, substrate

INTRODUCTION

Seaweed is used as a bioactive compound by the people of coastal areas. According to Michalak et al. (2022), Ya'la (2022), and Senthil and Muruggan (2013), seaweed contains various secondary metabolites, has enormous bioactive compound potential, and has been used in traditional bioactive, such as gallstones, gout, and scrofula disease, refrigerants for fever, menstrual disorders, kidney disorders, and scabies. Some species of seaweed contain high protein capable of improving the hormonal and nervous systems, the body's defense functions, and the working system of the heart, circulatory and digestive systems. According to Murugan and Iyer (2012), antioxidant compounds are used as bioactive. Teas et al. (2013), the prevalence of breast and prostate cancer in Japan and China is very low, directly related to seaweed consumed in considerable quantities in the country, compared to countries in North America and Europe.

Seaweed contains alginate, agar, carrageenan, and pigments as bioactive compounds. Therefore, seaweed is developed into food ingredients, cosmetics, pharmaceutics, bioethanol, animal feed, fish feed, aquaculture, and liquid waste handling processes (Freitas et al. 2022). Indonesia has at least 550 species of high economic-value seaweed variants out of around 8,000 species worldwide. In addition, 56 species are known to be used as food ingredients and natural bioactive (Darmawan et al. 2022). In Indonesian waters, there are many species of seaweed, but only certain species of seaweed are known to have high economic value and potential as bioactive. 13 species of seaweed have been widely reported, including sources of nutraceuticals, cosmetic raw materials, and seaweed salt preparations for hypertensive patients (Merdekawati and Susanto 2009). One of them is the *Eucheuma cottoni*, which is estimated to have a total potential value in Indonesia of USD 10 billion per year and that was controlled for more than 80% of the worldwide supply. For this reason, it is necessary to explore its derivative use, considering that materials derived from the sea have not received much attention.

Seaweed grows in intertidal or subtidal areas, preferring habitats with small daily temperature variations and dead rock substrates (Eggertsen et al. 2021). Seaweed, in nature, lives attached to the basic substrate of hard and soft types. Hard types are rocks, living corals, and volcanic rocks. While soft substrate types such as sand, mud, and mixtures (coral, sand, mud) (Ferawati et al. 2014). Oceanographic, topographic, and biological factors influence the diversity and dominance of seaweed in nature. Oceanographic conditions are a body of water (temperature, light intensity, depth, salinity, pH, nitrate content of waters, currents, and waves). While topographical factors such as bottom substrate and conditions of waters. Biological factors such as herbivorous animals and competition between seaweed. Those factors and human activities can affect the structure of seaweed communities (Premarathna et al. 2020).

Widyartini et al. (2017) state environmental factors can also cause variations in the shape of seaweed thallus.

The high or low level of diversity of seaweed species will be determined using the Shannon-Wiener index formula (H') and calculate the values of the supporting parameters, namely light intensity, temperature, salinity, and pH. The height or low of the dominance level of seaweed species will be determined using the Simpson dominance index formula. The value of the seaweed dominance index ranges from 0-1, with criterion D=0, meaning that no species dominate other species (abundant) or community structures in a stable state. If D=1, species dominate other species or unstable community structures due to ecological pressure or stress (Dewinta et al. 2021). Differences in diversity indices are influenced by competition. The seaweed that wins in the competition grows to be dominant, while the loser will be reduced in number (Al et al. 2020).

Menganti Beach, Kebumen District, Indonesia, has a rock-bottom substrate, rocky sand, mixed, and high current and wave speed. Seaweed with a strong holdfast will be stuck in the coral substrate, able to withstand high current and wave speeds. Beaches with a substrate of fragments of dead rock and coral are more stable and have high diversity compared to beaches with sand and mud substrates.

In exploring the potential of seaweed as a bioactive, information about species diversity and dominance and environmental conditions is basic information that is very necessary because the growth of a seaweed species has different living requirements. Special studies of the diversity and dominance of potentially bioactive compounds on seaweed in Menganti Beach do not yet exist. This study aims to determine seaweed's diversity, dominance, and distribution patterns with bioactive potential. The study results are basic data for developing, utilizing, and managing sustainable seaweed resources as bioactive compounds.

