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Biomass and Carbon Absorption in Mangrove Leaves and Roots in Lantebung Ecotourism, Makassar City

Stanislaus William Permadhi[a], Mesalina Tri Hidayani[a*], Sri Wulandari[a]
[a]Balik Diwa Institute of Maritime Technology and Business
Correspondent Author[*]: mesha.tri@gmail.com

Abstract

This study aims to analyze biomass and carbon absorption in mangrove leaves and roots, especially Rhizophora mucronata and Avicennia alba. Data collection was carried out using purposive sampling techniques at two different location points. The measurement of biomass, carbon absorption in mangrove leaves and roots begins by taking samples using scissors and saws on the three predetermined trees and then taking them to the laboratory for analysis. The results showed that the average value of biomass in Avicennia alba leaves was higher (42.69 grams) than that of Rhizophora mucronata leaves (34.66 grams). Meanwhile, the highest average value of root biomass was in the mangrove Rhizophora mucronata (127.86 grams) compared to the root biomass of Avicennia alba (89.43 grams). The highest average value of leaf organ carbon absorption was in the mangrove Rhizophora mucronata (11.21%) compared to the mangrove Avicennia alba (9.09%). Meanwhile, the highest average value of root carbon absorption was in the Avicennia alba mangrove (12.17%) compared to the root carbon absorption of Rhizophora mucronata (10.85%). The results of the T-test showed that the carbon uptake in Rhizophora mucronata leaves differed significantly at 0.031 (<0.05) which means that Rhizophora mucronata leaves absorbed more carbon than Avicennia alba leaves, while others did not differ significantly (>0.05). The measured water quality parameters including temperature, pH, and salinity show that all water quality parameters are within the range of quality standards according to PP RI no. 21 of 2022 for marine life, except for the temperature at station 1 of the Rhizophora mucronata mangrove (Station 1: temperature 25.66 °C; pH 7.12; salinity 27.33 ppt and station 2: temperature 29.4 °C; pH 7.25; salinity 25.16 ppt.

Keywords: blue carbon, coastal ecosystem, environmental conservation, organic matter, sediment storage

INTRODUCTION

Carbon is one of the essential elements in life and the global ecological cycle. Human activities such as fossil fuel use, industry, transportation, and land-use change cause increased carbon dioxide (CO_2) emissions in the atmosphere that contribute to global warming and climate change (Alongi, 2012). Increased carbon concentrations in the atmosphere can have various negative impacts on the environment, such as rising earth temperatures, changes in weather patterns, and damage to coastal ecosystems. Therefore, mitigation efforts are needed through natural carbon absorption and storage by vegetation, one of which is through mangrove ecosystems which are known to have high ability to absorb carbon or *blue carbon* (Donato et al., 2011).

Mangrove ecosystems are one of the coastal ecosystems that grow in tropical and subtropical areas with muddy substrates and are influenced by sea tides. Mangroves have a very important ecological role, not only as coastal protectors from abrasion and intrusion of seawater, but also as a large amount of carbon absorber and storer in biomass and sediment (Alongi, 2012). The ability of mangroves to absorb carbon is higher than that of other terrestrial ecosystems because the accumulation of organic matter in roots, stems, leaves, and sediment takes place continuously (Kauffman et al., 2018). Therefore, the existence of mangrove forests is an important part of global climate change mitigation efforts.

Vol. 2, Issue. 1, 2026 (Page 18-26) e-ISSN : 3124-1247

Various studies show that biomass and mangrove carbon stocks have high values in various coastal areas. Research conducted by (Sasmito et al., 2019) It shows that tropical mangrove ecosystems are able to store large amounts of carbon both in above-surface and subsurface biomass. Other research by (Adame et al., 2021) It also mentions that mangroves have a significant contribution to long-term carbon sequestration through the accumulation of organic sediments. In addition, the degradation of mangrove ecosystems can cause carbon release into the atmosphere, so mangrove conservation is very important in maintaining global carbon balance (Rovai et al., 2018; Simonassi, 2018).

