Mangrove litter production in correlation to environmental properties of water in Pusong Cium, Seruway, Aceh Tamiang

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Abstract. The purposes of the present study were to analyze the litter production of mangrove ecosystem in Pusong Cium Island, Seruway, Aceh Tamiang, and to analyze the relationship between physical and chemical factors of water to the litter production. The research was conducted from October until December 2019 in Mangrove ecosystem. The method used in determining the location was Stratified Random Sampling. This research was conducted at three stations distinguished from the density of mangrove vegetation with high density, medium and rare categories. The results showed that the total amount of litter production at Pusung cium was 35.65 g/m²/day and the highest contributor obtained was at station 1 and continued station 2 and 3 with the value 15.17 g/m²/day, 11.49 g/m²/day, and 8.99 g/m²/day, respectively with the highest mangrove density of 119 ind / 100m² in station 1. The average mangrove litter production in study area of 2.74 g/ m²/day categorized as moderate and not high enough compared to other research areas. The highest species contributed of litter production and carbon content in mangrove leaves were found in *Avicennia alba* by 29.64%. There was a significant correlation between temperature parameters, mangrove density, salinity and litter production, which was 0.677, 0.672 and -0.470. The correlation was positive and strong between temperature, mangrove density with litter production, and negative correlation between salinity and litter production.

1. Introduction

Mangrove litterfall consisted of leaves, twigs, flowers, propagules, and other tree components provides a significant contribution towards the coastal food chain, keeping the coastal ecosystems in balance condition through decomposition done by decomposer as biological activity [1, 2]. Microorganisms [3], invertebrates [4], fishes [5] have been reported to consume and help in mineralization. Nutrients resulted from the litter decomposition is very essential in growth vegetation itself and as a source of detritus for supporting various lives of aquatic organisms. Furthermore, detritus which comes from the mangrove tree eaten by detritivores, they will be eaten by fish larvae, crab, shrimp so that occurs food chain process takes up to high trophic level [6]. Calculation the litter production and mangrove biomass correctly will be important information in the production, decomposition, cycling of nutrients in mangrove ecosystems, and evaluate productivity of marine fisheries [7, 8].

Litter production of mangrove commonly influenced by several chemical and physical environment factors i.e. temperature, rainfall, type of substrate, and freshwater availability [9]. The differences result in the litter production may be attributed to climatic conditions in the study area and other factors an example forest type, sediment quality and available nutrients [10]. In a tropical mangrove forest, litter
production occurred throughout the year, with peaks influenced by both the rainy and dry seasons [11]. Hossain and Hoque [12] reported more than 50% of the total production come from leaves, Dewiyanti [13] found that leaves the highest litter component (54.07g/m²/day) compared the other litter component. Leaf litter was the greatest percentage of total annual litter production, followed by flower, twigs, and propagules which value of 70%, 15%, 10%, and, respectively [7].

Aceh Tamiang is one of the districts in Aceh Province which has a coastal area with enormous natural resources, it has ± 22,900 ha of mangrove area [14]. Based on field observation, the amount of mangrove vegetation start to decrease because mangrove vegetation exploited by local people for charcoal and land conversion to agriculture land and residence. This activity is very detrimental in term ecological factor, especially the mangrove ecosystem itself. Nevertheless, human populations directly depends on mangrove vegetation as coastal resources, particularly fisheries, as source of their income [15]. There is one of endemic species who depend on mangrove fruit (Sonneratia alba) as a food [16] namely Batagur borneonis, local people called tuntong laut. Pusung Cium is one of the conservation reserves in Aceh Tamiang, precisely located in Pusung Kapal village, Seruway District. Considering the significant role of mangrove litter to support productivity level in mangrove ecosystem, hence it’s essential to analyze the litter production of mangrove ecosystem in Pusong Cium Island, Suruway, Aceh Tamiang, and to analyze the relationship between physical and chemical factors of water to the litter production.