MATERIALS AND METHODS

Study area

The diversity and distribution of seaweed with bioactive potential from the Menganti Beach, in Ayah Sub-district, Kebumen District, Central Java, Indonesia (Figure 1), which is one of the tourist attractions in Central Java. The location with coordinates 7°27' - 7°50' S and 109°22' - 109 °50' E. Menganti Beach is a beach located in Southern Java and is directly adjacent to the Indian Ocean. It has distinctive characteristics, such as the rocky southern coast with huge waves, mostly composed of substrate base coral. Coral reefs are a natural substrate for seaweed growth. In addition, corals are a stable attachment point for the thallus to withstand strong waves (Widyartini et al. 2017; Domettila et al. 2013).

Procedure

The material used in this study was seaweed obtained from Menganti Beach. The tools used were identification books, GPS, thermometers, digital scales, pH meters, hand refractometers, square iron rods, Secchi disks, and cool boxes. The seaweed sampling location was determined by the purposive random sampling method based on different substrate types, namely hard substrates (corals, rocks, and mollusk shells) and soft substrates (sand, mixtures, and mud). Samples were taken from May to August 2022 at low tide. The seaweed sampling technique uses a randomly selected transect method. The transect line was made three perpendiculars to the coastline, and the distance between the transects is 50 m. Each transect is made of two plots on each substrate type and conducted at low tide. Researched variables include diversity, dominance, and distribution of seaweed species. The main parameters are the number of species and the number of individuals of each species of seaweed.

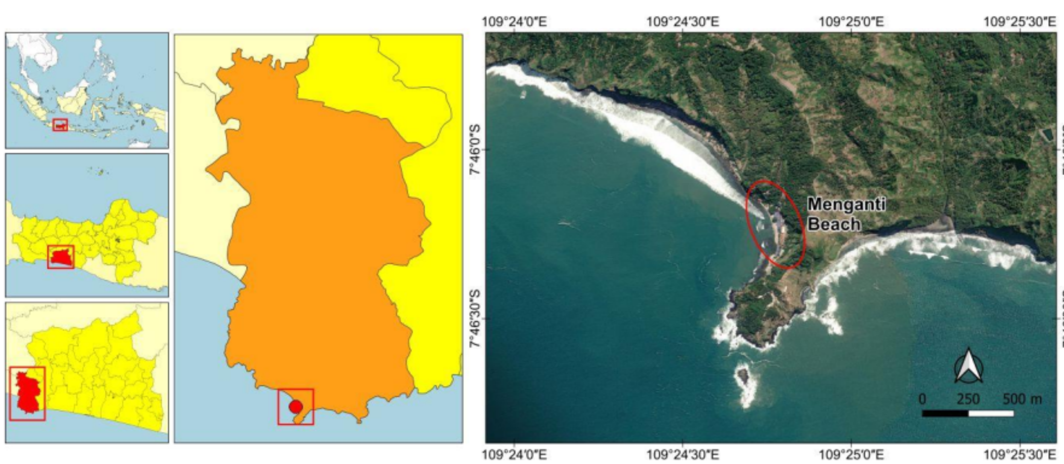

Figure 1. Locations of the Menganti Beach, Central Java, Indonesia

The supporting parameters consist of depth, salinity, temperature, and pH. Seaweed samples were identified by observing thallus and matching them to images in identification books following Waters et al. (2019), Sarita et al. (2021), Sudradjat (2015), Kasim (2016), and Algaebase.

Seaweed's potential as a bioactive compound was determined by literature studies from Shelar et al. (2022), Ya'la (2022), Veeragurunathan et al. (2022), Kumar et al. (2019), du Preez et al. (2020), Saito and Tamrin (2019), Darmawan et al. (2022), etc. This study's environmental parameters as supporting data measurement consisted of physical and chemical parameters (Arief 2015; García-Poza et al. 2020; Nathani et al. 2020). The parameters measured were depth, current speed, temperature, salinity, and acidity (pH), which were carried out in situ using the method according to APHA (2005). Significant wave measurements are accessed through the BMKG website (https://peta-maritim.bmkg.go.id/ofs/#). First, phosphate and nitrate content were tested at the UPTD Environmental Laboratory of the Banyumas Regency Environmental Service. Then, phosphate was analyzed using the UV-Vis spectrophotometer method at a wavelength of 880 nm. Finally, nitrate was analyzed using a spectrophotometer at a wavelength of 420 nm (BSN 2005). Species diversity in communities was calculated using the Shannon-Wiener diversity index (Shannon and Weaver 1949); Krebs (2014); Ghellai et al. (2021), with the formula:

