Production of Rhizophora Mangrove Leaf Litter in The Sungai Bersejarah Mangrove Ecosystem, Siak Regency

E Efriyeldi¹*, B Amin¹, T Hersa¹

¹ Marine Science Department of Fisheries and Marine Science Faculty Universitas Riau
*efriyeldiedi@gmail.com

Abstract. The mangrove ecosystem is one of the coastal ecosystems that has important ecological roles and functions in supporting marine and fishery resources. Marine and fisheries resources are largely determined by the contribution of mangrove litter. The aims of this study was to determine the production of Rhizophora mangrove leaf litter in Sungai Bersejarah mangrove ecosystem, and to determine the value of environmental parameters related to litter. The research was conducted in January until March 2021 in Sungai Bersejarah mangrove area Kayu Ara Permai, Siak Regency. Line transect plot were used to calculate the density of Rhizophora. Rhizophora litter production was measured using the trap net method placed at three sampling site. Three litter trap nets measuring 1 m x 1 m are placed at each station. Rhizophora tree density ranges from 316 - 444 ind./ha. The production of Rhizophora mangrove leaf litter in Sungai Bersejarah mangrove ecosystem was 0.82 – 1.39 g/m²/day (3.00 – 5.09 ton/ha/year), average was 4.11 ton/ha/year. Analysis of variance test showed that there was a significant difference in Rhizophora leaf litter production between sampling points with different Rhizophora tree densities (p<0.05). Mangrove vegetation density has a moderate relationship (r=0.43) to the production of Rhizophora mangrove leaf litter. Environmental parameters indicate that the condition of the Sungai Bersejarah mangrove ecosystem is still good and can support the life of mangrove vegetation.

1. Introduction
Mangrove ecosystem is one of the main ecosystems found in coastal areas in addition to seagrass and coral reef ecosystems. This mangrove ecosystem grows in the intertidal zone of tropical and subtropical beaches. The existence of mangrove ecosystems in coastal areas has an important function and role. [2] The functions and benefits of the mangrove ecosystem are as a barrier to waves and storm winds, protection coastal abrasion, mud retaining and trapping sediment transported by surface water, as a producer of a number of detritus from fallen leaves of mangrove tree branches, as a nursery ground, a feeding ground, and a spawning ground for various aquatic biota (fish, shrimp and shellfish), a producer of wood for various purposes, a supplier of fish larvae, shrimp and other marine biota as well as a tourist spot.

The role of mangroves as a producer of a number of litters cannot be separated from the litter produced by the mangroves. The litter produced by mangroves will be broken down by bacteria and
fungi into the most abundant nutrients that can be used directly by phytoplankton, algae or the mangrove themselves. The detritus is also used by fish and shrimp as food. The basic component of the food chain in the mangrove ecosystem is not the mangrove plant itself, but the litter from the mangrove plant. In addition, the mangrove ecosystem is also said to be an ecosystem that has high productivity due to the production of litter and detritus it produces. [2] The function of mangroves as a habitat for various marine biota, cannot be separated from the role of mangroves as exporters of weathering materials, which are an important food source for aquatic biota. Mangrove plants, especially their leaves, provide many benefits for the surrounding organisms.

The amount of litter production produced by a mangrove area will not be the same in every mangrove area, depending on conditions, such as the density and species of mangroves contained in the area. Mangrove ecosystems that are in good condition will produce a lot of litter. In addition, mangrove vegetation produces different types of litter, because the are some mangroves have wide and dense leaves, while some have small and not many leaves.

One of the mangrove ecosystems whose condition is relatively well maintained because it is used as an ecotourism area in Riau Province is the Sungai Bersejarah mangrove ecosystem, Siak Regency. Information about the production of Rhizophora litter is important while at this time there is no available information at this location. Based on this, this study aims to determine the production of mangrove leaf litter in the Sungai Bersejarah mangrove ecosystem, Sungai Apit District, Siak Regency, Riau Province.

2. Material and Methods
This research was conducted in February 2021. Mangrove litter samples were taken from the Historic River Mangrove Ecosystem, Kayu Ara Permai Village, Sungai Apit District, Siak Regency, Riau Province (Figure 1). The analysis of the litter samples was carried out at the Chemical Oceanography Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Riau.

![Map of research locations](image)

Figure 1. The research locations in the Siak Regency.
The method used in this study is a survey method. In this study, measurements and sampling were carried out in the field, then continued with analysis of mangrove leaf litter at the Oceanography Chemistry Laboratory, Marine Science Department, Faculty of Fisheries and Marine, Riau University.

2.1. Environmental Parameter Measurement

Environmental quality parameters were measured in-situ at each sampling point. Measurements were made in 3 repetitions. Environmental parameters measured include pH, temperature, salinity. Measurement of environmental parameters is carried out to determine environmental conditions for mangrove vegetation.

