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# Estimation of carbon upgrade content in mangrove leaf little based on density level in the Lantebung mangrove tourism area

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**Abstract**
The Latebung Mangrove Ecotourism Area is an example of a mangrove rehabilitation area that has been quite successful since 2010 until now. Now, mangrove ecotourism will be developed as a form of appropriate management to ensure the sustainability of conservation and rehabilitation while at the same time boosting the local community's economy. Lantebung has a mangrove forest of 25 ha. The area on the north is approximately 1,000 x 250 m and the area on the south is approximately 700 x 50 m. Mangrove forests have very important benefits and functions in forest ecosystems, water and the environment. Mangroves are also useful as carbon sinks, where the process of photosynthesis converts inorganic carbon (CO2) into organic carbon in the form of vegetation material. In most ecosystems, this material decomposes and releases carbon back into the atmosphere as carbon dioxide (CO2), but mangroves contain most of the non-decomposing organic matter. Mangroves function more as a carbon sink than other carbon sources.

This study aims to determine the value of carbon absorption in mangrove litter in the Lantebung Mangrove Ecotourism Area, Makassar City. This research was conducted in the Lantebung Mangrove Ecotourism Area, Makassar City. The material in this study is data on mangrove vegetation and mangrove litter. Mangrove vegetation sampling was carried out using the plot sampling method and location determination using the purposive sampling method taking into account the density of mangroves. Data collection for calculating the carbon content of mangrove litter was carried out by capturing fallen litter using a litter-trap (litter-catching net). Litter-trap is a litter-catching net measuring 1 x 1 m2, made of black nylon with a mesh size of about 0.2 cm.

Based on the research results, it was found that the density level of the mangrove ecosystem in the Lantebung Ecotourism Area of Makassar City is classified as medium to dense. The average wet weight litter production per day was 29.88 gram/m2/day to 11.47 gram/m2/day dry weight, this indicated that the dry weight litter production was around 38.40% of the wet weight litter production. The carbon content of mangrove litter in the Lantebung Ecotourism Area of Makassar City is an average of 23.333 gram/m2 or 0.023 Kg/ha, with a carbon absorption of 0.084 Kg/ha/day. The potential for carbon absorption in the Lantebung Ecotourism Area, Makassar City with an area of 58.53 ha is 4.94 tons/day.

**Keywords:** Mangroves, uptake, Carbon, Litter

## Introduction

Mangrove ecosystems are one of the ecosystems in coastal areas that have great potential as a provider of nutrients and also as a buffer between land and sea ecosystems. (Haris, *et al*, 2012; Rumengan *et al*, 2018) [7, 16]. Mangrove ecosystems also play an important role in the sustainability of biota that live in coastal areas, one example is as a place to spawn, find food and take shelter (Khatiresan and Bingham, 2001; Paruntu *et al*, 2017) [14]. In addition to the role of mangrove forests as a spawning ground and a place to find food for biota that live in mangrove forests, mangrove forests also absorb and store carbon which is very important in order to overcome the problem of the greenhouse gas effect which results in global warming (Yuniawati, *et al*., 2011) [19].

Falling mangrove litter is a source of nutrients for aquatic biota and nutrients which are very important in determining the productivity of marine fisheries (Rudiansyah, *et al*., 2013) [17]. According to Dharmawan, *et al*., (2016) [4], leaf litter as the main component in mangrove primary productivity is an important carbon source in the decomposition process. Although mangroves have the ability to absorb carbon, research on the carbon content of mangroves is generally focused on tree and sediment biomass. Therefore it is important to do research on the content of carbon absorption and density levels in mangroves in the Lantebung Mangrove Ecotourism Area, Makassar City.

Makassar City is one of the cities that is experiencing very rapid progress. As a city that is progressing, it certainly has several urban problems, one of which is the problem of rapid infrastructure development, which affects the presence of CO2 content. Even temperature, humidity and wind speed can also affect the increase in CO2 content in several places. One of the infrastructures in the Bira Village, Tamalanrea District, PT KIMA PERSERO is one of the largest companies located in the Makassar area and close to the mangrove tourism area which has domestic waste, in 2007.

