Litter production and decomposition of mangrove in the Northern Coast of Aceh Besar district, Aceh province

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Abstract. Mangrove vegetation plays an important role and supplier of organic matter derived from litter fall and litter decomposition. The purposes of this research was to obtain the productivity of mangrove vegetation by analyzing the litter fall, decomposition coefficient, and percentage of litter decomposed in the northern coast of Aceh Besar District. The research used purposive sampling method to determine the 6 stations divided into 2 substations (landward and seaward). This research was conducted in July to September 2016. Each substation was put one of the litter trap. The litter trap method was used to know the mangrove litter production. Litter decomposition focused on *R. mucronata* leaves were studied by using litterbag technique. The litter bags were made of synthetic nylon which had size 20cm x 30cm and mesh size was 1 x 1.25 mm². There were 3 types of mangrove found, litter production of *Rhizophora mucronata* as much as 79.21 g/m²/day, *Avicennia marina* as much as 0.70 g/m²/day and *Sonneratia alba* was 17.46 g/m²/day. Based on the substation influenced by tidal, mangrove litters found in the seaward higher than in the landward, the average litter fall was 52.05 g/m²/day and 43.32 g/m²/day. Result of mangrove decomposition showed that the percentage of decomposition for the 49th day in the seaward substation was 48.58 % and the landward was 41.53 %. Mangrove litter decomposition increased during the time at both substation. Decomposition rate of litter for *Rhizopora mucronata* species classified very quickly where the substation on the seaward was 0.012 (d⁻¹) and landward was 0.010 (d⁻¹). The half-time took in the leaf litter of mangroves for the landward was 69 days and seaward was 57 days, *R. mucronata* leaves litter decomposed in seaward substation was faster than landward.

1. Introduction

Ecologically, mangrove acts as a habitat for feeding, nursering and spawning ground of various aquatic biota [1]. Mangrove also serves as a supplier of organic materials derived from litter so that it can provide nutrients for organisms that live in the surrounding water. Litter is the dead material located above ground and it will experience decomposition and mineralization process. Castillo et al [2] explained that litter of mangrove represented that leaf litter was the greatest percentage of total annual litter production (70%), followed by flower litter (15%), twigs (10%), and propagules (5%).

Litter decomposition is a process in which organic matter produced by mangrove forests is transferred to the sediment influenced by dry and rainy seasons [3, 4]. Generally, four basic steps that decomposition of litter transferred to their habitat: (1) removal of leaves material compound by water, (2) microorganisms colonization, (3) consumption by herbivores, and (4) action of physical environmental factors [5, 6]. Measuring primary productivity in mangrove ecosystems are intricate but litter production and litter decomposition has been widely used as a measure of productivity, particularly to predict contribution of nutrient to the estuarine ecosystem [7]. The productivity is generally dependent
on nutrients derived from the litter present in the water. Factors that contribute to litter decomposition are litter type, temperature, pH, and microbial activity [8].

Aceh Province has potential marine biota resources such as crustaceans (shrimps, crabs) and mollusks (shells, snails). This high potential is because Aceh area has some coastal ecosystem that supports the primary productivity in the estuary and sea. For coastal areas, the existence of mangrove forests primarily as a green line along the coast is very important for the supply of fish and shrimp as well as maintaining the quality of the fishery ecosystem and also protecting the settlements from abrasion. Some of communities in Aceh Besar and Banda Aceh entrust their life as fishermen and they commonly use mangrove area for fishpond in order to increase their income. According to DKP [9], Aceh Besar has coral cover area of 1.155 ha and mangrove ecosystem area is 133.94 ha. The decomposition of mangrove leaf litter has been studied in tropical and subtropical regions on the word (e.g Southwest India [10], Peninsular Malaysia [11], Gazi Bay Kenya [12], Sabang Indonesia [5]. The decomposition of mangrove leaf litter has been studied in previous research explained that the percentage of leaves litter decomposed (Rhizophora stylosa) was 56.68% ± 0.67 in site next to the land and it was 59.30% ± 1.81 in site next to the sea [5].