2.2. Rhizophora Mangrove Density

The density of Rhizophora sp was determined using the line transect plot method. At each sampling point, one transect was assigned which consisted of three plots measuring 10 m x 10 m. In each plot, the density of tree group Rhizophora was calculated. Rhizophora mangrove density was calculated using the formula [1] namely:

\[
K = \frac{ni}{A} \times 10,000
\]

Information:
K : The species i density (individual/ha).
i : Number of stands of species i (individual).
A : Sample plot area (m²).

2.3. Sampling Rhizophora Leaf Litter

The sampling point was determined using a purposive sampling technique, i.e. sampling was carried out on the basis of certain considerations [3]. In this study, sampling locations for mangrove litter production were divided into 3 sampling points based on differences in mangrove density, namely: sampling point 1 with low mangrove density, sampling point 2 with moderate mangrove density, sampling point 3 with high mangrove density.

Rhizophora leaf litter was collected by laying trap nets (Figure 2). The litter collection net used has a size of 1 m x 1 m made of nylon material with a mesh size of 1 mm which is given weight at the bottom. At each observation sampling point, 3 nets were placed. The total nets in 3 sampling point are 9 nets. In its placement, the nets are tied on each side of 4 tree stands or tied to bamboo stakes that are plugged into the ground at a height of 1.5 m above ground level and free from tidal puddles. Sampling of mangrove leaf litter was carried out on days 7, 14, 21, 28.

![Figure 2. Mangrove leaf litter trap](image)
Leaf litter that has been collected is put into a plastic bag and then labeled, and then taken to the laboratory. The dry weight measurement of litter was carried out in the laboratory by drying the sample in an oven at 80°C for 2x24 hours or until the weight was constant. Rhizophora leaf litter data obtained from the results of four times sampling at the three sampling points were averaged and then converted into tons/ha/year.

2.4. Data Analysis
To find out the comparison of leaf litter production of Rhizophora sp between sampling points, a One-way ANOVA test was carried out using SPSS version 17.0 and discussed descriptively. If the test results are significantly different, then proceed with the LSD test. Simple linear regression equation was used to analyze the relationship between Rhizophora leaf litter production and Rhizophora density.

3. Results and Discussion

3.1. General Conditions of Research Location
Siak Regency is one area that has mangrove resources, including in Kayu Ara Permai Village, Sungai Apit District. Kayu Ara Permai Village is located on the coast which has a dense mangrove forest on its coast. This village has a flat topography. There is an organization engaged in the mangrove sector, namely the Laskar Mandiri Conservation Group which was formed by the people of Kayu Ara Permai Village. This organization manages mangrove forests as a center for educational tourism and has been doing conservation since 2018.

3.2. Water Quality Parameters
The results of measurements of temperature, salinity and pH of the water around the Sungai Bersejarah Mangrove ecosystem during the study can be seen in Table 1.

| No. | Parameter | Unit | Sampling Point |
|-----|-----------|------|----------------|
| 1.  | Salinity  | ‰    | 30 31 31       |
| 2.  | pH        | -    | 6.2 6.1 6.4    |
| 3.  | Temperature | °C | 28 30 29       |

Water quality in a mangrove ecosystem affects the life of mangroves. Salinity is one of the important factors affecting the growth, endurance and zoning of mangrove species. Salinity in this area is classified as good for mangrove growth. Mangrove vegetation grows well in estuary areas with a salinity of 10-30 ‰ [4]. The temperature at this research location is around 28-30°C, this includes conditions that are still good and suitable for the life of aquatic biota [5].

The results of measurements of water temperature during the research are an average of 27 °C. This temperature value is quite good for mangrove growth. Good temperature values for mangrove growth are approximately 30 °C, while temperatures above 40 °C tend not to have a significant effect on mangrove survival [6].
The pH value of the waters in this Sungai Bersejarah mangrove ecosystem is quite good, so there are many mangroves in this area. Each species of aquatic organism has a different tolerance to the pH of the water. In general, aquatic biota can live well in the pH range of 6-9 [7].

3.3. *Rhizophora* sp Mangrove Density

The results of the calculation of the density of *Rhizophora* sp mangroves at the three sampling points in the Sungai Bersejarah mangrove ecosystem, Kayu Ara Permai Village, Siak Regency, Riau Province obtained an average as can be seen in Table 2.

| Sampling Point | Plot | Mangrove Density | Mangrove Density average (ind./ha) ±st.dev |
|----------------|------|------------------|------------------------------------------|
| 1              | 1    | 366.67           | 316.67±50.0                              |
|                | 2    | 266.67           |                                          |
|                | 3    | 316.67           |                                          |
| 2              | 1    | 566.67           |                                          |
|                | 2    | 200.00           | 366.67±185.59                            |
|                | 3    | 333.33           |                                          |
| 3              | 1    | 333.33           |                                          |
|                | 2    | 400.00           | 444.44±138.78                            |

Based on the calculation of mangrove density in the Sungai Bersejarah mangrove ecosystem, Kayu Ara Permai Village, the highest *Rhizophora* mangrove density value was obtained at sampling point 3, namely 444.44 ind./ha. The density of mangroves in an ecosystem is not the same, depending on the inundation and substrate in the area. [8] *Rhizophora* mangrove communities usually dominate in all zones close to the sea or river. Substrates with muddy conditions are rich in organic matter which makes this type of mangrove grow well. *Rhizophora* mangroves have good adaptability. [9] Density affects the amount of litter production produced by a mangrove.