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

$$pi = \frac{ni}{N}$$

Where:
H' : Shannon-Wiener diversity index
Pi : $\frac{ni}{N}$
Pi : Proportion of i-th type in the total sample
ni : number of individuals on the i-th plot
N : Total number of individuals of all species
S : number of species

The Dominance Index of certain species in waters can be calculated using the Simpson Dominance Index (Krebs (2014); Pradana et al. (2020) with similarities:

$$D = \sum (ni / N)^2$$

Where:
D : Simpson dominance index
Ni : number of individuals of type to i
N : Total number of individuals of the whole species
S : number of species

The seaweed distribution pattern is calculated using the Morisita (Iδ) equation following Brower et al. (1990); Pradana et al. (2020) with similarities:

$$I\delta = \frac{ni\sum(Xi(Xi-1))}{N(N-1)}]$$

Where:
Iδ : Morisita spread index
Idea : number of sampling units
N : Total number of individuals
Xi : number of individuals of a species on the i-th plot

Analysis data

The data were calculated with the Shannon-Wiener diversity index (H'), Simpson dominance (D), and spread patterns using the BIO ENV feature of the Primer v5 application. The results of these calculations were then analyzed with the reference of Ayhuan et al. (2017). The Shannon-Wienner diversity index interpretation (H') is categorized as low if H' ≤ 1, medium if 1 < H' < 3, and high if H' > 3. The interpretation of the Simpson dominance index ranges from 0-1; the closer to 0, then the community there are no dominating species or the community is in a stable state; if the dominance value is close to 1, then in the community, there is a dominating species or the community in a labile state (Ayhuan et al. 2017). Interpretation of the Morisita (Ide) distribution pattern, which is categorized as having a random spread pattern if Iδ = 1, a clustered distribution pattern if Iδ > 1, and a uniform distribution pattern if Iδ < 1 (Pradana et al. 2020).

RESULTS AND DISCUSSION

The present study at Menganti Beach resulted in the identification of 21 seaweed species with bioactive compound potential, i.e., *Caulerpa lentillifera* L., *Caulerpa racemosa, Caulerpa taxifolia* L., *Ulva lactuca* L., *Ulva intestinalis* L., *Valoniopsis pachynema* (G. Martens) Borgesen, *Codium tomentosum* Stackhouse, *Callophyllis crispate* C.Agardh, *Chondrus crispus* Stackhouse, *Eucheuma spinosum* J. Agardh, *Halymenia harveyana* J. Agardh, *Gigartina stellata* (Stackhouse) Batters *Gracilaria gigas* Harvey, *Gracilaria canaliculate* Sonder, *Gracilaria lichenoides* J.V Lamouroux, *Gracilaria verrucosa* Papenfuss, *Palmaria palmata* Greville, *Portieria hornemannii* (Lyngbye) Silva, *Rhodymenia palmata* (L.) Greville, *Padina australis* Hauck and *Sargassum crassifolium* J. Agardh. (Figure 2).

The morphological characteristics of the species, the bioactive compounds contained, and their benefits are listed in Table 1. Seaweeds were identified based on thallus shape, size, color, branching type, and holdfast and were grouped into three species (phyla), i.e., Chlorophyta, Rhodophyta, and Phaeophyta. Phylum Chlorophyta is a sea vegetable used for antifungal, antibacterial, and high blood pressure bioactive (Shah et al. 2020). Phylum Phaeophyta is a producer of algin, iodine, and fucoxanthin pigments. The benefits of its bioactive compounds such as antimicrobial, anticancer, antioxidant, anti-inflammatory, antidiabetic, and antiparasitic properties (Remya et al. 2022). Phylum Rhodophyta produces carrageenan and agarose, while iodine is a preventive bioactive compound for goiter disease (Lomartire et al. 2021). Ficoeritrin pigment of chromatic adaptation. Carrageenan is a natural bioactive, antimicrobial, and antifertility (Pereira 2018).

