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Production and Decomposition Rate of Litterfall *Rhizophora mucronata*

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Abstract

This study aims to determine the amount of litter production and the decomposition rate of *Rhizopora mucronata* leaves in the Tongke-Tongke Village, Sinjai Regency, South Sulawesi Provincy, Indonesia. The results showed that the average productivity of *Rhizopora mucronata* litterfall is 2.89 g/m^2/day or 10.55 tons/ha/year. The highest production of *Rhizopora mucronata* litterfall came from observational station III, with an average of 3.18 g/m^2/day, while observational station IV shows the lowest production with an average of 2.29/m^2/day. During the study, decomposition rate of *Rhizopora mucronata* leaves showed that station I experienced the fastest decomposition with an average of 0.27 g/day and the slowest one originated from the station IV with an average of 0, 14 g/day.

Keywords; litterfall, decomposition, mangrove

1. Introduction

Mangrove, a type of plant, is commonly found in muddy coasts and estuaries. Mangrove ecosystem is one of unique areas due to integrating physical, biological and chemical elements on the land as well as sea. These combinations produce complex ecosystem between marine and terrestrial ecosystem. In addition to its unique, it also has economical function that is able to drive positive impact on coastal communities (Ulqodry, 2008). Physically, mangrove is capable of stabilizing and protecting coastline against erosion, abrasion, extreme wave, and salt intrusion, also trapping pollutant and waste. Ecologically, it acts as spawning, feeding and nursery ground for various species of fish, shell and others species (Bengen, 2004).

Mangrove, is one of the productive

ecosystems especially its primary production of litterfall, decomposition and nutrient in which its high productivity is related to food chain relied on decomposed litterfall. Decomposition of mangrove litterfall primarily from leaves is an important process because they contribute largely to sedimentary nutrients in the ocean in which only small number of leafy part decomposition is ingested by herbivore while the rest is available as potentially organic source for food web in estuary.

The litterfall that will undergo decomposed process by microorganisms become detritus in the ground. The more litterfall is produced in mangrove ecosystem, the more detritus is available. This detritus will be highly nutritious food source for various aquatic organisms which can benefit for other species in food web. (Zamroni & Rohyani, 2008).

In Tongke-Tongke Village, the rehabilitation of mangrove has been carried out since 1986 by local communities independently. The effort of forestation in coastal area has been done by environmental organization namely Sumber Daya Alam-Aku Cinta Indonesia (KPSDA-ACI), and now it has shown rapid progress and noticed that *Rhizophora mucronata* species is dominant in this ecosystem (Ernawati et al. , 2012).

Due less aware to the important of litterfall production toward costal ecosystem and limited information regarding to its production and decomposition rate especially *Rhizophora mucronata*, is needed further and extensive research to calculate the amount production of litterfall decomposition rate in Tongke-Tongke Village. The aim of this research is to provide information or description of productivity and decomposition rate mangrove ecosystem so that societies particularly local communities realize how crucial mangrove is.

2. Materials and Methods

The study is located in mangrove forest in Tongke-Tongke Village, Sinjai regency with four monitoring hotspots. The tools that are employed consist of litter bag, string, oven, plastic bag, pH indicator, hand anemometer, thermometer, books, ball station and camera digital.

Data collection to acquire mangrove density is transect line plots with transect gab 10 m x 10 m in which general method used to capture litterfall in mangrove forest in a given time is litter-trap (Brown, 1984). Litter trap is 1 m x 1 m container with the mesh size 1 mm, and in the bottom is weighted. Litter trap is placed on observational station under mangrove tree at a height of 1.5 m over underground to avoid extreme tide. Measurement of litterfall productivity was done simultaneously at the beginning of decomposition rate for 1 month in which data collection is every 7 days (4 times captured). After litter is taken from litter trap then separated based on each part such as leaves, twigs, flowers, and fruits. The litter then is in the oven with 80ºC degree for 2 days.