3.4. Production of *Rhizophora* leaf litter

The results of the calculation of production *Rhizophora* leaf litter in Sungai Bersejarah Mangrove ecosystem can be seen in Table 3 and Figure 3.

| Sampling point | Plot | Amount of *Rhizophora* Leaf Litter Production (ton/ha/year) | Average *Rhizophora* Leaf Litter Production (ton/ha/year) ±st.dev |
|----------------|------|---------------------------------------------------------|---------------------------------------------------------------|
| 1              | 1    | 3.04                                                    | 3.00±0.04                                                    |
|                | 2    | 2.95                                                    |                                                             |
|                | 3    | 3.02                                                    |                                                             |
| 2              | 1    | 4.27                                                    | 4.23±0.05                                                    |
|                | 2    | 4.18                                                    |                                                             |
|                | 3    | 4.25                                                    |                                                             |
| 3              | 1    | 5.07                                                    |                                                             |
Based on Table 3, it is known that the amount of litter produced at each sampling point is not the same. The production of Rhizophora mangrove leaf litter at sampling point 3 was the highest at 5.09 tons/ha/year, while the lowest leaf litter production at sampling point 1 was 3.00 tons/ha/year with an average leaf litter production of 4.11 tons/ha/year. This is because the sampling point 3 has a higher density than the sampling point 1 and sampling point 2. This value is lower than the results of research conducted by [10] with a litter production of 8.67 tons/ha/year at Teluk Sepi Beach and [11] in the Wonorejo area, East Coast of Surabaya, which obtained a mangrove litter production of 4.5 tons/ha/year. The litter production obtained was higher than that obtained [12], namely 1.14 tons/ha/year in the reforested mangrove forest, Nguling Pasuruan.

Mangrove leaf litter has a high contribution compared to other components such as flowers and twigs. The high contribution of leaves to the productivity of the resulting litter is related to the adaptation of mangrove plants to reduce water loss in order to survive at high salt levels. Compared to other organs, mangrove leaf litter is the most important litter. In the dry season, leaf fall will increase compared to other seasons. [13] obtained 66% of Rhizophora litter derived from leaf components.

| Sampling point | Leaf litter production (tons/ha/year) |
|---------------|--------------------------------------|
| 1             | 2.50                                 |
| 2             | 5.08                                 |
| 3             | 5.12                                 |

**Figure 3.** Rhizophora leaf litter production in Sungai Bersejarah mangrove ecosystem

Analysis of variance showed that there was a significant difference in Rhizophora leaf litter production between sampling points with different Rhizophora tree densities (p<0.05). The highest Rhizophora leaf litter production was obtained at sampling point 3 with the highest density. [10] Temperature and humidity greatly affect the fall of litter. [14] One of the factors that affect the amount of litter production is the diameter or size of mangrove trees. Furthermore, [15] stated that density, different types of mangroves and tree diameter can also affect litter production. Mangrove density also affects mangrove litter production, the higher the tree density, the higher the litter production. [16] stated that other factors that influence litter production are seasonal factors and wind speed. [11] Another factor that affects the fall of mangrove litter is rainfall and wind. The highest litter fall production in the rainy season compared to other seasons, this is due to low leaf mass which makes
leaves easy to fall off. Weather factors such as rainfall affect the productivity level of mangrove forest litter.

The amount of litter produced in each type of mangrove is different, this is due to interrelated internal and external factors. The difference in the amount of litter is caused by several environmental factors that affect productivity, soil fertility, density, season and forest stands. In addition, litter accumulation is also influenced by the age and type of mangrove plants. Older mangrove forests will produce more litter, and usually Rhizophora sp mangroves produce more litter than other types of mangroves.

3.5. The relationship between mangrove density and leaf litter production

The results of a simple linear regression test of Rhizophora mangrove leaf production with tree density obtained the equation $y = 2.9768 + 0.003x$ (Figure 4) with a correlation coefficient value $(r) = 0.43$ which means it has a moderate positive relationship and a coefficient of determination $(R^2) = 0.1888$. This value indicates that mangrove density affects the production of mangrove leaf litter by 18.88%, while the other 81.12% is influenced by other factors.

![Figure 4](image)

**Figure 4.** Relationship between leaf litter production and tree density Rhizophora

The moderate relationship between litter production and Rhizophora density was thought to be due to other factors, such as physical and chemical factors. Physical factors include wind speed and rainfall. In addition, the causes of high and low litter production are zoning and mangroves that are directly opposite the sea. [9] The higher the tree density, the higher the litter production. On the other hand, the lower the tree density, the lower the litter production.

4. Conclusions

The average leaf litter production of Rhizophora in the Sungai Bersejarah mangrove ecosystem is 4.11 tons/ha/year. Rhizophora mangrove leaf litter production was significantly different between sampling points. The relationship between mangrove leaf litter production and mangrove density is moderate.
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