Agarose is an antidysentery, diarrheal, and anti-goiter bioactive (Heriyanto et al. 2017). Seaweed is useful as an antioxidant (Sanger et al. 2018); antibacterial (Santoso et al. 2022); antihelmintic, anticholesterol, clot treatment, analgesic swelling, antipyretic, anti-inflammatory, antidiabetic, and anticancer (Rode and Sabale 2018).

Phylum Chlorophyta was represented by seven species (33%), Phylum Rhodophyta by 12 species (57%), and two species (10%) by Phylum Phaeophyta. The number of individuals on the coral substrate was 2,031 compared to the crushed substrate (corals-stone-sand); there were 1,796 individuals (Figure 3). The presence of high wave pressure on Menganti Beach causes seaweed with an epilithic type of living trait that can survive, namely seaweed that grows attached to hard substrates such as rocks. According to Aziz and Chasani (2020), many seaweeds' strong current and wave conditions are adapted to the hard substrate so that they are not easily carried away by the current. Umanzor et al. (2019) state substrate is an important factor in determining the presence of seaweed. Each seaweed can grow and develop by attaching to a specific substrate.

Figure 2. Seaweed has the potential to be bioactive on Menganti Beach, Kebumen District, Indonesia

Table 1. Seaweed species bioactive compound potential on Menganti Beach, Kebumen District, Indonesia

Species names	Morphology description of species	Compound content and its benefits	Reference sources
Callophyllis cristata C.Agardh	Red algae have pink thallus and brownish peacocks. The thallus is flat with a tapered or narrow end and solid above, with rounded or spreading corners—dichotomous branching type. The thallus is up to 15 cm long—discoid holdfast forms on coral and rubble.	As an antioxidant	Kang et al. (2005)
Caulerpa lentilifera L.	Thallus resembles grapes, bright green in color, slightly shiny, and soft in texture. Thallus length between 7-8 cm. The entire body consists of one cell, with the bottom spreading like a stolon—holdfast with rhizoids attached to rock or coral substrates.	Contain cellulose, hemicellulose, alkaloids, and antihelmintic as an antifungal, high blood pressure medication, and anthelmintic.	Kumar et al. (2019); Saito and Tamrin (2019); du Preez et al. (2020)
Caulerpa racemosa Dawson	Thallus is green, like a grass plant with many upright branches. Round conical thallus shape. The thallus is about 10-11 cm long—holdfast with stolons that stick or attach to the bottom substrate of dead coral.	Contain folic vitamins, folinic acid, glycoglycerol, and phenols as anti-inflammatory, antidiabetic, antibacterial, and antioxidant.	Kumar et al. (2018); Shelar et al. (2012); Srimariana et al. (2020)
Caulerpa taxifolia L.	The thallus is shaped like a fern, and the thallus's bottom is spread like a stolon. The thallus is about 9-10 cm long. Adhesive disc stolons attach holdfast to massive rocks.	Contain cellulose and hemicellulose as antibacterial and antifungal.	Etcherla and Rao 2014
Chondrus crispus Stackhouse	This species is red with a flat, ribbon-shaped thallus. Thallus 2-3 cm long with dichotomous branching. Holdfast discoid on a rock.	Contain Vitamin A. As a remedy for respiratory disorders and laxatives	Pereira et al. (2018)
Codium tomentosum Stackhouse	Thallus brownish green, cylindrical shape. The branching is dichotomous, with a thallus length of about 5cm. Holdfast with powerful discs	Contain flavonoids as antibacterial, antioxidant, and antitumor.	Ya'la (2022); Kallswari et al. (2016)
Eucheuma spinosum J. Agardh	Algae have brownish red, purplish red, and yellowish green. The thallus is a cylindrical, dichotomous branching type, about 6-7 cm long. The thallus has a sharp or blunt tip and is overgrown with nodules (protrusions) in the form of soft spines surrounding the branches. The holdfast is discoid in shape and grows attached to flat coral reefs, rocks, hard objects, and clam shells.	Contain flavonoids, triterpenoids, ascorbic acid, and sources of Iodine (I), Zinc (Zg), and Vitamin B. As an antioxidant, antibacterial, asthma medication for tuberculosis, abdominal pain, fever, anti-hyper cholesterol, anti-cancer, and lowers blood sugar	Damongilala et al. (2013)
Gigartina stellata (Stackhouse) Batters	A flat thallus with a smooth surface and a length of the thallus is about 12 cm. Branching type is dichotomous, regularly alternate, and widened. Small disc-shaped holdfasts attached to the coral reef substrate.	Contain a remedy for lung infections, peptic ulcers, bladder, and kidney failure.	Nguyen et al. (2018)
Gracilaria canaliculata Sonder	The algae are red and cylindrical, with a thallus reaching 7 cm wide by 6 cm high. The thallus cartilaginous substance is rigid in texture and has dichotomous branches, two branches at each branch point. Holdfast attaches firmly to hard substrates such as rocks and coral.	Contain alkaloids, phenols, tannins, and mineral sources. As an article, wound healing, hepatoprotective function, obesity medication, and coronary heart risk.	Senthil and Murugan (2013); Baghel et al. (2014)
Gracilaria gigas Harvey	The yellowish-green thallus is cylindrical in shape, 15 cm, and has a dichotomous branching type. Branches tend to center to the base, elongate, and alternate. The thallus is rather rough and stiff. It holdfast with a simple adhesive device that attaches to flat coral reefs, rocks, sand, mud, and clam shells.	Contain compounds bromophenol, beta-carotene, alpha-carotene, and lutein. As an antidiabetic and antioxidant	Pereira (2018)
Gracilaria lichenoides J.V. Lamouroux	The thallus is cylindrical in the form of a thin rod up to 10 cm long—cartilaginous thallus type with dichotomous and trichotomous branches. The pointed ends of the branches (acuminatus) and discoid-shaped holdfasts attach to the rock.	Contain proteins and fats, vitamin c, and iodine. As a remedy for diarrhea, dysentery, and goiter remedy	Ya'la (2022)