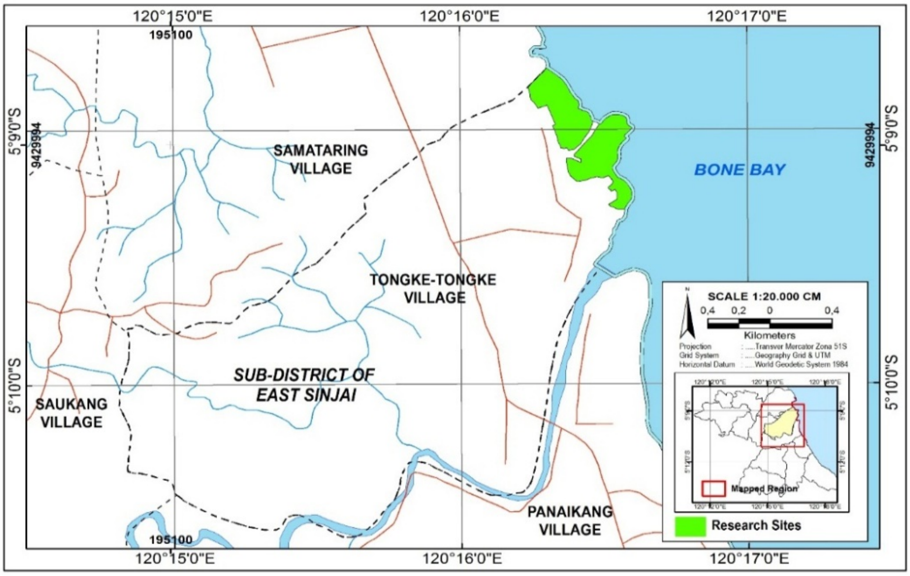

Figure. 1 Research Sites

Figure 2. Mangrove Forest Tongke-Tongke Sinj

Measuring decomposition rate of litterfalls carried out experimentally in the field by putting them which have been dried around 10 g into a liner bag, the size is 20 cm x 30 cm with mesh 1 mm (Personal, 1998; Ashton et al., 1999).

In calculating the decomposition rate of litterfall, part of litterfall mangrove that will be measured is only the leaf because it is the highest falling component compared to others and contributes more than any other organ. Biologically, leaf forming is much faster than others organ such as twig and branch. Its formation is also more sustainable (Hogarth (1999). In addition, it is more easily aborted by wind.

Experiment is held in the field by putting the dried litterfall around 10 g into litter bag, the bags after that is tied and placed in the root or the base of mangrove stem to avoid extreme wave.

During a month, a bag was taken from each station after 7th, 14th, 21st and 28th day. This observational method based on the previous study reveals that the decomposed process occurs from 7 to 15 days (Sa'ban, 2013). However, total decomposition each leaf is different from one another. Within 60 days, it shows that no litterfall has been completely decomposed 100%, it even can take a year to be decomposed perfectly. The remaining litterfall in the bag is cleaned and dried on the oven at 80ºC for 48 hours or until their weight is stable (Mahmudi et al., 2011).

3. Data Analysis

3.1 Litterfall Production Rate

The mangrove litterfall that falls into litter bag is loaded in the plastic bag, separated based on leaf, twig, flower-fruit, and measured their weight. The result is calculated by gram/m^2/week units. After drying at 80°C for 48 hours in the oven to reach the constant weight, it will be taken as litterfall production (Fitriyani, 2016).

3.2 Littering Decomposition Rate Analysis

Identifying decomposition rate in this study is to analyze the reduction of litterfall weight in the litter bag. Its loss is calculated by comparing the original weight to residual decomposition. Decomposition rate is then measured by formula that used by Hardianto (2012); Andrianto et al (2015):

$$R = \frac{Wo - Wt}{T}$$

R = Decomposition rate (g/day)
T = Observation time (day)
Wo = Dried weight of initial littering sample (g)
Wt = Dried weight of littering sample after observation (g)

The percentage of littering decomposition obtained by using Boonruang's formula (Boonruang, 1984) as follows:

$$Y = \frac{Wo - Wt}{Wo} X\ 100$$

Y = Percentage of leafy littering decomposition
Wo = Dried weight of initial littering sample (g)
Wt = Dried weight of littering sample after observation t-to (g)

4. Results

4.1 Litterfall Production

Based on the observational result of production of Rhizophora mucronata litterfall for 28 days after drying on the oven reveals that there is different amount of littering production in each station in which leaves produce the largest litterfall components followed by twig and flower respectively. The data shown in Table 1.