2. Material and Methods

2.1. Study site

The study was conducted for 2 months starting in October until November 2019 located in the mangrove ecosystem of Pusung Cium Island, Aceh Tamiang (Figure 1). Stratified random sampling technique was applied to select the sampling location, there are 3 station determined by the total amount of mangrove vegetation, namely station 1 was dense, station 2 and 3 were moderate and rare vegetation. Each station consisted of three replications. The coordinates of station 1, 2 and 3 were 4°24’6.31” N, 98°17’4.98” E, 4° 23’46.42 “ N, 98°17’7.21” E, and 4°23’25.08 " N, 98°17’11.65E, respectively. The analyze of litter production was carried out in Marine Laboratory, Marine and Fisheries Faculty and Carbon content of leaves conducted at soil laboratory, Agriculture Faculty, Universitas Syiah Kuala.

2.2. Litter production measurement

Productivity of mangrove ecosystem can be analyzed by litter production measurement. Mangrove litter was collected at each station, whereas at each station consists of 3 plots as replication and in each plot one litter trap with size 1m x 1m was installed. Commonly, litter production used litter trap technique with transect size 1m x 1m [17]. The litter trap was placed under the tree canopy at a height of 1.5m above ground, in order to avoid tidal affect that can inundated litter trap [18]. Calumpong and Cadiz [19] installed litter trap 1 m above ground to avoid flooded due to high tide. Measurement procedure for litter production was taken every 8 days (weekly) for one month by taking all litter fall in the litter trap [13]. The litter collected is separated into different component i.e. leaves, fruits, flowers and twigs and miscellaneous (all plant materials <2 mm and occasional structures of other species) based on the method of Bernini and Rezende [20] that were caught in the litter trap. Furthermore, litter was air dried and oven dried in marine biology laboratory at 80°C for 48 hours [28] until constant weight and final dry weight was recorded with a precision of 0.0 g. A total of 5 grams of dry mangrove leaves litter were extracted and analyzed for carbon content (C) based on wet destruction method Soil Laboratory. Litter production was calculated by following equation [21] below.

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

Where g is gram of dry weight; m²/day is squared meter per day
2.3. Mangrove vegetation and physical-chemical parameters measurement

The square transect was established 10m x 10m² to measure mangrove density [22] perpendicular from the sea to the land. The species of mangrove and number of individuals each species was noted as a primary data. Identification of mangrove species in the field identified based on [23; 24]. The environmental parameters (physical-chemical water properties) were observed including temperature, pH, salinity, and dissolved oxygen directly in the field in each plot and 3 replications on it.

2.4. Data analyze

Pearson correlation analysis is one of the statistical analysis techniques used to analyze the correlation between mangrove litter and physical-chemical of water, and mangrove density using IBM SPSS Statistics software or commonly called PAWS (Predictive Analytic Software). Pearson correlation analysis used the dependent variable and the independent variables.

3. Result and Discussion

3.1. Litter mangrove production

Mangrove community in Pusung Cium Island, Aceh Tamiang consisted of 3 families covered by 5 genera and 6 species, namely Rhizophora apiculata (RA), Rhizophora mucronata (RM), Avicennia alba (AA), Bruguiera gymnorrhiza (BG), Ceriops decandra (CD) and Soneratia alba (SA). A alba is dominance species in research area. A alba is a pioneer species in mangrove swamp which protected coastal area, it can growth not only in salty condition influenced by tides but also can adapt well in substrate dominated by sand fraction [25].

The results showed that the total litter production at all stations was 35.65 gr/ m²/day and the total of litter production at station 1, 2 and 3 was different, with the value 15.17 g/m²/ day, 11.49 g/m²/ day, and 8.99 g/m²/ day, respectively. In detail, litter production of mangrove ecosystem explained in Table 1. The litter production in present study is less than litter production in Northern coast, Aceh besar reported by Dewiyanti [13] with value 52.05 g/m²/ day (seaward) and 43.32 g/m²/ day (landward). This differences was caused by several factors such as mangrove species, mangrove density, and environmental factors. The largest litter production in the island of Pusung Cium was at station 1 due to the highest mangrove density. The density on mangrove in station 1 was 119 ind/100m² followed by station 2 and 3 (96 ind/100m² and 85 ind/100m²). Tree density certainly affects the production of litter produced at each
station. The higher the density of mangrove, the higher the production of litter produced [26]. Similar pattern recorded by Zhila [27] mangrove vegetation in natural condition will produce litter 5% higher than the degraded mangrove.