Gampong Leungah, Beurenut, Lamreh, Lampah, Ladong are some villages located on the north coast of Aceh which has a large community of mangrove forest. Rhizophora sp. and Avicennia sp. are the most dominant mangrove species in this mangrove area. According to Dewiyanti [13] Rhizophora apiculata, R. stylosa, and Avicennia marina were the dominant species of mangrove pre tsunami in Ulee Lheue coastal, Banda Aceh city. The mangrove ecosystem is decreasing in the northern coastal area of Aceh Besar with increasing the amount of pond area and the excessive exploitation. Those make the role of mangrove as feeding and spawning area for macro fauna is also decreasing and it impacts low coastal productivity. Considering the importance of mangrove litter and litter decomposition to support the production of aquatic fauna in coastal areas, it is necessary to know the amount of litter production available on the mangrove forest floor and its decomposition rate. Therefore, the present study aimed (1) to measure the productivity of mangrove vegetation by analyzing the litter fall and also the factors that affected the mangrove litter, (2) decomposition coefficient, and percentage of litter decomposed in the northern coast of Aceh Besar District, Aceh Province.

2. Methodology

2.1 Time and Research Location
This research was conducted for 3 months starting from July to September 2016. The method used in this research was survey method by taking sampling directly in mangrove ecosystem. The determination of research station was done by using purposive sampling method based on the desired goal. According to field assessment, there were 6 observation stations, namely Alue Naga village (station 1), Ladong village (station 2), Beurenut village (station 3 and 4), Lampah village (station 5), and Leungah village (station 6). At each station divided into 2 substations (landward and seaward), three transects as a plot (10m x 10m) were established in each substation for replication. The location of the research can be seen in Figure 1.

2.2 Measurement of Litter Production
Litter fall production used litter trap technique with transect size 1m x 1m [14], and the net mesh size for litter trap was 1cm x 1cm. Litter trap was placed with a height of 1.5 m above ground level, so it can avoid from the tidal effect. Measurement procedure for litter fall production was taken every 8 days (weekly) for two months by taking all litter fall accommodated in the litter trap. Litter samples were separated based on litter components including leaves, branches, twigs and reproductive organs (flowers and fruits). The litter sample were oven dried at 60°C for 48 hours and weighed until constant and final dry weight was recorded with a precision of 0.01 g.
Figure 1. The map of study sites located at Aceh Besar districts.

2.3 Measurement of Litter Decomposition

Litter samples taken for this study were *Rhizophora mucronata* leaves because they were easily obtained and abundant in the mangrove area. Criteria of the leaves taken were senescent leaves, and the leaves were still intact located on the floor of mangrove forest. Leaf litter decomposition is commonly measured by using the litter bag technique [11]. Commonly, litter bag method is used for the decomposition research [15]. The litter bags were made of synthetic material and had size 20cm x 30cm [16] with mesh size 1.5 x 1.5 mm².

Leaves litter that has been collected from the field was taken to the laboratory and oven dried at 60°C for 48 hours or until the litter is completely dry. Furthermore, 12 g of leaves after oven dried was placed in each litter bag and every bag was tied in the mangrove prop root in order not to drift or disappear during the tide. Litter bags were placed as many as 6 bags on each substation with 3 replications. Sampling time was daily, weekly and biweekly, i.e the 3rd day, 7th day, 14th day, 21st day, 35th day, and 49th day. Sampling time was determined based on the results of several studies that have been found the litter decomposition process started between 7-15 days. Monitoring of the litter bag was carried out at certain intervals to estimate the litter decomposition rate [17]. Totally, 36 litterbags were needed in each observation and for 6 time observations in 10 weeks, dry leaves needed were 2592 g and litter bags were 216 bags. After collecting sample, the bags were returned to laboratory where they were rinsed in a sieve to remove sediment, and then continue with oven dried to have a constant mass. The samples were oven dried at 60°C for 2 days and weighed until constant and then final dry mass was recorded.

2.4 Statistical Analysis

2.4.1 Production of Mangrove Litter. Litter production analysis was conducted using the equation below [18]

\[
Dry \ Weight = \frac{g}{m^2/day}
\]

Where g is gram of dry weight; m²/day is squared meter per day

2.4.2 Decomposition of Mangrove Litter. Litter which was already decomposed and percentage of leaves decomposed were calculated by using formula [11]

\[
D (\%) = \frac{B1 - B2}{B1} \times 100\%
\]
Where D is litter decomposed; B1 is dry weight before decomposition; B2 is dry weight after decomposition.