Lantebung Mangrove Ecotourism which is located in Bira Village, Tamalanrea District, Makassar City is one of the mangrove areas that has ecological and economic potential. This area is the habitat of various types of mangroves that function as a buffer for the coastal ecosystem of Makassar City. However, information on biomass and carbon sequestration in mangrove vegetation in this region is still limited, especially on the leaves and roots of mangroves. In fact, biomass and carbon stock data are needed to determine the ability of mangrove ecosystems to absorb carbon and support sustainable coastal environmental conservation efforts.

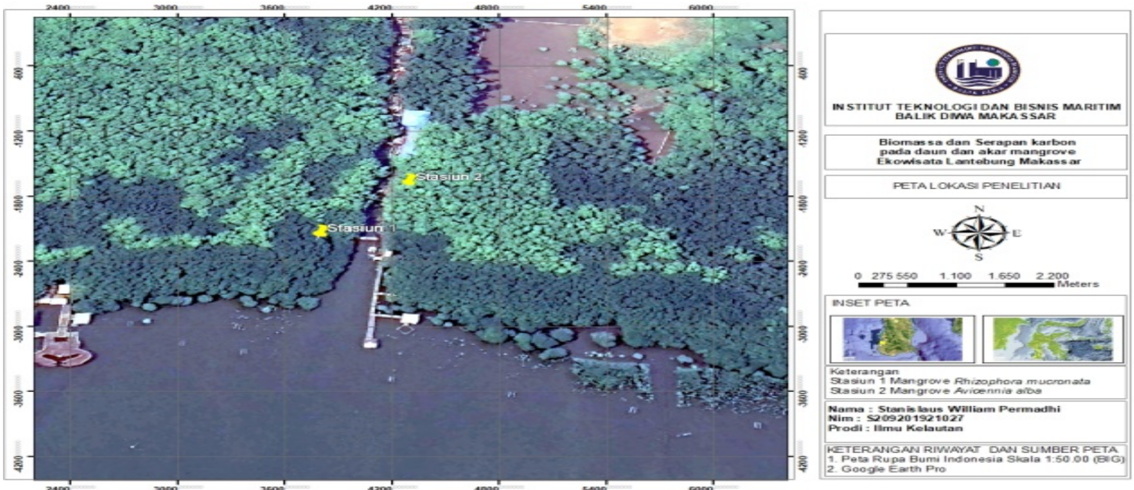
Based on these conditions, research on biomass and carbon absorption in mangrove leaves and roots in Lantebung Mangrove Ecotourism needs to be carried out. This research is expected to provide scientific information about the potential for carbon storage in mangrove ecosystems and become the basis for mangrove management and conservation in the coastal area of Makassar City. In addition, the results of this research can also support the development of environment-based ecotourism and climate change mitigation through the preservation of mangrove ecosystems.

METHODS

This study aims to analyze biomass and carbon absorption in mangroves of *Rhizophora mucronata* and *Avicennia alba* in the Lantebung Mangrove Ecotourism area, Makassar City.

Figure 1.

Map of the Research Location



The research method used is a descriptive method with *purposive sampling technique*, which is the determination of the research location based on certain considerations according to the characteristics of the research location and the existence of the type of mangrove being researched (Etikan et al., 2016). Sampling was carried out at two location points, namely the area dominated by *Rhizophora mucronata* and the area dominated by

Avicennia alba. Mangrove leaf and root samples were taken from three trees in each type of mangrove using scissors and saws, then weighed about 200 grams and put in labeled plastic bags for analysis in the laboratory.

Biomass and carbon sequestration analysis was carried out at the Laboratory of Productivity and Aquatic Quality Management, Department of Fisheries, Faculty of Marine and Fisheries Sciences, Hasanuddin University. In addition to mangrove sampling, water quality parameters were also measured which included temperature, salinity, and pH of the water. Temperature measurements were carried out using a thermometer, salinity using a hand refractometer, and pH using a pH meter. Measurement of water quality parameters is important because aquatic environmental conditions affect the growth and ability of mangroves to absorb carbon (Alongi, 2012). The data from the research results were then analyzed descriptively to describe the biomass and carbon absorption in the two types of mangroves studied.

