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Carbon Absorption Potential in *Sargassum* sp. and *Padina* sp. in The Waters of East Melano Bay, Lemukutan Island, Bengkayang District, West Kalimantan Province

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Abstract

Increasing human activities have caused negative impacts on the environment, such as rising earth's surface temperature and extreme climate change. This impact is caused by increased greenhouse gas emissions such as carbon dioxide and methane. Marine vegetation such as seaweed *Sargassum* sp. and *Padina* sp. It can also help absorb carbon and reduce carbon emissions through the process of photosynthesis. Seaweed that has the potential to reduce carbon emissions is *Sargassum* sp. and *Padina* sp. which is located in the waters of East Melano Bay, Bengkayang Regency. This study aims to determine the density of seaweed species *Sargassum* sp. and *Padina* sp. in East Melano Bay, as well as analyzing the carbon sequestration potential of seaweed. The method used is to use the descriptive method of exploration. The descriptive method of exploration aims to describe the state of a phenomenon. This study uses the quadrant transect method in sampling in the field, while the determination of carbon content uses the analysis of biomass, ash content, moisture content and volatile substances. The results of the analysis that have been carried out show the density value of *Sargassum* sp. has the highest value of 102.4 Ind/m^2 and *Padina* sp. 76.05 Ind/m^2. Carbon sequestration by seaweed *Sargassum* sp. is 105,637 tons of C/ha and *Padina* sp. amounting to 78,032 tons of C/ha. Based on the description in this study, it can be concluded that the highest carbon absorption is in *Sargassum* sp.

1. Introduction

Increasing human activities have led to negative environmental impacts, such as extreme climate change. Climate change is caused by increased greenhouse gas emissions such as carbon dioxide (CO_2) and methane (CH_4). Negative impacts are also felt in the marine sector, where coral reefs and other marine life are damaged due to climate change (Fitria and Ghesang, 2021). The waters of East Melano Bay are also affected by coral reefs that are in poor to moderate condition. Damaged coral reefs are caused by high seawater temperatures so that coral reefs can experience bleaching (Nurcahyanto *et al.*, 2021). The waters of East Melano Bay have abundant natural resources, including seaweed. Seaweed has an important role in maintaining the condition of the marine environment, especially in absorbing carbon through the process of photosynthesis. Previous research has shown that seaweed can help reduce carbon emissions and contribute to carbon sequestration on earth. This tall plant is the same as a true plant, which is able to make its own food through the process of photosynthesis with the help of sunlight and the availability of CO_2 (Erlania *et al.*, 2015). Seaweed is able to convert CO_2 into biomass which can be useful in forming body structures and producing its own food reserves through the process of photosynthesis. The biomass produced will enter the food web through the decomposition process, therefore seaweed has an important role in reducing global warming (Irawan, 2017). Pribadi and Ihsan (2019) assert that seaweed can contribute up to 50% of carbon fixation on earth and cover as much as 71% of carbon storage in marine sediments.

Research on carbon sequestration in seaweed has been carried out by Fakhraini *et al.* (2020), namely *Kappaphycus alvarezii* seaweed cultivated in Alang Village, Along East Nusa Tenggara. The results showed that the carbon absorption in adult *K. alvarezii* seaweed (60 days) was higher than that of young *K. alvarezii* seaweed (25 days). The carbon yield in adult seaweed is able to absorb 26.23 tons of C/cycle, while young seaweed is 13.28 tons of C/cycle. This shows that adult *K. alvarezii* seaweed is able to absorb 32.78% more carbon than young seaweed. Seaweed can

absorb carbon which is influenced by various factors such as the type of seaweed and the characteristics of the coastal area where the seaweed grows.

More specific research is needed to deeply understand the ability of seaweed to absorb carbon in the waters of East Melano Bay. This is because the condition of the East Melano Bay Waters has a sloping beach, calm waves and there is a coral reef ecosystem in its shallow waters. The purpose of this study is to determine the density value, affect carbon absorption in seaweed and analyze the ability of *Sargassum* sp. and *Padina* sp. in the waters of East Melano Bay store carbon.