Like the problem above, we need to know that the mangrove forest is located in the North Makassar region, which is located in Lantebung Village, Bira Sub-District, Tamalanrea District, in this area it is increasing day by day, so that the density of mangroves in the area is getting higher. Due to the increasing density of mangroves in the Lantebung area due to mangrove planting, it is estimated that the stored carbon stock will increase. To estimate or estimate stored carbon stock, effect of density on biomass, carbon stock and CO2 uptake as well as comparison of biomass, carbon stock and CO2 uptake in 3 density categories of mangroves found in the Lantebung area.

It is time for the mangrove ecosystem to have a role as an absorber of carbon from the air. Mangrove forests store more carbon than most tropical rainforests. This is in accordance with Handoko *et al*. (2016) [6], which states that mangroves have a high rate of carbon assimilation and absorption. By measuring the amount of carbon stored in the body of living plants in a field, it can describe the amount of carbon in the atmosphere that is absorbed by plants. One way to control this is to reduce greenhouse gas emissions by increasing the role of forests as absorbers of harmful gases such as CO2.

### Research purposes

Based on the description of the problem formulation, this study has several objectives as follows;

1. To determine the level of density in the mangrove ecosystem in the Lantebung Mangrove Tourism area, Makassar City
2. To determine the content and absorption of CO2 carbon in mangrove litter in the Lantebung Mangrove Ecotourism Area, Makassar City.

### Research Methods

This research was carried out at the Lantebung Mangrove tourist site, Bira Village, Tamalanrea Subdistrict, from September 2022 to November 2022.

### Work procedures

Plots were determined based on the level of density in the mangrove ecosystem, in plot division each plot was divided into 3 plots where in one plot the size was 10 x 10 m, the distance between plots was ±50 meters.

### Litter Sampling Method

The method used to catch litter fall is Litter-trap (litter catching net). Litter-trap is a litter-catching net measuring 1 x 1 m2, made of black nylon with a mesh size of about 0.2 cm. The steps for taking leaf litter samples are as follows:

a. In each plot, identify each type of mangrove in the plot by grouping it according to the category of tree stands, saplings and seedlings.
b. The most important collection of stem circumference is carried out using a measuring tape and recorded on a sheet to be converted to stem diameter.
c. DBH measurements are carried out at chest level (equivalent to 1.3 m) or for several different growths measurements can be carried out with reference to (Lugiana *et al*., 2011)
d. Mangroves biomass data was obtained based on tree DBH (Breast Height diameter) measurements taken for each plot and then the data was entered in the allometric equation for each species. Biomass calculations are carried out using allometric equations.

Here are some allometric equations for mangrove species:

| | |
|---|---|
| Avicennia marina $B = 0.1848\ (D)^{2.3624}$ | Dharmawan & Siregar, 2008 |
| Avicennia alba $B = 0.079211\ (D)^{2.470895}$ | Sutaryo, 2009 |
| Rhizophora apiculata $B = 0.043\ (D)^{2.63}$ | Amira, 2008 |
| Rhizophora mucronata $B = 0.128\ (D)^{2.60}$ | Fromard et al., 1998 |
| Sonneratia alba $B = 0.3841\ (D)^{2.101*\rho}$ | Kauffman & Donato, 2012 |
| ($\rho = 0.475$) Komiyama, 2005 | |

### Information

B: Biomass (kg/$m^2$, tonnes/ha)
D: Tree Diameter (cm)
P: Density of wood (gr/$cm^3$)

### Data analysis

### Density Analysis

1. Care for each category (trees, seedlings and seedlings)
2. All species present in each plot are counted for the category (trees, seedlings, seedlings) and the number of each stand is recorded. Specific density (Di) is calculated using the formula (Bengen, 2004) [2]:

$$Di = ni/A$$

### Information

Di: Number of stands
ni: Total number of stands
A: Total plot area ($m^2$)

### Carbon Stock Analysis

The carbon content in mangrove stands can be determined by converting the biomass into the formula used to measure/estimate carbon content. Calculation of mangrove carbon uses a formula that refers to the National Carbon Measurement Standards Agency, 2011, namely:

$$C = B \times \%\ C\text{-Organic}$$

### Information

C: Carbon content of mangrove biomass (gr)
B: Total Biomass (gr)
%C Organic: The percentage value of carbon content, is 0.47

or using the percent carbon value obtained from laboratory measurements.