Gracilaria verrucosa Papenfuss	The cylindrical thallus is a thin rod up to 10 cm long. The ramifications alternate irregularly with elongated hair-like lateral branches, and the discoid holdfast attaches to the rock.	Contain phenol compounds, alkaloids, flavonoids, and tannins. As an antioxidant, antibacterial, antiviral, and anti-inflammatory.	Widowati et al. (2014); Fadhlullah et al. (2022)
Halymenia harveyana J. Agardh	This brownish flat thallus has a shape with jagged thallus edges, 7-8 cm long. The branching type is a pinnate alternate, angular, and tapers towards the top—Holdfast in the form of an adhesive disc.	Contain compounds carotene and chlorophyll. As an antioxidant, it relieves stress.	Wulandari et al. (2018)
Padina australis Hauck	The thallus consists of a thin sheet-shaped blade with flat edges, a smooth surface, and light brown. The thallus is about 13 cm long and has no branching type. The stipe is not visible, so the thallus structure only consists of the blade and holdfast. The adhesive (holdfast) is thin and stringy. Grows attached to rocks	Contain fucoxanthin, phenols, and flavonoids as antibacterial, antibleeding, and antitumor.	Shelar et al. (2012); Nandya et al. (2021); Chantarasiri (2020)
Palmaria palmata Greville	The thallus is brownish red and in the form of a flat sheet that has a width of 2.5 cm. Thallus height reaches 21 cm with a finger shape so that branching only occurs at a distance of 1.5 cm from the end of the thallus. Holdfast is discoid in shape with rhizoids.	Contain phenol compounds, polyphenols, and iodine sources. As an antioxidant, anti-inflammatory, and improved thyroid function.	Allsopp et al. (2015)
Portieria hornemanii (Lyngbye) Silva	The thallus is flat with a smooth surface, forming small clumps and overlaps. The length of the thallus is about 4-5 cm. The branching type is dichotomous, regularly alternate, and compact. Small disc-shaped holdfasts attached to the coral reef substrate	Contain high levels of phenol compounds as an antioxidant and a cure for cancer and Alzheimer's.	Cojandaraj et al. (2020)
Rhodymenia palmata (L.) Greville	The thallus is flat with a smooth surface, forming small clumps and overlaps. The length of the thallus is about 4-5 cm. The branching type is dichotomous, regularly alternate, and compact. Small disc-shaped holdfasts attached to the coral reef substrate	Contain phenol compounds. As an antioxidant, melanin synthesis fights skin cancer.	Cortes et al. (2019)
Sargassum crassifolium J. Agardh	The holdfast is discoid in shape with a cylindrical axis and has a thallus in the form of a rod (stipe), leaf (blade), and vesicles. The branching type is pinnate alternate. Blade surface width 0.5-1.3 cm. The thallus is about 17-18 cm long. The vesicles are spherical or oval in shape, medium in size, and numerous in the adult thallus. They have pneumatocysts in the form of an air bladder as air floats to keep them afloat on the water's surface.	Contain phenol compounds, iodine, tannins, and vitamin C. As an antibacterial bioactive, antitumor, high blood pressure medication, and adenoid disorder bioactive.	Shelar et al. (2012); Saraswati et al. (2019); Santoso et al. (2022)
Ulva intestinalis L.	Green algae with long, tube-like filamentous tubular thallus, about 15 cm long, has no branching type. Holdfast adheres to sandy rock substrates or attaches to the thallus of other algae. This alga is also identified as Enteromorpha intestinalis by several references.	As an antibacterial and lowers high blood pressure.	Shelar et al. 2012 Pereira et al. (2018)
Ulva lactuca L.	The thallus is green with a membranous type, in the form of sheets like thin and smooth leaves with a width of 3 cm. The edge of the sheet is wavy and 4 cm high. Disc-shaped holdfast attached to rock/coral substrate. The shape of the thallus resembles an elongated rectangle like a leaf.	Contain phenol compounds, flavonoids, and carotene. As an antioxidant, antibacterial, antifungal, antitumor, boil bioactive, and nosebleed bioactive.	Rinawati and Muhsin (2022); Zulfadhli and Rinawati (2018)
Valoniopsis pachynema (G. Martens) Borgesen	The filamentous thallus forms dense aggregations of green or dark green color. It has irregular branches at the terminal and is curved to form bunches. Tacos' length of about 3-4 cm. Dichotomous branching type.	It contains flavonoids, alkaloids, and terpenoids, as antifungals, antioxidants, nausea medications, and vomiting medications.	Ahmed et al. (2012); Dhinakaran et al. (2016); Khavita et al. (2015)