2. Material and methods

2.1 Material

The material taken and analyzed in this study is seaweed *Sargassum* sp. And *Padina* sp. from the area waters of East Melano Bay

2.2 Methods

2.2.1 Sampling

Seaweed samples were carried out using the purposive method which is the determination of samples with consideration techniques or certain criteria (Komala and Nellyaningsih, 2017). Seaweed is taken from the waters of East Melano Bay. East Melano Bay is a body of water that has a type of beach that is sloping, with calm waves and is a tourist attraction. The methods used for seaweed sampling are the transect line method and transect quadrant which are 1 x 1 m^2 in size. Each station is determined by a coordinate point. Transect is used for data collection along a straight line (Prayitno. G. *et al.*, 2022). The research began by measuring the quality of the water in situ which consisted of measuring depth, pH, temperature, current and salinity. The transect line in the irrigation area is stretched from the coastline to the sea along 50 m by placing quadrant transects 5 times on each line. The transect line stretching from the coast to the sea can be assumed that the distribution of existing seaweed communities is evenly distributed (Achmad *et al.*, 2021).

Seaweed was then identified by preparing an identification sheet that was interesting to Dhargalkar and Kavlekar (2004) and www.algaebase.org, the seaweed found was matched morphologically with the seaweed morphology on the identification sheet. The density of seaweed was calculated using the calculation of formula Odum (1993) in Ain *et al.* (2014), by calculating the number of each type of seaweed in the quadrant transect and then counting all types of seaweed in the quadrant transect. Seaweed density was carried out on all quadrant transects of each transect line. After that, seaweed samples were taken from each station by sampling all parts of the seaweed tallus from the quadrant transect. Seaweed samples were collected as much as 500 g of wet weight.

2.2.2 Data analysis

2.2.2.1 Seaweed identification

Seaweed density *Sargassum* sp. and *Padina* sp. Were recorded and counted at each station. The calculation uses the formula Odum (1993) in Ain *et al.* (2014), namely the relative density (KR) of seaweed species with the formula:

$$\frac{\text{Relative density (Species A)}}{\text{Number of individuals of all Species (m2)}} \times 100\%$$

2.2.2.2 Carbon content analysis

Carbon content analysis refers to research that has been carried out by Akmal *et al.* (2009) by measuring biomass, moisture content, ash content, evaporated substance content and carbon content.

2.2.2.2.1. Biomass

Seaweed samples are dried using an oven at 80°C for 2 - 4 days until the weight is constant (Ludang and Palangka Jaya, 2007). Dried seaweed samples It is then weighed to calculate the weight of its biomass.

2.2.2.2.2. Moisture Content

Water content is the weight lost after heating. Seaweed samples weighed in a porcelain cup then the sample is heated at 105°C until constant weight is obtained. Next, the results of the water purification level analysis using a desiccator and weighed. Water content is obtained using the formula referring to (SNI, 1992, 1995).

2.2.2.2.3. Ash Content

The ash content was obtained after the sample was grayed at a temperature of 550°C to perfectly exposed samples. The ash that has been obtained is then cooled using a desiccant. The ash content was obtained referring to (SNI, 1992).

2.2.2.2.4. Evaporated Substance Content

The sample is put into a porcelain cup, then the lid of the cup is tightly closed porcelain. Put it in the oven at 900°C for 6 minutes. After warming up finished, the porcelain cup and the heating result are cooled using a desiccant for 1 hour then weighed. The volatile substance content is obtained by the formula refers to (SNI, 1995).

2.2.2.3 Carbon content

Carbon sequestration is obtained by the formula (SNI, 1995; UNEP, 2004):

[Carbon Sequestration (%) = 100% − a – b – c]

Remarks:

a= moisture content

b= volatile substance content

c= ash content

2.2.2.4 Carbon absorption estimation

The calculation of carbon sequestration uses the equation used by Muraoka (2004) by including the variables of area (km^2), standing stock (g/m^2), biomass production ratio, and carbon content (%). Where carbon sequestration per cycle is: Total Carbon Sequestration = [Total area]x[Standing stock]x[P-B ratio]x[Carbon content]

3 Results

3.1 Seaweed identification

Seaweed that grows wild in the waters of East Melano Bay has a variety of types, it is based on the results of direct surveys/observations. Seaweed that can be found in the waters of East Melano Bay Island are *Sargassum* sp., *Caulerpa* sp., *Padina* sp., *Dictyota* sp., and *Turbinaria* sp. This is in accordance with the results of research conducted by Safitri *et al.* (2022), where the same type of seaweed was found, namely *Sargassum* sp., *Caulerpa* sp., *Padina* sp., and *Turbinaria* sp. The results of the identification of seaweed in the waters of East Melano Bay can be seen in Table 1.