Calculation of mangrove carbon stocks per hectare can use a formula that refers to the National Agency for Carbon Measurement, 2011, namely:

Cn = Cx/1000 x 10000/(L plot)

**Information**

Cn: Mangrove carbon stock per hectare (tonnes/ha).

Cx: Carbon stock in each carbon pool in each plot (Kg).

Lplot: Plot area in each carbon pool ($m^2$).

**Carbon Uptake Analysis**

Carbon content data is used to determine CO2 carbon uptake. Calculation of absorption of carbon dioxide gas can use a formula that refers to (Bismark *et al*., 2008), namely

S CO2=(Mr.CO2 )/(Ar C) x Kc

**Information**

S CO2: Absorption of carbon dioxide gas (CO2) expressed in kilograms (kg)

Mr.CO2: The relative molecular weight of the C atom, which is 44

Kc: Carbon content of mangrove biomass (kg)

Ar.C: Relative atoms of C, namely 12

**Results and Discussion**

**1. Density Level of Mangrove Ecosystems in the Lantebung Ecotourism Area, Makassar City**

Based on the results of the identification carried out, the types of mangroves found in the Lantebung Mangrove Ecotourism Area are true mangroves. The mangrove vegetation found was Rhizophora mucronata and Avicennia marina. The most common type of mangrove found in the plot is Rhizophora mucronata, this is presumably because the environmental conditions, both substrate and salinity, can still be tolerated by mangrove plant species, so this species is heterogeneous when compared to Avicennia marina species, as shown in Table 1 below.

**Table 1:** Mangrove Density in the Lantebung Ecotourism Area (ind/$m^2$)

| No | Type | Total (ind/$m^2$) | | | Total | Average Types Per Hectare |
|---|---|---|---|---|---|---|
| | | Plot I | Plot II | Plot III | | |
| 1 | *Avicennia marina* | 12 | 5 | 12 | 29 | 966 |
| 2 | *Rhizophora mucronata* | 1 | 12 | 56 | 69 | 2300 |
| Total | | 13 | 17 | 68 | 98 | 3266 |
| Average (ind/ha) | | 1300 | 1700 | 6800 | 9800 | 6533 |

Based on the observed data in Table 1, it was found that the highest species density was 2,300 ind/ha with the most dominating species Rhizophora mucronata while the Avicennia marina species had the lowest density of 966 ind/ha. Based on the standard standard for damage to mangrove forests in the Decree of the Minister of State for the Environment No. 201 of 2004 that the quality standard criteria for mangrove density, It was found that the type of Rhizopora mucronata was classified as very dense and the type Avicennia marina was classified as rare.

The results of measuring the density of mangroves based on the plot found that plot 1 had a density of 1300 ind/ha, in plot 2 it was 1700 ind/ha and in plot 3 it was 6800 ind/ha. This shows that the density level in plot 1 is classified as moderate, while in plots 2 and 3 it is classified as very dense. The density level of mangroves in the Lantebung Mangrove Tourism Area shows that the farther towards the sea the density level is higher.

**2. Stock, CO2 Carbon Absorption in Mangrove Leaf Litter in the Lantebung Mangrove Ecotourism Area.**

**Mangrove Litter Production**

Litter production is the loss of vegetative and reproductive structures caused by age, stress, mechanical factors (eg angina), or a combination of both, death or damage to the entire plant by climate (rain and wind) (Soenardjo, 1999). Litter can consist of fallen leaves, twigs, flowers and fruit produced by mangrove plants. The resulting litter is the main source of carbon and nitrogen elements both for the mangrove trees themselves and for the aquatic ecosystem of the area. According to Farhaby (2011), a small proportion of leaf litter production is carried away by the currents and most of it remains on land or in the forest. Leaf litter that remains on land becomes animal food and most of it will undergo partial or complete decomposition carried out by microorganisms and bacteria. The higher the litter production, the higher the productivity in mangrove forests.