The calculation of the water content is carried out in order to calculate the biomass of mangroves. Moisture content is calculated using the formula (Kauffman & Donato, 2012) :

$$\%KA = \frac{BB - BK}{BK} x\ 100$$

Information:

%KA	=	Percentage of moisture content
BB	=	Wet weight (g)
BK	=	Dry weight (g)

The weight of biomass is obtained using dry weight, if the wet weight is known and the water content has been obtained from a small test sample (Kauffman & Donato, 2012) Furthermore, the dry weight of the sample can be calculated by the formula:

$$BK = BB$$
$$1 + \left(\frac{\%KA}{100}\right)$$

Information:

BK	=	Dry weight/biomass (g/m2)
BB	=	Wet weight (g/m^2)
%KA	=	Percent moisture content

Calculation of organic carbon from mangrove biomass using the formula (Kauffman & Donato, 2012):

$$Cb = B\ x\ \%\ C\ Organik$$

Information:

Cb	=	Carbon content of biomass (g/m^2)
B	=	Biomass (g/m^2)
%C Organik	=	Value of the percentage of carbon content

According to (Heriyanto & Subiandono, 2012), to calculate CO2 absorption using the formula:

$$CO_2 = \frac{\mathrm{Mr.CO2\ X\ Cb}}{Ar.C}$$

Vol. 2, Issue. 1, 2026 (Page 18-26)
e-ISSN : 3124-1247

Information:

CO_2 = Carbon dioxide absorption (g/m^2)
Mr = Relative carbon molecules (C) 44
Ar = Relative atoms (C= 12)
Cb = Carbon content

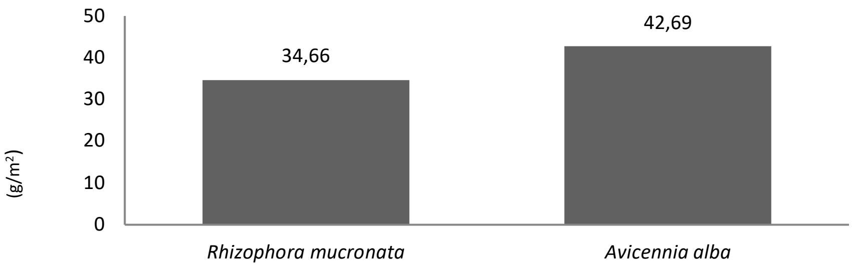
The data obtained was then analyzed in the form of tables and graphs followed by a t-test to determine the comparison of biomass values and carbon absorption in the leaves and roots of mangroves of *Rhizophora mucronata* and *Avicennia alba*.

RESULTS AND DISCUSSION

Mangrove Biomass

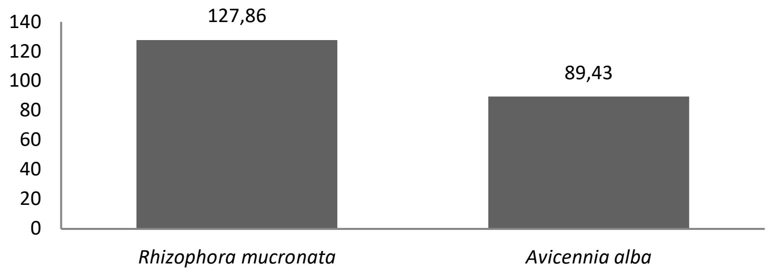
The results of the measurement of the average value of leaf and root biomass of the mangroves *Rhizophora mucronata* and *Avicennia alba* can be seen in Figure 2 and Figure 3.