Observational station III shows the highest production, with total litterfall at 92.8 g/m2/ 28 days, or the average per week is 23.2 g/m2/week, followed by observational station II at 89.1 g/m2/28 days or 22.3 g/m2/week. Meanwhile, Observational station II is at 78 g/m2/28 days or the average per week 19.5 g/m2 /week and observational station IV is 64.1 g/m2/28 days or averaged 16 g/m2/week per week. The average of littering productivity in each observation station is presented in the following figure 3. The production of litterfall in all observational stations indicates that leaf is the most contributed component of Rhizophora mucronata compared to other. Littering production presented in the following Table 2.

Table 1. Littering production results

$g/m^2/28$ day					
	Week -1	Week -2	Week - 3	Week -4	Total
Observational Stations I	24,3	21,5	23,6	19,7	89,1
Observational Stations II	21,4	20,8	18,9	16,9	78
Observational Stations III	23,6	22,4	21,7	25,1	92,8
Observational Stations IV	16,5	14,9	17,4	15,3	64,1

Table 2. Total littering production during the study

Littering production (g/m^2/28 day)			
Observational Stations	Leaf	Twig	Flower
I	68,8	13,1	7,2
II	59	11,9	7,1
III	77,5	11,6	3,7
IV	50,2	11	2,9
Total	255,5	47,6	20,9
Average	63,875	11,9	5,225

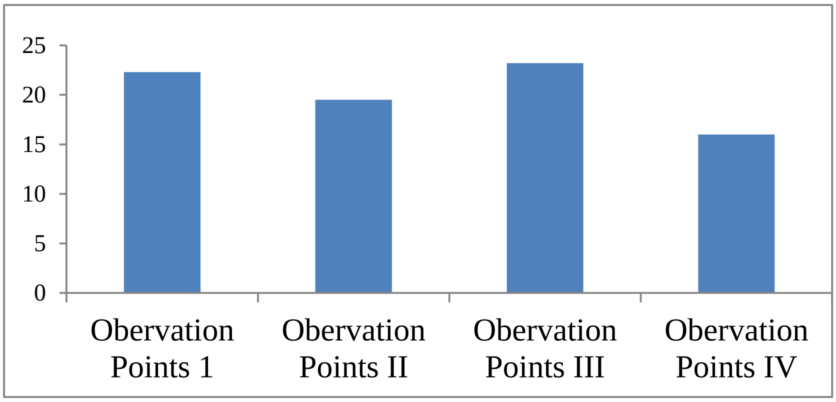

Figure 3. On average litter production each observation point (g/m^2/week)

following Table 2. The average littering production in each observational station for each littering component, can be seen as following the figure 4.

4.2 Littering Decomposition Rate

The result of observational littering decomposition rate for 28 days in each station reveals that none of litterfalls have been completely decomposed in all stations. The dried weight of mangrove litterfall that decomposed for 28 days shown in the following Figure 3. Decomposition of litterfall *Rhizopora mucronata*, during the study for 28 days can be seen in the following Table 3 and Figure 4