The relationship between percentage dry mass remaining in litter bags and sampling time at all sites best fitted in a negative single exponential model [11]. The formula was:

\[ Xt = X_0 e^{-Kt} \]

\( Xt \) is percentage of initial material; \( X_0 \) is remaining after time \( t \) (days) and \( K \) is a decay coefficient (d\(^{-1}\)).

The times required for decomposition of half the initial material (t50) were determined by using the formula:

\[ t_{50} = \frac{ln2}{K} \]

3. Results and Discussion

3.1. Litter Fall Mangrove Production

The result showed that there were three mangrove species found namely, *Rhizophora mucronata*, *Avicennia marina* and *Sonneratia alba*. In the observation area, the existing mangrove vegetation was dominated by *R. mucronata*. The dry weight average of litter fall from *R. mucronata* was 37.44 g/m\(^2\)/day in seaward and in landward substation was 41.77 g/m\(^2\)/day, totally 79.21 g/m\(^2\)/day leaves litter contributed by *R. mucronata*. *Avicennia marina* had weight average 0.70 g/m\(^2\)/day in seaward and *Sonneratia alba* was 3.55 g/m\(^2\)/day in landward and 13.90 g/m\(^2\)/day in seaward substation (Table 1).

According to Andrianto et al. [19] the shape and size of leaves of *R. mucronata* larger than the other species causing the leaves to fall easily when the wind blows and *R. mucronata* often appears in every station, it has a high density of 20 individuals/100 m\(^2\). The results of research conducted by Andrianto et al., [19] in Durian Village and Batu Manyan Village, Padang showed that the productivity of *R. mucronata* mangrove litter obtained as much as 34.8 g/m\(^2\)/day with a density of 10 individuals/10 m\(^2\), while *R. stylosa* was 15.74 g/m\(^2\)/day with density of 3 individuals/10 m\(^2\). These information indicated that the litter mangrove productivity on the northern coastal area of Aceh Besar was higher than previous study.

In average, mangrove leaves litter production obtained in seaward was 52.05 g/m\(^2\)/day, and in landward was 45.32 g/m\(^2\)/day. The productivity of mangrove litter found in seaward higher than landward due to the mangrove density in seaward was 30 individuals/100 m\(^2\) and in landward was as many as 25 individuals/100 m\(^2\). In additional, the litter fall higher in seaward than landward assumed because of environmental condition such as salinity, temperature and dissolved oxygen. Salinity is one of aquatic parameters which is influence the litter production. Lestarina [20] mentioned that the higher the salinity, the higher the productivity of the mangrove litter. In additional, high contribution of leaves to litter productivity is related adaptation mangrove to reduce water loss in order to survive in high salinity conditions. The average of salinity in field study was 33.5 ppt in seaward and 28 ppt in landward. Mangrove vegetation that inhabit at a higher salt content will produce a high mangrove litter as well, it is related the ability to accumulate excess salt in the leaf components and then it fall as a litter [20].

Leaf is the largest contributor of litter compared to other plant components (Table 1). There was a correlation between peaks in litter fall and peaks in leaf fall whereas leaf fall contributed 67% of total litter fall [21]. The litter composition was primarily structured of leaves which accounted for 65–75% of total litter production in our study sites [22]. The result showed that leaves litter production in study area was 67.07 g/m\(^2\)/day. The leaf component as a mangrove litter was more than other component as much as 17.69 g/m\(^2\)/day [23]. This was thought due to leaf shape, size wide and thin, moreover the characteristics make leaves easy to fall. It was also caused by the physiological properties of the leaves, where the leaves play an important role in the process of photosynthesis. The old leaves will fall and be replaced by relatively young leaves. Mangrove is generally located in the forest tightly, the old leaves located at the bottom or inside of the canopy get less light and they can’t photosynthesis perfectly
affected leaves fall faster [24]. In the energy flow of mangrove forests, leaves litter as a source of nutrients for organisms in surrounding area [25]. On the other hand, litter of flowers and fruits were 22.69 g/m²/day. Lack of fruit and flower production due to the observation time wasn’t in flowering season. In additional, they were produced by some individuals’ mangrove species (R. mucronata) while leaves were produced by all individual observed of mangrove species.