Observation of mangrove litter production was carried out 3 times, namely the first observation on the first day and the second observation on the third day and the third observation on the seventh day. Observations were divided into 3 litter traps. The litter production that fell on each plot showed different results during the study period. The results of measuring the level of litter production contained in the litter trap in this study with 3 observations can be seen in Table 2 below.

**Table 2:** Amount of Mangrove Litter Production Per Day

| Days | Plot | Gross weight ($m^2$/day) | dry weight ($m^2$/day) | % C Organic |
|---|---|---|---|---|
| 1 | I | 12,00 | 5,10 | 18,85 |
| | II | 24,00 | 11,70 | 10,85 |
| | III | 36,00 | 17,00 | 22,09 |
| Average H1 | | 24,00 | 11,27 | 51,79 |
| 3 | I | 33,00 | 16,18 | 20,25 |
| | II | 95,00 | 34,60 | 21,15 |
| | III | 63,00 | 15,75 | 20,17 |
| Average H3 | | 31,83 | 11,09 | 61,57 |

| | | | | |
|---|---|---|---|---|
| 7 | I | 96,40 | 40,30 | 22,04 |
| | II | 89,10 | 30,16 | 18,30 |
| | II | 220,00 | 74,30 | 24,09 |
| Average H7 | | 33,79 | 12,06 | 64,43 |
| Average/day | | 29,88 | 11,47 | |
| Average (Tonnes/ha/year) | | 109,06 | 41,87 | |

Based on the results of measurements made in accordance with Table 2, it was found that the average rate of wet weight litter production per day was 29.88 gram/m2/day to 11.47 gram/m2/day dry weight, this shows the production the dry weight of litter is around 38.40% of the wet weight litter production. This data also shows that the more seaward the mangrove leaf litter production is the higher, the same is true for the density level where the mangrove density is obtained the further towards the sea the higher the density. The litter potential that can be produced in the Lantebung Ecotourism Area covering an area of 58.53 ha is 6,383.28 tons/year, with a dry litter potential of 2,451.35 tons/year.

Environmental factors also affect litter production such as temperature and salinity. One form of adaptation of mangrove plants to reduce water loss in order to survive in conditions of high salt levels is by dropping their leaves (Murdiyanto, 2003) and mangrove plants will shed their leaves below optimum temperature (Farhaby, 2011). In addition, the factor of taking mangrove leaf litter will affect litter production.

### C-Organic Content of Mangrove Litter

According to Rosita *et al*. (2013) [15] the denser the mangrove tree stands, the more litter production, the higher the carbon content of the litter. The carbon content in plants describes how much plants can bind CO2 from the air. Some of the carbon will become energy for plant physiological processes and some will enter the plant structure and become part of the plant, for example cellulose stored in stems, roots, branches and leaves (Heriyanto and Enro, 2012) [8].

The results of laboratory analysis of the carbon content of mangrove litter, obtained carbon content (C-Organic), as presented in Table 3, as follows.

**Table 3:** Value of Carbon Content kg/m$^2$

| Day | Plot | Content Carbon (gr/m$^2$) | Carbon Content (kg/m$^2$) |
|---|---|---|---|
| 1 | I | 24,000 | 0,024 |
| | II | 13,000 | 0,013 |
| | III | 24,000 | 0,024 |
| Average P1 | | 20,333 | 0,020 |
| 3 | I | 26,000 | 0,026 |
| | II | 25,000 | 0,025 |
| | III | 22,000 | 0,022 |
| Average P3 | | 24,333 | 0,024 |
| 7 | I | 28,000 | 0,028 |
| | II | 22,000 | 0,022 |
| | III | 26,000 | 0,026 |
| Average P7 | | 25,333 | 0,025 |
| Average/day | | 23,333 | 0,023 |

Based on the results of an analysis of the carbon content of mangrove litter (Table 7), it was found that the carbon content of mangrove litter per day averaged 23.333 gram/m2 or 0.023 Kg/ha. The carbon content on the first day of sampling was 20.333 gram/m2, the third day of sampling was 24.333 gram/m2, and the seventh day of sampling was 25.333 gram/m2. The potential carbon content in the lantebung ecotourism area of Makassar City with an area of 58.53 ha is 13.462 tons. According to Handoko, *et al*. (2016) [6], the greater the vegetation in mangrove forests, the greater the ability to produce organic litter, which is the main constituent of organic matter in the soil. This can be interpreted that litter production affects carbon storage in mangrove leaf litter. According to Rositah, *et al*., (2013) [15] the denser the mangrove tree stands, the more litter production, the higher the carbon content in the litter.