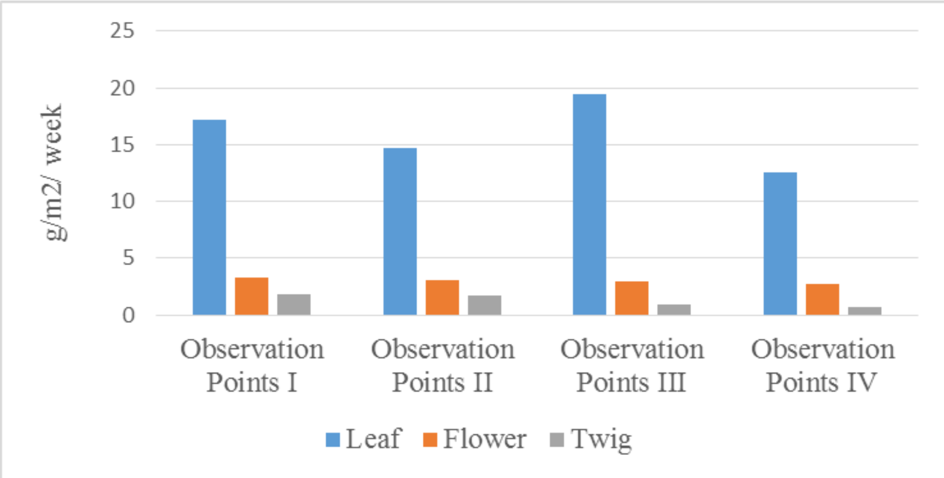

Figure 4. Average littering production during the study

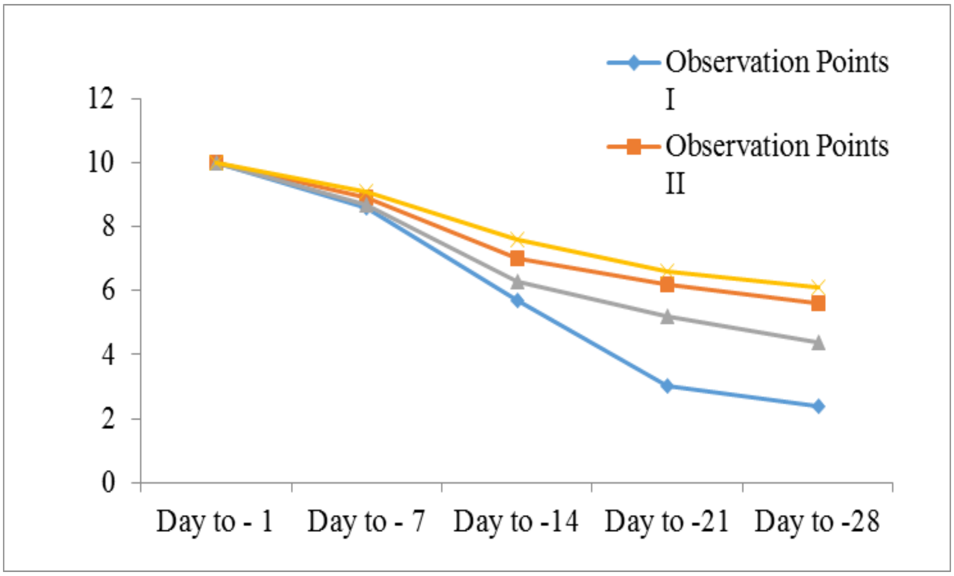

Figure 5. Fluctuations of residual decomposition in each observational period (7 days)

Table 3. The total loss of dried weight of litterfall *Rhizopora mucronata* (g/week)

Obsevational Stations	Day 0	Days 7	Day 14	Day 21	Day 28
I	10 (0%)	8,6 (14%)	5,7 (43%)	3 (70%)	2,4 (76 %)
II	10 (0%)	8,9 (11%)	7 (30 %)	6,2 (38%)	5,6 (44%)
III	10 (0%)	8,7 (13%)	6,3 (37%)	5,2 (48%)	4,4 (56%)
IV	10 (0%)	9,1 (9%)	7,6 (24%)	6,6 (34%)	6,1 (39%)

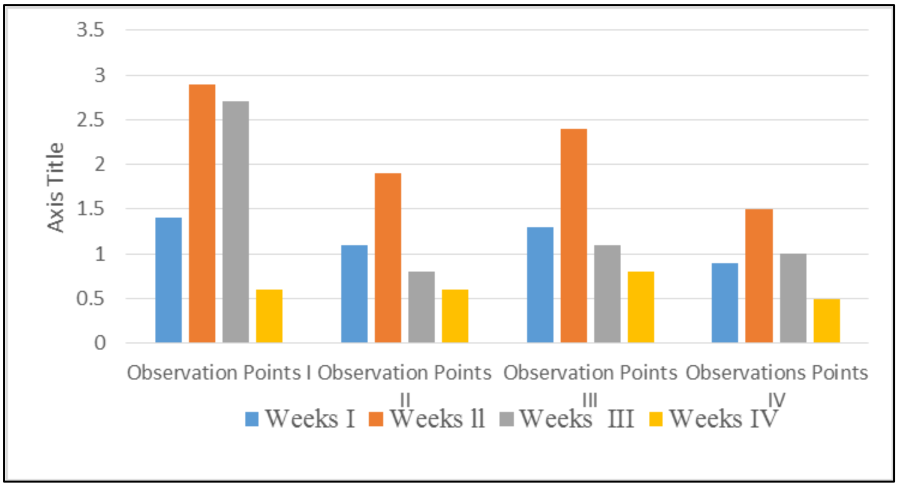

Figure 6. The total loss of dried weight of litterfall *Rhizopora mucronata* (g/week)

Table 4. Factors affecting the production and decomposition rate of litterfall

Observational Stations	I	II	III	IV
Water Temperature	29°C	28°C	29°C	28°C
Air Temerature	31°C	30°C	31°C	29°C
pH	7	7	7	6
Salinity	28 ‰	28 ‰	27 ‰	26 ‰
Wind	0,9 m/s	0,4 m/s	0,7 m/s	0,3 m/s

Influential factors toward productivity and decomposition rate of Rhizopora mucronata litterfall

Based on the result of observational field shows that Influential factors toward productivity and decomposition rate of *Rhizopora mucronata* litterfall consist of salinity, pH, temperature, wind velocity, and *Rhizopora mucronata* density.