Table 1. Average of Mangrove Litter Dry Weight in Study Area

| Species                  | Litter component | Average Litter dry weight (g/m²/day) |
|--------------------------|------------------|-------------------------------------|
|                          | Landward | Seaward | Total    |
| *Rhizophora mucronata*   |          |         |          |
| Leaf                     | 27.9     | 26.17   | 54.07    |
| Fruit                    | 7.05     | 5.17    | 12.22    |
| Flower                   | 2.55     | 2.77    | 5.32     |
| Twig                     | 4.27     | 3.33    | 7.60     |
| Total                    | 41.77    | 37.44   | 79.21    |
| *Avicennia marina*       |          |         |          |
| Leaf                     | -        | 0.70    | 0.70     |
| Fruit                    | -        | -       | -        |
| Flower                   | -        | -       | -        |
| Twig                     | -        | -       | -        |
| Total                    | -        | 0.70    | 0.70     |
| *Sonneratia alba*        |          |         |          |
| Leaf                     | 2.79     | 9.51    | 12.3     |
| Fruit                    | 0.76     | 4.39    | 5.15     |
| Flower                   | -        | -       | -        |
| Twig                     | -        | -       | -        |
| Total                    | 3.55     | 13.90   | 17.45    |
| Total                    | 45.32    | 52.05   | 97.37    |

3.2. Decomposition of Mangrove Litter

Observation of litter decomposition was conducted for 49 days. *R. mucronata* leaves observed because of dominance species in study area. Decomposition of mangrove leaves litter from the 3rd day to 49th day showed that percentage of litter decomposed increased with increasing time of decomposition period (Figure 1). The dry weight of the mangrove litter during the decomposition process decreased from the initial dry weight. Dry weight was required to know the percentage of decomposition rate during observation. Where the initial dry weight of the litter was 12 gr each bag. Dry weight of mangrove litter began to decline on the 7th day and continued to decrease with increasing incubation time. The dry weight of leaves litter has an average 7.02 g in landward and 6.17 g in seaward at the last observation period on the 49th. Leaves decomposed were high in the beginning and at the end of decomposition process and they were fluctuated during experiment period. Decomposition process is initially rapid in the beginning than slow, after one week showed a rapid initial mass loss indicated by fresh leaves had lost 31.4% and dried leaves had lost 38.3% because of leaching in a mangrove of Southwest India [10]. Furthermore, this condition was suspected by the existence of influence in quality and quantity of the litter element content that as food for the soil microbe. The abundance of bacteria, microorganisms and invertebrates enormously accelerates the decomposition process of the organic material produced by mangrove forest [26].

Furthermore, the percentage of litter decomposed in seaward was higher than landward during the observation. On the 49th day, the percentage of decomposed litter was 41.53% (landward) and 48.58% (seaward) (Figure 2). The mangrove location next to the sea decayed faster than the location next to the land, the comparison between both sites at the end of observation on the 68th day showed that the percentage of decomposed litter next to the sea was 59.30% ± 1.81 and percentage of decomposed litter in the to the land was 56.68% ± 0.67 [5]. In toward the sea, the decomposition process is influenced by
physical factors such as the movement of tidal currents and inundation by longer seawater. The mechanism of loss of soluble materials from litter is caused by rain or water flow [26]. Increasing decomposition rates because of water soaking caused leaching of labile material and high inundation caused more litter will be decomposed rapidly [11].

![Figure 2. Percentage of Litter Decomposed During the Observation Period](image)