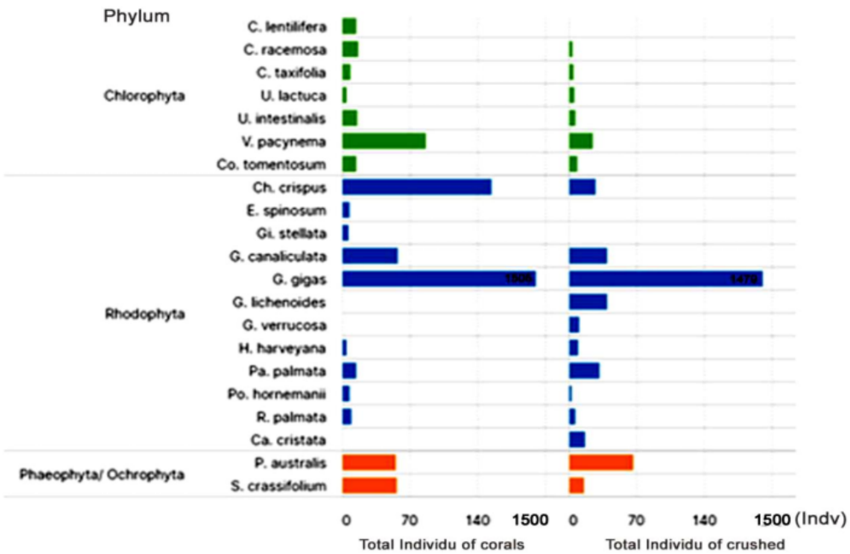

Figure 3. Number of individuals on the coral substrate and crushed substrate (corals-stone-sand)