The measurement results can be seen in the following table. The density of mangrove, *Rhizopora mucronata,* in Tongke-tongke village shows different results. Observational station III is the Tongke-Tongke Village shows different results. Observational station III is the highest density which the density value is 97 trees per 100 m^2, while station III is the lowest density with 60 trees per 100 m^2. Additionally, the station II and I show 82 trees per 100 m^2 and 79 trees per 100 m^2 respectively.

5. Discussion

5.1 Litterfall Production

Litterfall productivity for 28 days in each observational station shows different results. Station III is the highest production at 92,8 $g/m^2/28$ days or 23,2 g/m^2/week, followed by station I at 89,1 $g/m^2/28$ days or 22,3 g/m^2/week, while station II and IV are at 78 $g/m^2/28$ days or 19,5 g/m^2/week and 64,1 g/m/28 days or 16 g/m^2/week respectively.

The difference of production of mangrove *Rhizopora mucronata* litterfall due to various factors, based on observational results reveal that there are diverse densities in which station III is the highest density while station IV is the lowest density. According to Aida et al. (2014) stated that the density of mangrove vegetation effected the litterfall production, the denser the trees, the higher littering production. Another study Andrianto (2015) noticed the station that had the densest vegetation produced highest. However, different results are shown in station I and II where the density is 79 trees per 100 m^2 and production is 89,1 $g/m^2/28$ days or 22,3 g/m^2/week even though it has less density but is able to produce more compared to station II, 82 trees per 100 m^2 and production 78 $g/m^2/28$ days, which is denser but produces less. These occurs because there are other factors. In addition to density effect, other factors such as diverse temperature, salinity, pH, and wind velocity contribute to different results.

In this study shows that different temperature leads to diverse results in which station I is higher (31^{o}C) than station II (30^{o}C) but can produce more litterfall. This finding is encouraged by Riyanto (2013) stated that temperature effects the amount of litterfall production because in the lower temperature in order to reduce transpiration rate, the vegetation naturally aborts its leaves to survive. According to Panjaitan et al (2014) the appropriate temperature for the life and litterfall productivity in the tropical region is approximately 26-32 °C. Based on the observation shows that the temperature in the field study is 26-32 °C which is livable for growing mangrove.

Salinity monitoring in observational field shows ranging from 26 ‰ to 28 ‰ which station III and IV have less salinity than station I and II. Less salinity in station III and IV is caused by water intrusion from Baringeng River. In station III, Having 27 ‰ salinity, produces more litterfall than station I and II. Although station I and II have similar salinity 28 ‰, they produce different amount of litterfall. This is because station I has higher temperature than station II has. Bengen (2004), stated that one of mangrove ecosystem identities consisted of normal salinity (2-22 ‰) and salty salinity (38 ‰), so all stations have high salinity. Regarding to salinity, leaves play an important role in mangrove adaptation against high level of salinity by storing the salt in their particular cells (Fitriyani, 2016). Another finding by Zamroni and Rohyani (2008) shown that leaves had high contribution to the litterfall decomposition due to adaptation pattern to reduce the water loss in highly salty environment.

Wind velocity monitoring in each station reveal that wind velocity rate is low where station I and III have higher wind velocity than station II and IV have. This is because the station I and III directly face the open ocean, but its category level is still low between 0, 9 m/s and 0, 7 m/s. While station II and IV located in onshore which receive less wind. Therefore, the production of litterfall in station II and IV is fewer than station I and III, supported by Zamroni and Rohyani finding (2008) stated that there was a positive correlation between production of litterfall and wind velocity, the faster wind velocity, the more production.