The decomposition of the litter was also caused by the erosion of litter by the movement of waves. The moist substrate conditions of the water as compared to the mainland also play a role in litter decomposition, an environment that is always alkaline and moist causing the litter decomposition process faster. The compounds contained in the litter also affects the ability of a microbe to decompose complex compounds contained in the litter [8]. The average of temperature in seaward and in landward were 39.5°C and 37.2°C. The high temperature causes a faster decomposition process due to high temperatures can increase the level of chemical weathering. Climate plays an important role in the decomposition rate of organic matter, increasing temperature and humidity causes the decomposition process quickly, on the other side low temperatures may impair the decomposer communities [27]. Furthermore, there was statistically correlation between temperature of water and rate of decomposition (P<0.05); a higher the temperature the less remaining litter [5]. The breakdown of the leave is defined as weight loss due to some physical-chemical properties caused by environmental conditions such as high temperature and decomposition process increases in accordance with temperature [28, 29]. Other studies have shown that temperature to be a necessary element for mangrove decomposition, increasing a few degrees of temperature could be adequate to increase the decomposer activity whereas consequently accelerating the process [30]. The tree abiotic factors which are significantly liable for the leaf breakdown rate involved dissolved oxygen, electrical conductivity in the winter and temperature in the summer [31].

3.3. Decomposition/Decay coefficient (K) and half-time (t50)

K (d⁻¹) is decay coefficient that can determine the rate of decomposition. Average of K in landward was 0.010 d⁻¹ and in seaward was 0.012 d⁻¹ (Table 2). The exponential value of K can be classified into three classes i.e. very fast (K > 0.01), medium (K = 0.005-0.01) and slow (K <0.005) [10]. The decay coefficient in study area was categorized fast and medium. The decay coefficient in seaward was faster than landward, it assumed due to the influence of the tides. According to the result found by Dewiyanti [5] the average value of K at the substation next to the land was 0.010 d⁻¹ and next to the sea was 0.011 d⁻¹ but the K value wasn’t significantly different between both substations. Seaward substation received greater influence from the physical tide directly impacting the fragmentation of leaves. Increasing the
level of decomposition due to the water immersion leads to washing of unstable materials and high inundation causes waste to decompose, the decomposition rate is influenced by environmental factors such as temperature, nutrient content, leaf density and soil moisture. [11, 32] Litter mass loss was greater on the tidal side of the floodgates than landward and lower decomposition rates at the landward side are due to tides not reaching the landward side [33]. Moreover, decay coefficient found in study area was similar to those reported for other species of *Rhizophora*, i.e. in Malaysia (K = 0.01 day\(^{-1}\) [11]; Trinidad and Tobago (K = 0.01 day\(^{-1}\) [33].

| Species                  | Sub Station | Decay Coefficient/ K (d\(^{-1}\)) | \(t_{50}\) (days) |
|--------------------------|-------------|-----------------------------------|-------------------|
| *Rhizophora mucronata*   | Landward    | 0.010                             | 69                |
|                          | Seaward     | 0.012                             | 57                |

Time required for the decomposition of half the initial material (\(t_{50}\)) was 69 days in landward substation and 57 days in Seaward substation. The \(t_{50}\) is the time needed for the litter to break down 50% (half) of the initial amount before the litter is perfectly decomposed. The \(t_{50}\) of *R. mucronata* can be seen in Table 2. The time required for the decomposition of half the leaves litter (\(t_{50}\)) was 67 days and 63 days for next to the land and site next to the sea [5]. The \(t_{50}\) indicated that the time to decompose litter from half of the starting material in seaward decomposed faster than landward. Ashton et al. [11] found that the required \(t_{50}\) of *Rhizophora apiculata* litter was 76 days and 43 days in the Malaysian Peninsula mangrove forest. Several factors are suspected to influence the high leaves decomposed in the field study such as factor of inundation, environment and decomposer. Overall leaf mass may be lost by leaching up to 33% during the initial phase from several days to several weeks [34]. Furthermore, in previous study showed that week showed a faster initial mass loss indicated by residual leaves that had been lost 38.3% due to immersion in the Southwest Indian mangrove forests after one week [10].

## 4. Conclusion

The highest mangrove litter production was *Rhizophora mucronata* with the average 79.21 g/m\(^2\)/day compared *Avicennia marina* and *Sonneratia alba*. The productivity of mangrove litter found in seaward higher (52.05 g/m\(^2\)/day) than landward (45.32 g/m\(^2\)/day) due to the mangrove density and environment condition. Based on the mangrove litter components, leaves was the largest contributor of litter compared to other plant components within leaves litter was 67.07 g/ m\(^2\)/day. Some factors was influencing mangrove litter productivity i.e. temperature, salinity and mangrove density. The decomposition percentage of *R. mucronata* leaves increased with increasing period observation time, and the percentage of litter decomposed in seaward was higher than landward were 48.58% and 41.53% at 49th day, respectively. The coefficient of decomposition showed very fast and medium category. Time required for the decomposition of half the initial material (\(t_{50}\)) was 69 days in landward and 57 days in seaward, the values showed that the leaves litter incubated in seaward decomposed faster than landward substation.