### CO2 Carbon Sequestration Mangrove Litter

According to Hidayanto, *et al*., (2004), the larger the vegetation in the mangrove forest, the greater the ability to produce organic litter, which is the main constituent of organic matter in the soil. This can be interpreted that litter production affects carbon storage in mangrove litter. Mangrove leaves that fall and have been decomposed will be a source of nutrition/food for organisms. Decomposed litter is the main source of carbon and nitrogen for both the mangrove forest itself and the surrounding ecosystem. So with this it can be assumed that mangroves have a direct role in the circulation chain of energy and nutrients that are important, meaning for the continuity of biological resources. The results of the carbon absorption analysis of mangrove leaf litter were obtained as presented in Table 4. The following.

**Table 4:** Carbon uptake of Mangrove Litter

| Day | Plot | Gross weight (gram/m$^2$) | Dry weight (gram/m$^2$) | % carbon | Carbon content (Kg/ha) | Carbon content (Ton/ha) | Carbon uptake SCO$^2$ (Kg/ha) |
|---|---|---|---|---|---|---|---|
| 1 | I | 12,000 | 5,100 | 18,850 | 0,024 | 0,240 | 0,088 |
| | II | 24,000 | 11,700 | 10,850 | 0,013 | 0,130 | 0,048 |
| | III | 36,000 | 17,000 | 22,090 | 0,024 | 0,240 | 0,088 |
| Rata-rata H1 | | 24,000 | 11,267 | 51,790 | 0,020 | 0,200 | 0,073 |
| 3 | I | 33,000 | 16,180 | 20,250 | 0,026 | 0,260 | 0,095 |
| | II | 95,000 | 34,600 | 21,150 | 0,025 | 0,250 | 0,092 |
| | III | 63,000 | 15,750 | 20,170 | 0,022 | 0,220 | 0,081 |
| Rata-rata H3 | | 31,833 | 11,088 | 61,570 | 0,024 | 0,240 | 0,088 |
| 7 | I | 96,400 | 40,300 | 22,040 | 0,028 | 0,280 | 0,103 |
| | II | 89,100 | 30,160 | 18,300 | 0,022 | 0,220 | 0,081 |
| | III | 220,000 | 74,300 | 24,090 | 0,026 | 0,260 | 0,095 |
| Average H7 | | 33,792 | 12,063 | 21,840 | 0,025 | 0,250 | 0,092 |
| Average/ Day | | 29,875 | 11,473 | | 0,023 | 0,230 | 0,084 |

Based on the analysis of mangrove litter carbon uptake data in Table 4, it was found that the average carbon absorption capacity was 0.084 Kg/ha/day. Carbon uptake on the first day sample (litter day 1, litter stored 1 day) was 0.073 Kg/ha/day, then carbon uptake on the third day (litter days 2 and 3, leaf litter stored 1-2 days) was 0.088 Kg/ha /day and carbon uptake on the seventh day (4 to 7 day litter, 1-4 day stored leaf litter) was 0.092 Kg/ha/day. The data shows that the longer the litter is stored the higher the carbon uptake. Based on the results of this study, it was found that the potential for carbon absorption in the Lantebung Ecotourism Area of Makassar City with an area of 58.53 ha is 4.94 tons/day.

## Conclusion

Based on the research results, it can be concluded that:

1. The level of density of the mangrove ecosystem in the Lantebung Ecotourism Area of Makassar City is classified as medium to dense.
2. The carbon content of mangrove litter in the Lantebung Ecotourism Area of Makassar City is an average of 23.333 gram/m$^2$ or 0.023 Kg/ha, with a carbon absorption of 0.084 Kg/ha/day.

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