Gracilaria gigas has the highest number of individuals, averaging 1,505. *G. gigas* has a holdfast shape in the form of a simple adhesive device that can be attached to corals, coral fragments, and sand, according to the substrate found at Menganti Beach. Waters et al. (2019) state that *G. gigas* can adapt to several habitats with simple holdfasts that can stick to sand substrates and attach to corals. *G. gigas* generally grows in waters with coral reefs, flats attached to dead coral substrates or shells, and fragments of coral rocks with sandy bottoms below tidal areas. According to Ferawati et al. (2014), *Gracilaria* has a tolerance that is resistant to dehydration or water loss between 60-90% so that it still can survive even though the thallus dries out due to exposure to direct sunlight.

Thallus drying out due to evaporation causes seaweed to lose biomass but does not affect the growth of *Gracilaria* (Oliveira et al. 2012). Jung et al. (2022) stated that *Gracilaria* has a beach habitat with a sandy coral substrate, shallow depth, and warmth. This was also stated by Oliveira et al. (2012) and Majnaoui and Kadmiri (2021), that *Gracilaria* from the Rhodophyta Phylum has wider adaptability both in shallow areas and in deeper areas than seaweed from the Chlorophyta and Phaeophyta Phyla.

The calculation of potentially bioactive compounds on seaweed diversity index results shows that the two substrates have different value compositions, with a diversity index ranging from 0.903-1.153. The results of the analysis of the seaweed diversity index on coral substrates were higher compared to mixed substrates. The coral substrate is stable so that seaweed can adhere firmly to the substrate so that it is not easily blown away and carried out by currents during high waves. The mixed substrate consists of corals or fragments of coral mixed with less stable sand, so high currents and waves will be easily blown away (Ghellai et al. 2021). Sumandiarsa et al. (2021) state that beaches with a substrate of living corals, igneous rocks, and mollusk shells have a high level of diversity compared to places with sand, mud, and coral fragments and their combinations. Jung et al. (2022) state that the high level of diversity can be caused by habitat complexity due to substrate damage caused by sedimentation processes on the average coral reefs derived from land abrasion during rains or high currents and wave speeds.

The analysis results of the dominance index of potentially bioactive seaweed from the Simpson index ranged from 0.559-0.681 on coral substrates D=0.559, while on mixed substrates D=0.681. The dominance index of seaweed on each substrate ranged from 0-1, indicating the individuals' dominance. Kepel et al. (2019), the dominance index value getting closer to one indicates that the distribution of individuals is concentrated on one species of seaweed, meaning that there is dominance of a species of seaweed in the community. According to Sofiana et al. (2021), a high dominance index indicates competition between members of the seaweed community related to the necessary minerals; if the necessary minerals support, then the species will be more dominant than other seaweed species.

As a result of the interpretation of the distribution pattern of all seaweed species using a Morisita index greater than 1, the biota has a clustered distribution pattern (Pradana et al. 2020). This spread pattern is the most common in nature. Individuals who live in groups have low mobility abilities making it difficult to spread and move around. In addition, individuals with clustered distribution patterns indicate that the individuals have a distinctive habitat, so the distribution pattern of the biota is narrow and limited. The grouping distribution pattern, i.e., individuals' presence at one point, decreases the chances of the same individual's existence at another point nearby (Ayhuan et al. 2017).

Physical and chemical environmental factors influence the presence of seaweed in the waters. The results of temperature measurements at Menganti Beach on coral substrates between 31-32°C and on mixed substrates are 31°C. The temperature at the study site exceeded the normal range tolerated by seaweed. According to Holdt and Kraan (2011) and Torres et al. (2019), the optimum temperature for seaweed growth in tropical waters is 15-30°C. Water temperature plays an important role in helping seaweed's metabolic processes, respiration, and photosynthesis. The optimum temperature for the rate of photosynthesis is different in each type of seaweed. High temperatures can cause proteins to denature and damage enzymes and cell membranes that are labile to high temperatures. High temperatures can cause proteins to denature and damage enzymes and cell membranes that are labile to changes in temperature. The optimum temperature for the rate of photosynthesis is different for each species of seaweed. At the time of the study, the dominant seaweed was *G. gigas*. Kim et al. (2016) stated that *G. gigas* has a high tolerance for water temperatures between 0-35°C.