Seaweed in the waters of East Melano Bay Island grows wild on rocky substrates, dead corals and sand. The results of observations that have been made in the waters of East Melano Bay refer to www.algaebase.org. namely four types of brown seaweed (*Phaeophyta*) and two types of green seaweed (*Chlorophyta*) were found. The types of grass found are suspected to consist of *Padina Australis*, *Sargassum cristaefolium*, *Dictyota dichotoma* and *Turbinaria ornata* which are a group of brown seaweed (*Phaeophyta*). Seaweed derived from green seaweed (*Chlorophyta*) was also found, namely the presence of *Caulerpa racemosa* and *Halimeda macroloba* seaweed. The identification results have similarities with the types of seaweed in the waters of Kabung Island, West Kalimantan found by Agustina *et al.* (2023) in

their research. The results of the identification of seaweed found in the waters of Kabung Island are *H. macroloba*, *C. racemosa*, *P. australis* and *L. intricata.* This shows that the waters of West Kalimantan it is suitable to be overgrown with seaweed with these types

Table 1. The results of the identification of seaweed in the waters of East Melano Bay

Seaweed Class	Seaweed Type	East Melano Bay
Phaeophyta	*Padina* sp.	✓
	Sargassum sp.	✓
	Turbinaria sp.	✓
	Dictyota sp.	✓
Chlorophyta	*Caulerpa* sp.	✓
	Halimeda sp.	✓

3.2 Seaweed Density

Based on the observation results, the density of grass species in the waters of East Melano Bay has a density ranging from 0.4 to 102.4 Ind/m^2. Seaweed *Sargassum* sp. with the highest density of 102.4 Ind/m^2 and the lowest density of the type of seaweed *Halimeda* sp. namely with a density value of 0.4 Ind/m^2. The results of seaweed density in the waters of East Melano Bay are better than the density of seaweed in the waters of Temajuk Village, West Kalimantan, which only obtained a density between 0.07-21.31 Ind/m^2.

Table 2. The results of seaweed density in the waters of East Melano Bay

Types of Seaweed	**Seaweed Density (ind/m^2)**
Padina sp.	76.05
Sargassum sp.	102.4
Caulerpa sp.	23.55
Turbinaria sp.	2
Halimeda sp.	0.4
Dictyota sp.	6.8
Total Density	40.88

The density of seaweed in the waters of Temajuk Village is lower and can be strengthened by the results of the density of each seaweed in the waters of Temajuk Village, which is 16.76-19.28 Ind/m^2 (*Sargassum* sp.), 4.01-21.31 Ind/m^2 (*Padina* sp.), and 0.07-0.11 Ind/m^2 (*Turbinaria* sp.), while the density of each seaweed in the waters of East Melano Bay is 76.05 Ind/m^2 (*Padina* sp.), 102.4 Ind/m^2 (*Sargassum* sp.), 23.55 Ind/m^2 (*Caulerpa* sp.), 6.8 Ind/m^2 *Dictyota* sp. and 2 Ind/m^2 (*Turbinaria* sp.). The results of seaweed density in the waters of East Melano Bay can be seen in Table 2.

3.2 Carbon Sequestration

The carbon content contained in plants shows how much carbon dioxide the plant can bind from the air. Carbon in a plant will partly be energy to help the growth process and partly absorbed to produce compounds (Heriyanto and Subiandono, 2016). The results of the study show that the carbon sequestration potential in *Sargassum* sp. and *Padina* sp. in the waters of East Melano Bay reached 78.032 – 105.637 tons of C/ha. The amount of carbon content in *Sargassum* sp. which reaches 105.637 tons C/ha can be attributed to its greater density value than the density of *Padina* sp. The average value of total carbon stocks in the seaweed ecosystem waters of East Melano Bay can be seen in Table 3.

Table 3. 3 The average value of total carbon stocks in the seaweed ecosystem waters of East Melano Bay

Types of Seaweed	Analytical Tests	Result	Standard Deviation (%)	Reference
Sargassum sp.	Biomass (g)	0.714	-	-
	Moisture Content (%)	80.393	15	SNI 06-3730- 1995
	Ash Rate (%)	5.152	10	SNI 06-3730- 1995
	Evaporative Substance Levels (%)	8.418	15	SNI 06-3730- 1995
	Total Carbon Sequestration Ton C/Ha	105.637	77	SNI 06-3730- 1995
Padina sp.	Biomass (g)	0.554	-	-
	Moisture Content (%)	78.591	15	SNI 06-3730- 1995
	Ash Rate (%)	7.865	10	SNI 06-3730- 1995
	Evaporative Substance Levels (%)	9.414	15	SNI 06-3730- 1995
	Total Carbon Sequestration Ton C/Ha	78.032	77	SNI 06-3730- 1995