Figure 2.
Average value of biomass on leaves



Source: research results

Figure 3.
Average value of biomass on roots



Source: research results

Figure 2 shows that the average value of biomass in the leaf organs of *Rhizophora mucronata* is 34.66 grams while the average value in *Avicennia alba* leaves is 42.69 grams, this shows that the average value of biomass in *Avicennia alba* leaves is higher when compared to the average value of *Rhizophora mucronata leaf biomass*. The biomass value of *Avicennia alba leaves* is higher because it is suspected that the age of the tree at station 2 is relatively older and the availability of nutrients in the substrate, and the high biomass of

Vol. 2, Issue. 1, 2026 (Page 18-26)
e-ISSN : 3124-1247

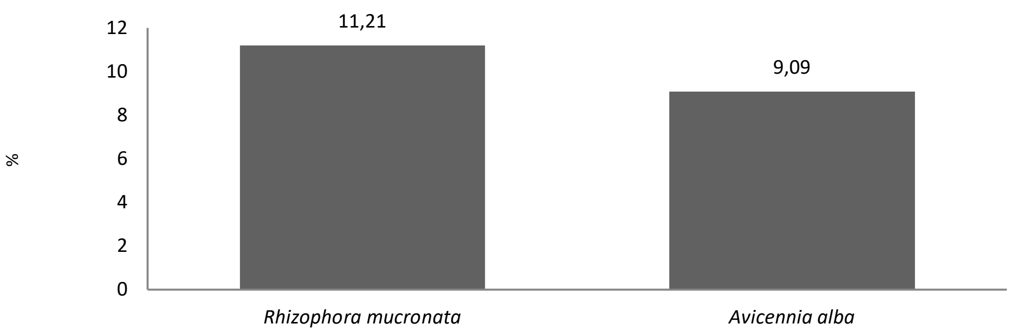
Avicennia alba leaves is due to the larger diameter of the tree. In accordance with research (Susanti, 2022), that the value of stored carbon will increase followed by an increase in the diameter of the tree. Previous research conducted by (Adame et al., 2021) in the mangrove beejay mangrove mangrove resort of Probolingo City, East Java, the leaf biomass *of Avicennia alba* has a higher biomass with a value of 57.35 grams and research Mayang (2017) with a biomass value of 55.11 grams. This is influenced by the fact that the larger the diameter of the tree, the greater the biomass content as the diameter increases. This is in line with the results of the research Adinugroho (2001) which states that there is a strong correlation between the size of the tree (diameter and height) and its biomass, especially diameter.

Figure 3 shows the average biomass value of *Rhizophora mucronata* mangrove roots of 127.86 grams while the average value of biomass in *Avicennia alba* roots is 89.43 grams, it is known that the biomass in *Rhizophora mucronata* roots is higher than the biomass of *Avicennia alba* roots. The biomass value in the mangrove root *of Rhizophora mucronata* in the previous study had a value of 155.77 grams Aprilita *et al.,* (2024). This shows that the biomass of *Rhizophora mucronata* mangrove roots in Lantebung Mangrove Ecotourism is larger than the research conducted in Riding Panjang Village, Bangka Regency. The high biomass value of *Rhizophora mucronata* roots is due to soil fertility, and mangrove sediments rich in organic carbon contribute significant biomass to mangrove ecosystems. The location of station 1 near the coast is suspected to have a supply of organic particles carried by the influence of tides that transport nutrients that can increase soil fertility, in line with the opinion (Nedhisa & Tjahjaningrum, 2020), that mangrove habitats around the estuary are influenced by several environmental factors such as sea tides, temperature, salinity, and soil conditions. Organic particle material comes from heaps of plant remains as well as from animals associated with mangroves that fall into the substrate, so the area becomes fertile. The presence of biomass as a key indicator to reduce CO_2 emissions through its physiological processes. Mangrove biomass provides important information to estimate the potential for CO_2 absorption and the amount of organic matter stored in the staple biomass of mangrove productivity (Baderan, 2017).