Acidity (pH) is another factor in the water chemical environment that determines seaweed's good and bad growth and plays a role in metabolism. The degree of acidity (pH) obtained during sampling was 7.0. The results obtained are quite ideal conditions for the growth of seaweed. Harley et al. (2012) and Campbell et al. (2019) state that a good pH suitable for seaweed cultivation ranges from 6-9. A pH range of < 6 will suppress the growth rate. The salinity obtained when sampling coral substrates ranges from 20-25 ‰ and mixed substrates at 25‰. The results showed that salinity was quite low for seaweed growth. Sudradjat (2015) stated that good and optimal salinity for seaweed growth ranges from 28-35‰ because, at this level, the process of diffusion of nutrients absorption is going well. Salinity in the range of 20-25‰ at the sampling time causes the *Gracilaria* species to have high biomass compared to other seaweed species. Tresnati et al. (2021) state that 20‰ and 25‰ salinity provide a high daily growth rate, and 20‰ salinity provides a high agar content in the *Gracilaria* spp. High salinity is a hypertonic environmental condition of seaweed, so the fluid in the cell tends to move into the cell membrane, resulting in a lack of fluid in the cell. Therefore seaweed must overcome water loss when salinity is at a high level. While salinity is lower than optimal, environmental water is hypotonic, and then water penetrates the cells so that water saturation occurs.

The depth and brightness of a body of water is a factor that affects the richness of seaweed species. When sampling, the results of depth measurements range from 65-80 cm, which is ideal for seaweed growth because it is still reached by sunlight penetration (Oliveira et al. 2012). That is following the research conducted by Munawan et al. (2021) that at depths between 60-200 cm, seaweed growth proceeds quite well. Waters that are too shallow will inhibit the growth of seaweed because when high waves the bottom of the water is easily stirred, causing turbidity that interferes with the process of photosynthesis; seaweed will also be easily reached by predators such as sea urchins (Almeida et al. 2011). The low growth rate of seaweed, along with the increasing depth of the growing place, can be caused by the ability to penetrate light and oxygen circulation, which gets lower with the increasing seawater depth (Kuda et al. 2013). Optimal reception of sunlight will facilitate the absorption process of nutrients during photosynthesis, directly affecting the increase in the length and biomass of seaweed (Messyasz et al. 2015). The brightness level of the water depends largely on the charge of suspended solids. Good water brightness is optimal for seaweed growth up to 5 m or the sun's limit to penetrate seawater (Tresnati et al. 2021).

In conclusion, 21 species of seaweed have the potential to be bioactive on Menganti Beach, i.e., *Caulerpa lentillifera* L., *Caulerpa racemosa, Caulerpa taxifolia* L., *Ulva lactuca* L., *Ulva intestinalis* L., *Valoniopsis pachynema* (G. Martens) Borgesen, *Codium tomentosum* Stackhouse, *Callophyllis crispate* C.Agardh, *Chondrus crispus* Stackhouse, *Eucheuma spinosum* J. Agardh, *Halymenia harveyana* J. Agardh, *Gigartina stellata* (Stackhouse) Batters *Gracilaria gigas* Harvey, *Gracilaria canaliculate* Sonder, Gracilaria *lichenoides* J.V Lamouroux, *Gracilaria verrucosa* Papenfuss, *Palmaria palmata* Greville, *Portieria hornemannii* (Lyngbye) Silva, *Rhodymenia palmata* (L.) Greville, *Padina australis* Hauck, and *Sargassum crassifolium* J. Agardh. This seaweed species as a natural resource has a bright future perspective in the bioactive industry, so it is necessary to study its biochemical composition and bioactive potential in addition to its development efforts. The distribution pattern of all seaweed species on Menganti Beach is clustered, a typical habitat with a narrow and limited distribution. Diversity in the coral substrate was higher than in the crushed substrate. Furthermore, *G. gigas* has the highest number of individuals as an antidiabetic and antioxidant.

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Diversity and distribution pattern of bioactive compound potential seaweed in Menganti Beach, Central Java, Indonesia

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