The component of litter was primarily contributed by leaves followed by twigs, organ reproductive (fruit and flower), and barks. Leaves litter production were 13.09 g/m²/day (station 1), 8.81 g/m²/day (station 2), and 7.37 g/m²/day (station 3). The composition of leaves which accounted for 77-86% of total litter production in study area (Figure 2). This is similar with the previous study done by [13, 28-31].

**Tabel 1.** Mangrove litter production in study area

| Station | Species | Component (g/m²/day) | Total |
|---------|---------|----------------------|-------|
|         |         | Leaves | Twig | Bark | Fruit, flower |       |
| 1       | A.A     | 5.74   | 0.88 | 0    | 0.06          | 6.68  |
|         | R.M     | 0.19   | 0.04 | 0.04 | 0             | 0.28  |
|         | S.A     | 0.11   | 0    | 0    | 0.23          | 0.33  |
|         | R.A     | 5.40   | 0.61 | 0    | 0             | 6.01  |
|         | B.G     | 1.21   | 0.19 | 0    | 0             | 1.41  |
|         | C.D     | 0.44   | 0.01 | 0    | 0             | 0.45  |
| Total   |         | 13.09  | 1.75 | 0.04 | 0.29          | 15.17 |
| Average |         | 2.18   | 0.29 | 0.01 | 0.05          | 2.53  |
| 2       | A.A     | 8.06   | 0.85 | 0.53 | 0.11          | 9.55  |
|         | R.A     | 0.49   | 0.51 | 0.15 | 0             | 1.15  |
|         | B.G     | 0.05   | 0.45 | 0    | 0             | 0.50  |
|         | C.D     | 0.21   | 0.07 | 0    | 0             | 0.28  |
| Total   |         | 8.81   | 1.89 | 0.68 | 0.11          | 11.49 |
| Average |         | 2.20   | 0.47 | 0.17 | 0.03          | 2.87  |
| 3       | A.A     | 6.92   | 1.30 | 0.11 | 0.20          | 8.53  |
|         | C.D     | 0.06   | 0    | 0    | 0             | 0.06  |
|         | B.G     | 0.39   | 0    | 0    | 0             | 0.39  |
| Total   |         | 7.37   | 1.30 | 0.11 | 0.20          | 8.99  |
| Average |         | 2.46   | 0.43 | 0.04 | 0.07          | 3.00  |
| Total   |         | 35.65  |      |      |               |       |

_A alba_ species contribute the higher litter production not only leaves but also twig, bark, and organ reproductive than other species. The mangrove species at station 1 was dominated by _A alba_ and _R apiculata_, while both stations 2 and 3 were dominated by _A alba_. The shape and size of the _A alba_ leaves smaller than _R. apiculata_ leaves which causes this leaves easy to be shed off by wind gust and rain exposure. _A alba_ contributed as much as 9.55 (g/m²/day) in the station 2, followed by station 3 and 1 because of dominant species in research study. Leaves as the highest litter component assumed that the shape of leaves and size which are wide and thin, making it easy to fall off. Moreover, it is also caused by the physiological properties of the leaves, where the leaves play an important role in the photosynthesis process to produce carbohydrates. On the other hand, leaves will experience shedding and will be replaced by relatively young leaves [32]. Climate and environmental condition such as high temperature and wind significantly affected leaf fall easier than other component [28]. In detail, figure 2 showed the litter component composition in study area.

The production of fruit and flower litters was less, this was because the mangrove species observed were not in the fruiting and flowering season. According to Wetlands international, _A alba_ or known as fires bear fruit in January, while the research was conducted in October-November so that only a few fruit components were produced.
3.2. Mangrove density

The mangrove density was divided into 3 locations that have different density levels for each station. Table 2 showed that the station with the highest density was obtained at station 1 with a density of 119 ind/100m², station 2 with a moderate density 96 ind/100m² and the lowest density is at station 3 (85 ind/100m²). Tree density certainly affects the production of litter produced at each station. This is in accordance with the results of the study which showed that the highest amount of litter production was at station 1 and the lowest litter production was at station 3 with the lowest density level as well.