4 Discussion

4.1 Seaweed identification and Seaweed Density

Seaweeds found in the waters of East Melano Bay are *Sargassum* sp., *Caulerpa* sp., *Padina* sp., *Dictyota* sp., and *Turbinaria* sp. This is in accordance with the results of research conducted by Safitri *et al.* (2022), where the same type of seaweed was found, namely *Sargassum* sp., *Caulerpa* sp., *Padina* sp., and *Turbinaria* sp. Seaweed derived from green seaweed (*Chlorophyta*) was also found, namely the presence of *Caulerpa racemosa* seaweed and *Halimeda macroloba* seaweed. The identification results have similarities with the type of seaweed in the waters of Kabung

Island, West Kalimantan found by Agustina *et al.* (2023) in their research. The results of the identification of seaweed found in the waters of Kabung Island are *H. macroloba*, *C. racemosa*, *P. australis* and *L. intricata*. This shows that the waters of West Kalimantan are suitable for seaweed with this type. Not only that, the seaweed found in the waters of East Melano Bay is varied. The varied seaweed is caused by supportive environmental conditions, which are having diverse substrate types consisting of coral, sandy and dead coral. In addition, the availability of abundant nutrients can also be a supporting factor in a water so that it has a diversity of seaweed species (Baba *et al.*, 2012).

The density of sargassum seaweed has the highest amount among others, this is due to several factors, including the quality of the water. The water quality parameters of the East Melano Bay Waters are having a current velocity of 0.1 m/s, a temperature of 28.6°C, a salinity of 25‰, a brightness of 233 cm, a depth of 40 cm, and a pH of 7.76. Based on the observation results, it shows that the water quality value is acceptable for the life of *Sargassum* sp. Seaweed *Sargassum* sp. can thrive in tropical waters with a salinity range of 29-33.5 ‰ (Ibrahim *et al.*, 2014). The depth at the research site also supports the growth of *Sargassum* sp., because the depth of a water can also affect the life of aquatic organisms including seaweed. The depth of a body of water is related to the entry of sunlight into the waters used by chlorophyll plants for photosynthesis. The sun's irradiation will decrease rapidly according to the depth of the sea (Ibrahim *et al.*, 2014).

4.2 Carbon Sequestration

The results show that the carbon sequestration potential of *Sargassum* sp. Greater than the carbon sequestration of padina sp. This is attributed to its greater density value than the density of *Padina* sp. This is supported by the statement delivered by Haruna (2020) that the carbon content of a plant can be influenced by the density value of the plant itself, this is related to the value of biomass that is getting larger along with the measure of the value of a density, so that it also makes a large contribution to the carbon content of a plant. Biomass has the potential to affects the carbon content of a plant, it is because of the carbon absorbed by plant parts converted into organic matter stored in the form of biomass and distributed in the body parts of the plant (Ohorella *et al.*, 2022). Seaweed in nature has more variation in carbon absorption because it is species-specific. The absorbed carbon can be influenced by various factors, namely influenced by the morphological structure and pigments contained in each type seaweed. Seaweeds that belong to the *Phaeophyta* group generally have higher carbon storage. This is because seaweed is guilty of *Phaeophyta* groups such as *Sargassum* sp. and *Padina* sp, have additional pigments in the form of *phycobilins* (*phycoerythrin*, *phycocyanin*) or *carotenoids* (Erlania *et al.*, 2015).

5 Conclusions

Based on the description in this study, it can be concluded that the density index value of seaweed *Sargassum* sp. in the waters of East Melano Bay is greater than the value of the *Padina* sp. The density index value of *Sargassum* sp. which is also proportional to the carbon storage yield is larger than *Padina* sp. This is supported by the environmental conditions in the waters of East Melano Bay which have a type of substrate and water quality that is classified as suitable for the survival of seaweed. The quality of the water can affect the absorption of absorbed carbon, because it is directly related to the process of photosynthesis and nutrients received by seaweed.

Ethics approval

No permits were required.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Author contributions

IQS is doing research ideas, sample image collection, water quality sampling collection, BY and ABS are supervising and writing

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Declaration of competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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