Mangrove Carbon Absorption

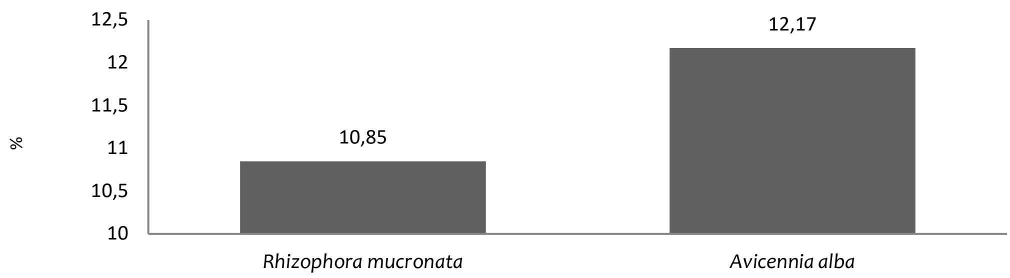
The results of the measurement of the average value of carbon absorption in the leaves and roots of the mangroves *Rhizophora mucronata* and *Avicennia alba* can be seen in Figure 4 and Figure 5.

Figure 4.
Average value of carbon absorption in leaves



Source: research results

Figure 5.
Average value of carbon uptake at the root



Source: research results

Figure 4 shows the average value of carbon absorption in *Rhizophora mucronata* mangrove leaves is 11.21%, while the average value in *Avicennia alba* leaves is 9.09%, it is known that the carbon absorption value in *Rhizophora mucronata* leaves is higher when compared to *Avicennia alba*. The value of carbon absorption in the leaves of *the mangroves Rhizophora mucronata* and *Avicennia alba* in the Lantebung Mangrove Ecosystem is lower when compared to the study (Anggreini, 2023) in the Tanjung Batu Mangrove Area, Central Sekotong, West Lombok with a carbon absorption value of 12.01% in the *Rhizophora mucronata* mangrove. The high value of carbon absorption in *Rhizophora mucronata* leaves is suspected to be due to its higher moisture content. The large amount of water content in the leaves is because each leaf has a cell cavity that can be filled with water and mineral nutrients, and the large amount of stomata in the leaves causes water from the environment to be absorbed in large quantities, and the stomata found in the leaves also function as absorbers of carbon dioxide from the atmosphere.

Based on the results in Figure 5, the average value of carbon absorption in the roots *of Rhizophora mucronata* is 10.85%, while in *the roots of Avicennia alba* it is 12.17%. The average value of carbon absorption in the root *of Avicennia alba* is higher when compared to the value of carbon absorption in the root *of Rhizophora mucronata.* Plants will absorb carbon from the atmosphere and will convert it into organic compounds through the process of photosynthesis, which is the advantage *of Avicennia alba* having breath roots. Mangrove *Avicennia alba* has a larger stem diameter than *Mangrove Rhizophora mucronata*. The larger the diameter of the tree, the more carbon is absorbed by the tree (Sumarni et al., 2024)

The level of carbon dioxide absorption of *Avicennia alba* mangroves in the previous study had a value of 29.67% (Anugerah, 2018). This shows that the ability to absorb carbon from the roots of mangrove *vegetation Avicennia alba* in the Lantebung Mangrove Ecosystem is lower when compared to research conducted a few years ago in Bontobangun Village, Kecematan Bontoharu, Selayar Islands Regency. The large ability to absorb carbon dioxide makes the biomass value large in the vegetation. The larger the size of mangroves, the greater the impact of silviculture will be, resulting in the spread of mangroves in a certain area.

Perbandingan biomassa dan serapan karbon

The results of the t-test of biomass and carbon absorption in leaves, mangrove roots *Rhizophora mucronata* and *Avicennia alba* obtained the results in Table 1.

Table 1.
T-test results Comparison of biomass and carbon sequestration

Independent Samples Test						
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig	t	df	Sig.(2-tailed)
Leaf biomass	Equal variances assumed	6,476	,064	-,722	4	,510
	Equal variances not assumed			-,722	2,413	,534
Root biomass	Equal variances assumed	,357	,582	1,863	4	,136
	Equal variances not assumed			1,863	3,859	,139
Leaf carbon uptake	Equal variances assumed	4,769	,094	3,257	4	,031
	Equal variances not assumed			3,257	2,563	,059
Root carbon uptake	Equal variances assumed	,026	,881	-1,805	4	,145
	Equal variances not assumed			-1,805	3,996	,145

Source: data processing results

The results of the t-test of biomass and carbon absorption values in 2 types of mangroves, namely *Rhizophora mucronata* and *Avicennia alba*, showed that the carbon absorption value in *Rhizophora mucronata* leaves was significantly different at 0.031 (<0.05) which means that *Rhizophora mucronata* leaves absorbed more than *Avicennia alba* leaves, while the others did not differ significantly (>0.05).