3.3. Carbon nutrient content

The highest carbon nutrients content in leaf was *A. Alba* (29.64%), while the lowest carbon content was obtained from *Rhizophora apiculata* (25.67%). The nutrient content of C-organic in mangrove leaf litter is higher than nutrients in elements N, P and K. This is because C-organic has the most important role compared to elements N and P which act as a limiting factor. In line with [33] opinion that 45% to 50% of plant dry matter consists of carbon content. The carbon content in plants describes how much these plants can bind CO₂ from the air. Some of the carbon will be used as energy for plant physiological processes and some will enter the plant structure and will become part of the plant, such as cellulose stored in stems, twigs, roots and leaves [34].

### Table 2. Mangrove density in study area

| No | Species                        | Leaves Carbon Component (%) | Mangrove density |
|----|--------------------------------|----------------------------|------------------|
|    |                                |                           | Station 1 | Station 2 | Station 3 |
|    |                                |                           | Tree Sapling | Tree Sapling | Tree Sapling |
| 1  | *Rhizophora apiculata*         | 25.67                     | 9          | 58        | 14        | 0           | 1           | 1           |
| 2  | *Rhizophora mucronata*         | 28.99                     | 2          | 0         | 0         | 0           | 0           | 0           |
| 3  | *Avecennia alba*               | 29.64                     | 17         | 14        | 49        | 31          | 26          | 46          |
| 4  | *Sonneratia alba*              | 29.58                     | 2          | 0         | 0         | 0           | 0           | 0           |
| 5  | *Bruguiera ghynmoriza*         | 29.11                     | 0          | 10        | 0         | 1           | 0           | 7           |
| 6  | *Ceriop decandra*              | 28.99                     | 0          | 7         | 0         | 1           | 0           | 4           |
|    | **Total**                      |                           | 30         | 89        | 63        | 33          | 27          | 58          |
|    | **Total each station**         |                           | 119        | 96        | 85        |              |             |

Tree (ind/100 m²), Sapling (ind/25 m²)

3.4. The correlation between mangrove litter production and mangrove density, physical and chemical water properties

There is a significant correlation between mangrove litter production with temperature, salinity and mangrove density where P sig<0.05, but there is no significant correlation between litter production with DO and pH (P sig> 0.05). The results of Pearson correlation analysis can be seen in table 3. Pearson correlation showed that temperature and mangrove density have higher values compared to other parameters, with value of (0.677 and 0.672), these parameters have a strong correlation to mangrove litter productivity. Criteria to determine the correlation level based on [35] interpreted that the coefficient correlation 0.6 – 0.79 is strong and 0.40 - 0.59 is moderate. The positive correlation for temperature and mangrove density indicates higher the temperature would result higher litter production due to evaporation which causes litter fall rapidly, in particular leaf component. High air temperature
will cause a decrease in air humidity, then transpiration will increase, and leaves will shed themselves to reduce the level of transpiration [36]. The highest water temperature in the study area at station 1 was 33°C, station 2 and 3 were 32°C and 3°C. The climate parameters such as winds and temperature strongly correlated with leaf litter production [28]. Furthermore, the correlation between mangrove density and litter production was high because station 1 has the higher density than station 2 and 3. The enhancement of mangrove density is linearly related to increase litter production and detritus [37]. Correlation between salinity and litter production was moderate correlation and it has negative correlations (-0.470), meaning that higher water salinity will effect low litter production. Similarly, [38] found that salinity levels did not affect the amount of litter produced. Otherwise, Andrianto et al. [39] reported that the salinity values obtained ranged from 26-32 ppt, it has strong effect on the mangrove litter production.

### Table 3. Pearson Correlation

| Variable          | Temperature | Salinity | DO  | pH   | Mangrove Density |
|-------------------|-------------|----------|-----|------|------------------|
| Average           | 31.72       | 26.39    | 5.65| 6.61 | 16.61            |
| Pearson Correlation | .677**     | -.470*   | .351| .309 | .672**           |

4. Conclusion

Litter production contributed 35.65 gr/m²/ day, with the largest contribution obtained in the leaf litter component (29.27 gr/m²/day). *A alba* was dominant species and it has the highest litter production contributed in the mangrove ecosystem. There was a significant correlation between temperature parameters, mangrove density, and litter production, which were 0.677 and 0.672. The positive and strong correlation occurred between temperature parameters, mangrove density, and litter production, but negative correlation between salinity and litter production. The higher mangrove density and water temperature would be higher litter produced and higher salinity could be less litter produced. There was no significant correlation between pH and DO of water with litter produced.

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