Litter Decomposition Rate of *Avicennia marina* and *Rhizophora apiculata* in Pulau Dua Nature Reserve, Banten

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**ABSTRACT**

Litter decomposition rate is useful method to determine forest fertility level. The aims of this study were to measure decomposition rate of litters from *Avicennia marina* and *Rhizophora apiculata* forest in Pulau Dua Banten, and analyze their nutrient content during the process. Litter was obtained using a trap system and the decomposition was done on the field. Our results showed that the decomposition rate of *A. marina* (k = 0.83) was higher than that of *R. apiculata* (k = 0.41). The k value was an average of C/N ratio further whom showed that litter decomposition rate in Pulau Dua Nature Reserve was relatively slow.

**Keywords**: *Avicennia marina*, leaf anatomical structure, litter decomposition, Pulau Dua, *Rhizophora apiculata*, salinity

**INTRODUCTION**

Mangrove leaf litter has a very important function for mangrove ecosystem, especially to maintain soil fertility. Soil fertility and plant growth are depending on the litter productivity and decomposition rate [1]. Decomposed litter contributes to the availability of organic matter in the forest soil as well as source of food for soil fauna. Accumulation of organic matter has a beneficial function to enrich the nutrient of the mangrove ecosystems as nursery grounds, spawning ground, and protection place for a variety of aquatic biota [2].

The stable decomposition process has a role to keep the nutrients supply to the soil. If decomposition process is too slow, nutrient availability will decrease. In the other hand, rapid decomposition process can cause the nutrient lost during soil leaching and evaporation, affecting to the disruption of plant growth [3].

Controlling factors effecting the rate of litter decomposition are pH, climate (temperature and humidity), the chemical composition of litter, and soil microorganisms [4]. pH affect the activity of cellulose enzymes produced by microorganisms such as fungi in the litter decomposition [5]. Temperature is a physical parameter that affects physiology properties microorganisms that live in the environment. The chemical composition from litter as organic carbon (C), nitrogen (N), and phosphor (P) to affect the speed of litter decomposition rates. According Aprianis (2011) [1], that the C/ is an indicator to see decomposition rate of organic material. Phosphorus is one of the essential nutrients due compound will be absorbed by phytoplankton and get into the food chain [6].

Geographically, Pulau dua is located between 06°01’SL and 106°12’EL. It is a lowland with total area of 30 ha. Vegetation type that grown in this island is mangrove community in which 60% dominated by *A. marina*, especially in the southern part of the island, while the eastern part is over-grown by *R. apiculata* [7]. Pulau Dua Nature Reserve is known as a habitat for many species of birds and a haven of migratory birds [8].

The mangrove ecosystem in Pulau Dua Nature Reserve has been degraded due to the expansion of aquaculture and accumulation of trash around the river. It was affects to the low density and uneven distribution of mangrove. The mangrove ecosystem has an important role to decomposition rate. Therefore, research on...
the decomposition rate of A. marina and R. apiculata litters in Pulau Dua Nature Reserve, Banten, was needed to be done.

This research is expected to basic data of management mangrove forest sustainable. In addition, this study can be used as additional information about decomposition rate of mangrove species that contributes to as the biggest contributor to the fertility of estuaries and coastal waters, so that stakeholders can optimize prioritized mangrove species to be planted in the area of Pulau Dua Nature Reserve Banten.

The aims of this study were to measure the rate of litter decomposition and nutrient content (organic C, N, and P) produced during decomposition process on the A. marina and R. apiculata in the Pulau Dua Nature Reserve, Banten.

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MATERIALS AND METHODS

**Time and place of research**

This study was conducted from August 2014 to May 2015 in Pulau Dua Nature Reserve Banten, on two forest community were A. marina and R. apiculata. Analysis of organic C, N, and P of leaf litter was carried out in the laboratory of Soil Research Institute Cimanggu, Bogor.