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References

[1] Sjöling S, Salim M, Thomas J, Jasson J K 2005 Journal Estuarine Coastal and Shelf Science 63:397-406.
[2] Castillo J A, Gabriela V, Jorge L P 2006 Hydrobiologia 559:101–111.
[3] Margarita L Naranjo, Jeffrey A, Jorge C 2018 Journal of Coastal Research 00 (0): 0000.
[4] Polidoro B A, Carpenter K E, Collins L, Duke N C, Ellison A M, Ellison J C, Farnsworth E J, Fernando E S, Kathiresan K, Koedam N E, Livingstone S R, Miyagi T, Moore GE, Nam V N, Ong J E, Primavera J H, Salmo SG, Sanciangco J C, Sukardjo S, Wang Y, Yong J W H 2010 PLoS ONE 5(4): e10095.
[5] Dewiyanti I 2010 Jurnal Biodiversitas 11 (3): 139-144.
[6] Kathiresan K, Bingham B L 2001 Advances in Marine Biology 40: 81–251.
[7] Morrisey D, Beard C, Morrison M, Craggs R, Lowe M 2007 Auckland Regional Council Technical Publication Number 325.
[8] Osono T, Takeda H 2006 Mycologia 98: 172- 179.
[9] Dinas Kelautan dan Perikanan Provinsi Aceh 2012 Laporan Kegiatan Assessment lapangan ecosystem perairan Aceh Besar.
[10] Ananda K, Sridhar K R, Raviraja N S, Baerlocher F 2007 Wetlands Ecol Manage 112: 73-81
[11] Ashton E C, Hogarth PJ, Ormond R 1999 Hydrobiologia 413: 77-88
[12] Bosire J O, Dahdouh-Guebas F, Kairo J G, Kazungu J, Dehairs F, Koedam N 2005 Biological Conservation 126: 287–295.
[13] Dewiyanti I 2005 Jurnal Natural 5(2):12-16.
[14] Ribeiro C, Madeira M, Araujo M C 2002 Forest Ecology and Management 171: 31-41.
[15] Mackay A P, Smail G 1995 Hydrobiologia 332: 93-98.
[16] Haraguchi A K, Hisaya C, Hesegawa, Takahashi T I 2002 Europ Jurnal Soil Biology 38: 89-95.
[17] Hamidy R, Soelaksono S, Adianto, Taufikurrahman 2002 Biologi 2(13):755-768.
[18] Andrianto F, Bintoro A, Yuwono S B 2015 Jurnal Kehutanan dan Pertanian 1 (3): 13-15.
[19] Lestarina M P 2011 Produksi dan laju dekomposisi serasah mangrove dan potensi kontribusi unsur hara di perairan Mangrove Pulau Panjang Banten Tesis Institut Pertanian Bogor.
[20] Juman R 2005 Revista de Biolog’ia Tropical 53(1); 207–217.
[21] Mehea I S S, Ali A I 2017 Journal of East African Natural History 106(1): 5–18.
[22] Aida G R, Yusli W, Fahrudin A, Mohammad M K 2014 Jurnal Ilmu Pertanian Indonesia 19 (2): 91-97.
[23] Munir A M 2004 Pendugaan Produktivitas Serasah Hutan Mangrove di Pulau Gili Sulat, Nusa Tenggara Barat Tesis Institut Pertanian Bogor.
[24] Bunyavejchewin S, Nuyim T 2001 Silvicultural Research Report 28-38.
[25] Sa’ban M, Ramli W N 2013 Jurnal Mining Laut Indonesia 3 (12): 132-146.
[26] Mfilinge P L, Tsuchiya M 2008 Journal of Sea Research 59 (1-2): 94-102.
[27] Graça M A S, Baerlocher F, Gessner M O 2005 A practical guide; methods to study litter decomposition Springer Netherlands.