Water Quality Parameters

In an effort to support this research, the researcher measured water quality parameters including temperature, pH, and salinity in each of the 3 trees and then continued to calculate the average value. The value of the parameters of this study is presented in the Table 2.

Table 2.
Water Quality Parameters at the Research Site

Parameter	Observations						Average	
	Rhizophora mucronata			*Avicennia alba*				
	P 1	P 2	P 3	P 1	P 2	P 3	ST 1	ST 2
Salinity (ppt)	28,5	26,1	27,4	26,2	25,3	24	27,33	25,16
Temperature (°C)	25	26,5	25,5	29	29,2	30	25,66	29,4
pH	7,06	7,21	7,10	7,26	7,25	7,26	7,12	7,25

Source: data processing results

Based on the results of measuring water quality parameters at the research site at stations 1 and 2, where the average salinity value at station 1 is 27.33 ppt, station 2 is 25.16

ppt, then the average temperature value at station 1 is 25.66 °C, station 2 is 29.4 °C, and the average value for pH at station 1 is 7.12, station 2 is 7.25. The water quality parameters are still classified as normal because they are still included in the standard threshold that has been set, except that the temperature at station 1 which is relatively lower is not included in the water quality standard, this is due to various factors, namely at different measurement times, where measurements at station 1 are carried out in the morning at around 8:30 WITA and measurements at station 2 are carried out during the day at around 11:35 WITA. Then the intensity level of sunlight entering at station 1 tends to be small, this is influenced by the mangrove canopy cover. The high and low temperatures at each station are influenced by the light intensity factor. This is in line with the opinion Fadhillah *et al*., (2018) The temperature at each station can be different because it is influenced by the intensity of sunlight entering the body of water, the cover of mangrove vegetation and the measurement time at each station.

Research conducted by Savitri (2020) in the mangrove tourism area of Beejay Bakau Resort, Probolinggo City, East Java, at a temperature of 30 oC, salinity of 20 ppt, and pH parameters in the study Fitri (2019) 7,9. This indicates that the water quality parameters in Lantebung Ecotourism are relatively normal when compared to previous research.

Table 3.
Quality standards for seawater quality parameters

Parameter	Quality standards	Source
Salinity (ppt)	s/d 34 ppt	PP 22/2021
Temperature	28-32°C	PP 22/2021
pH	7,8-5	PP 22/2021

Source: research results

Based on Table 3, the water quality parameters in the Lantebung Mangrove Ecotourism area are still within the range of quality standards set in Government Regulation No. 22 of 2021. The salinity value obtained is still below the maximum limit of 34 ppt, the water temperature is in the optimal range of 28–32°C, and the pH value is close to normal marine water conditions, which is 7.8–8.5. This condition shows that the quality of the waters at the research site is still relatively good and supports the growth of mangroves.

When compared to previous research conducted by Fitri (2019), The value of water quality parameters in Lantebung Ecotourism did not show a significant difference. The water temperature is 30°C, the salinity is 20 ppt, and the pH is 7.9 is still within the tolerance range of mangroves to grow and develop optimally. Thus, the water quality conditions at the research site can be categorized as normal and appropriate to support the biomass process and carbon absorption in the mangrove ecosystem.

CONCLUSION

The average biomass value in Avicennia alba leaves is greater at 42.69 grams compared to Rhizophora mucronata leaves of 34.66 grams. And the value of root biomass is greater in the root of Rhizophora mucronata, which is 127.86 grams compared to the root of Avicennia alba of 89.43 grams. The average value of carbon absorption in Rhizophora mucronata leaves was significantly higher, at 11.21%, compared to Avicennia alba leaves of 9.09%. And the carbon absorption value for Avicennia alba root is higher, at 12.17% compared to Rhizophora mucronata root 10.85%.

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