**Observation of litter decomposition rate**

Observation of litter decomposition rate was using litter bag method Ashton et al. (1999) [9], it was started with the collection of leaf litter for two weeks under the tree. Sample collection was carried out by putting 13 litter traps in each station. After two weeks, leaf litter was gathered and dried by oven with a temperature of 80°C (to constant weight). About 50 g of dried leaf litter from each station was analyzed for organic C, N, and P. The rest of leaf litter was put in 36 litterbags (size 30 × 40 cm with mesh size 2 mm), of 36 litterbags were filled by dried leaf litter (weight 35 g), tied to the roots or trees to avoid drifting sea water. Every fifteen days 6 litterbags were taken from the second observation station [9]. Litter sample was dried in oven at 80°C to achieve a constant weight, and the nutrient content i.e. organic C, N, and P was analyzed. The measurement of environmental parameters such as temperature, salinity, pH, and dissolved oxygen (DO) were performed in situ with 3 repetitions. The measurements of environmental parameters were done in the morning around 07.00-10.00 pm, at the same timing with litter bags collection.

**Results and discussion**

**The rate of decomposition**

The litter that fall to the forest ground will undergo the decomposition process. The weight of leaf litter decreased in each period of observations for 90 days. The percentage of the rest litter weight of A. marina and R. apiculata were significantly different (P = 0.001). The rest litter weight of A. marina was lower (31.3%) compared to R. apiculata (56.38%) (Figure 1). Constants (k) of the decomposition rate of A. marina and R. apiculata litters were 0.83 and 0.41, respectively. It was indicated that decomposition of A. marina leaf litter was faster than R. apiculata. Such condition was influenced by several factors, such as; morphology and anatomy of leaves, N element, substrate, physical and environmental factors.

**Measurement of leaf area**

About 30 healthy leaves and in the absence of holes from A. marina and R. apiculata trees were taken for the measurement of leaf area. Leaves were photographed using a camera and measured its area by using ImageJ software.

**Leaf anatomy**

Anatomical observation of leaf was done by using the frozen section technique: leaf prepare of A. marina and R. apiculata were made by slicing the leaf crosswise with a thickness of 20-30 µm using a freezing microtome. Sliced leaf was taken by using a pin and soaked in the petri dish containing chlorox, washed with water, and stained with safranin. After the staining, the sliced leaf was placed on the glass object, dropped by glycerin 30%, and covered by a cover glass. Prepare was observed under a microscope and photographed using optilab. Parameters measured were the arrangement, shape, and thickness of the tissue.
Leaf of A. marina has a different morphology compared than R. apiculata, it showed by the value Specific Leaf Area (SLA). Leaf of A. marina has SLA is larger (105.17 cm².g⁻¹) compared with R. apiculata (66.07 cm².g⁻¹). Garnier et al. (2004) [11] stated that there is a positive relationship between the SLA with the rate of leaf litter decomposition. Large SLA tends to have faster decomposition rate [12].

Leaf litter of A. marina has the nitrogen content higher than R. apiculata (Table 2). Based on Choong et al. (1992) [13], decomposers like the litter that has a high nitrogen content. In addition, the high rate of A. marina leaf litter decomposition was caused by environmental substrates [14]. Substrate in A. marina community dominated by mud, while in R. apiculata community by muddy sand. It is supported by the study of Syamsurisal (2011) [15] that prove that in the muddy soil microbial decomposers are more common than in the muddy sand soil. Mud accumulates a lot of organic material as a potential food for the organisms [16].

The anatomy layer of A. marina is thinner than R. apiculata leaf (Figure 2). A. marina has one layer epidermis, while R. apiculata has two layers epidermis. Decomposition rate was affected by the thickness of epidermis layers. Epidermis layer will protect the underneath tissue from the damage. The thicker epidermis layer has a lower decomposition rate. Salt gland of A. marina is wider than R. apiculata. Wider salt glands will have more microorganisms because the humid condition that supports litter decomposition process. This is consistent with Chapman (1976) [17] which describes salt glands has a role to hold the tide inundation and give the humid condition to support the activity of soil microorganisms in the leaf litter decomposition.

Environmental conditions greatly affect do to process of litter decomposition. Temperature, salinity, humidity, DO, and pH observed in the Pulau Dua Nature Reserve were still in a good range value for the decomposition process. Regression results indicated the environmental condition factors have significant effect on the decomposition rate of A. marina leaf litter (P = 0. 000), while the environmental condition factors did not have a significant effect on the decomposition rate of R. apiculata leaf litter (P = 0.078) (Table 1). Salinity value (P = 0.041) and DO (P = 0.000) have a significant effect on the rate of leaf litter decomposition of A. marina, while the salinity factor (P = 0.023) has a significant effect on the rate of leaf litter decomposition of R. apiculata.