Observational result shows that the largest production of mangrove litterfall is leaves coming from *Rhizopora mucronata.* According to Yulma (2012) said that it caused by fall season of mangrove in dry season with high temperature. Moreover, leaves contribute more on production of litterfall than any other organs because compared to twig and branch, biologically they are formed quickly and aborted easily by wind. Additionally, Gunarto (2004) stated that mangrove ecosystem was a main food chain that played significant role in food web as producer in marine ecosystem. This ecosystem provided adequate food and shelter for various marine species such as fish, crab, shell, and shrimp. Meanwhile, Kawaroe & Mujizat (2001) said that mangrove contributed significantly to the juvenile fishes. As a result, if mangrove underwent degradation either quality or quantity, it would drive negative impact for marine creatures especially fish as a main source of food.

5.2 Decomposition rate of Rhizopora mucronata litterfall

Mangrove leaves that fall in the ground need long time to be decomposed depending on several factors. Based on the observational result reveals that the decomposed process in station IV is the slowest among other stations. It can be seen from the mass of dried leaves before was 10 g, but after decomposing, the mass fall into 2, 4 g. The composition rate in station I 76%, station II 44%, station III 56% and station IV 39% show that during study, 28 days, none of litterfall has been completely decomposed.

The highest decomposition rate in all stations occurs in the second week, 15 days, which encouraged by Sa’ban (2013) stated that mostly mangrove litterfalls had decomposed from 7 to 15 days. This was due to organic material and soluble organic material loss or the presence of microorganism. In addition to Yulma (2012) said that the highest fungal cellulitis enzyme more likely happened in the beginning of decomposition, but after 14 days decomposition rate declined. Similarly, Ulqodry (2018) found that the average of decomposition rate in the first 14 days ranging from 0.563-0.601 g/day while Lestarina (2011), obtaining an average decomposition rate in the first 14 days was 0.415-0.420 g/ day. According to Yulma (2012) it ws caused by decreasing organic materials and nitrogen contents in the rest of the leaves.

The different amount of decompositions in each station is dependent on several factors. The results of measurements in the study sites reveals that the average of water temperature is 28-29 ºC. It shows that the decomposition rate in every station is quite high while all stations reached 1.3 g/week or 13% per week. Section I that has water temperature at 29^{o}C is the highest decomposition rate reaching 76% in 28 days, followed by section III in the second place at 56% in 28 days.

Manan (1978) stated that the humid and high temperatures region throughout the year led to the decomposition of mangrove litterfall rapidly, so that the process of forming topsoil was followed by the mineralization process. The optimum temperature for bacteria was at 27 - 36 ºC which was the best condition for decomposing mangrove litterfall as if mangrove leaves were their basic metabolism.

pH monitoring in the field shows that all station have 7 pH except station IV 6 pH because it is located in Baringeng River. This finding supported by Annas (2014) said that water pH played significant role to maintain the decomposed process of *Rhizopora mucronata* litterfall.

Litterfall decomposition rate was well known as the litterfall loss rate due to the removal of litter components by physical conditions such as tidal currents (Personal, 1998). In the waters, the decomposition process assisted by the physical mechanism such as the movement of tidal currents and inundation by sea in which the tidal stream in the study area occurs in the morning then at night new receding. The decomposition of litterfall can also be caused by the erosion of the wave movement. Wet and humid environment led to decomposition process faster (Manan, 1978). In field, the largest exposed to the tidal currents is station I and III. Thus, it also affects the high decomposition rate. Furthermore, station II still influenced by tidal water puddles, and also receded. However, although station IV is not influenced by the tidal, it is always submerged by river water. This is because station IV is located in Baringeng River.

6. Conclusion

6.1 The observational result in Tongke-tongke, mangrove ecosystem, East Sinjai obtained the average productivity of *Rhizopora mucronata* litterfall is 2.89 g/m^2/day or 10.55 tons/ha/year with the largest contributor from the leaf litter then followed by the organ of twigs and also the flowers while the fruits are not found. The highest production of mangrove litterfall in station III, with an average at 3.18 g/m^2/day, and the lowest production found in station IV point, with an average of 2.29 g/m^2/day.

6.2 During the study, the decomposition rate of *Rhizopora mucronata* litterfall shows that station I experiences the fastest decomposition at 7.6 g/28 days or an average of 0.27 g/day, and station IV reveals the slowest decomposition at 3.9 g/28 days or an average of 0.14 g/day.

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