Water salinity in A. marina community ranged of 25.33-27.87 psu, and the R. apiculata community ranged of 28.00- 29.67 psu. In both mangrove communities, the salinity of water was quite high. Yunasfi (2006) [18] reported that litter production at salinity 20-30 psu are less than salinity <10, 10-20, and >30 psu. Dix and Webster (1995) [19] reported that the salinity of 20-30 psu found more worms than the salinity of less than 20 psu or higher than 30psu. It indicates that fastest decomposition rate can be reached at salinity 20-30 psu. Worms has a role to break down the litter in which faster fragmentation of litter will affect to the faster rate of litter decomposition.

DO value of two communities in Pulau Dua Nature Reserve ranged between 5.60 – 8.20 ppm. The value of DO from this study was categorized quite high. The DO value need for macrobenthos ranges from 1.00 to 3.00 ppm [20]. Tahir (2012) [21] explained that greater DO content in ecosystem will affect to the better macrobenthos life. Lee et al. (1978) [22] categorized water quality based on the DO content namely; not polluted (< 6.5 ppm), lightly polluted (4.5 – 6.5 ppm), moderate polluted (2.0 – 4.4 ppm), and heavily polluted (<2.0 ppm). The value of DO in this A. marina community ranged between 5.70 – 8.20 ppm and R. apiculata community ranged between 5.60 – 7.80 ppm.

The releasing of nutrients from decaying organic matter is very important for the ecosystem. The nutrients will lost if the decomposing process is too fast due to the soil leaching and evaporation. Conversely, if the decomposing process is too slow, the plant growth will be disrupted because the lack of nutrient supplies [3]. In this study, nutrients matters i.e. C tended to decrease, N and P tended to increase (Table 2). This result has a similar case with Ulqodry (2008) [23] in which C content tended to decrease along with the decomposition period and litter size reduction.
The increasing of N content may be caused by the nitrogen-fixing bacteria role in the leaf litter [24]. Whereas the increase of the phosphor content according to Wijiyono (2009) [25] is due to the high decomposition rate that cause the release of phosphorus into the litter greater than to the environment.

P element content of the litter was lower than N because P is needed more compared to N. The P elements make up about 2/5 of the total microorganism ash. About 1/10 of P elements from N necessity are needed to arrange the cell. Total of phosphate levels in the water are classified into water with low fertility rate.
have a total phosphate ranging from 0 – 0.02 mg/L, water with moderate fertility rate ranging from 0.021 – 0.05 mg/L, and water with high fertility rate ranging from 0.05 – 0.1 mg/L [26]. Based on the classification above, A. marina belongs to the water with high fertility rate category, while R. apiculata belongs to the water with moderate fertility rate category.

Another factor that affecting the litter decomposition rate is the nutritional value of the leaves. The nutritional value can be analyzed from C/N ratio [9]. C/N ratio ranging between 25 : 1 and 30 : 1 is the optimum combination for rapid decomposition. [27]. If the C/N ratio is too high, the microbes will lack of N supply for protein synthesis thus affecting to the slow decomposition process. C/N ratio of A. marina leaf (21.53) was lower than R. apiculata leaf (26.56), which causes leaf decomposition process of A.marina was faster than R. apiculata. Low C/N value showed high content of nitrogen and its indicated the rapid decomposition rate [7]. The value of C/N ratio in pulau dua nature reserve, banten indicated that the litter decomposition rate is relatively slow.

CONCLUSION

The average of leaf litter decomposition rate A. marina faster (0.83) than the leaf litter R. apiculata (0.41), indicating that A. marina leaf litter contributes greatly to soil fertility forest mangroves in Pulau Dua Nature Reserve Banten. During the period of weathering litter A. marina and R. apiculata of N and P were removed more and more with the length of the litter weathering, contrary to the element C. The nutrients are released in succession P> N> C.

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