The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/9NZHC

RATE AND RELEASE OF NUTRIENTS IN DECOMPOSITION PROCESS IN MEDIUM HIGH TIDES AREA, MUARA ANGKE MANGROVE PROTECTED FOREST

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Abstract

The Angke Kapuk Protected Forest is a mangrove area managed by the Provincial Government of DKI Jakarta which functions as a life help system safety to regulate water management, prevent flooding, control erosion, save sea water intrusion, and maintain soil fertility. This study aims to estimate the rate of decomposition of *Avicennia marina* leaf litter and to analyze the macro nutrient N, P, K, and C-organic content in *Avicennia marina* leaf litter during the decomposition process. The method used in this study was 200 grams of dried *Avicennia marina* leaf litter, put in a 40 x 30 cm litter-bag made of nylon with a mesh size of 1 x 1 mm, then the litter bags were placed systematically and spread throughout the sub-plots. The decomposed leaf litter was removed from the mud and then dried to obtain wet weight data. After taking the wet weight data, it is then baked in the oven at 65℃. The dried litter was then weighed as dry weight and analyzed to obtain the results for the levels of macro-nutrients N, P, K and C-organic. The highest rate of decomposition of *Avicennia marina* leaf litter occurred on the 15th day. The remaining litter on the 15th day was 96.949 g and on the 120th day it was 157.887 g. The increase and decrease in yield from the analysis of N, P, K and C-organic nutrients in *Avicennia marina* leaf litter was influenced by several environmental factors such as weather, humidity, salinity and other factors.

Keywords: Medium-High Tides Area, Angke Kapuk Protected Forest, *Avicennia marina,* Decomposition Rate, Macro Nutrients

INTRODUCTION

The mangrove ecosystem is one of the aquatic ecosystems that has a high level of productivity. It grows and develops in the intertidal area and is influenced by tides and environmental fluctuations that change at any time. Mangrove ecosystems are generally found in tropical areas and only partially in subtropical areas. Mangroves have an important role because they are the place where complex relationships occur between physical, chemical and biological properties. The existence of mangrove ecosystems in coastal waters is a very potential habitat for the life of various aquatic biota (Alamsyah et al., 2018).

The mangrove forest area is inundated by regular tides, so the mangrove forest environment is saline and the soil is saturated with water. Under waterlogged conditions, it is difficult for oxygen to penetrate the roots of mangrove trees. These trees need to adapt, such as forming certain roots, one of which is a breathing root so that oxygen can be absorbed. The trees in the mangrove forest try to survive by fulfilling their needs even though they face obstacles in getting them. One of the needs of living things is oxygen (O2). The roots in mangrove forests

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ISSN 1533-9211
DOI 10.17605/OSF.IO/9NZHC

also need oxygen to burn carbohydrates in the roots, thereby producing energy so they can carry out activities such as absorbing elements and absorbing water (Robianto et al., 2020).

Mangrove litter has an important role in the fertility of coastal waters because decomposed mangrove litter will produce nutrients that are absorbed by plants and used by microorganisms on the forest floor, then some of it will likely be dissolved and carried away with the aid of low tide into the encircling waters (Saibi and Tolangara 2017). Decomposition is an important process in ecosystem functioning. Decomposition of mangrove litter, mainly leaf clutter, contributes most of the nutrients to sediments and surrounding waters. Most effective a small portion of rotted leaves is fed on at once by herbivorous animals, while mangrove detritus is a potential source of natural material for meals webs in estuaries (Mahmudi et al., 2011).

Decomposition is the manner of destroying or decomposing dead organic matter achieved by way of organic sellers into mineral materials and organic colloidal humus. Consequently, the decomposition of organic depend is also regularly referred to as the technique of mineralization. This system is a microbial system in obtaining strength for its proliferation. The elements that affect the decomposition technique of organic matter from the decomposer side are temperature, humidity, salinity, and pH. This system performs a very big position inside the power cycle and meals chain in mangrove ecosystems (Andrianto et al., 2015). The role of trees in the nutrient cycle is through the absorption of nutrients from the soil and the release of nutrients through dead tissues. The part of the tree that is most often aborted and decomposed is the leaves. Fallen leaves have a higher transfer of nutrients from vegetation to the forest floor compared to fallen branches and rainwater leaching. The release of nutrients due to the decomposition process increases soil fertility, not only increasing fertility through the addition of nutrients but leaf fall under the trees will also increase the number of soil animals that are beneficial for soil aeration (Wowor et al., 2019).

The Angke Kapuk Protected Forest is a mangrove area managed by the Provincial Government of DKI Jakarta with an area of 44.76 hectares. The principle function of the Angke Kapuk protection forest is as a tools to change the water system, prevent flooding, control erosion, save seawater intrusion, and preserve soil fertility. The Angke Kapuk Protected Forest is one form of green open space in DKI Jakarta. Research on decomposition in the protected mangrove forest of Angke Kapuk will be limited to *Avicennia marina* leaf litter in areas of medium high tides, which are inundated 9 to 20 times a month. The selection of *Avicennia marina* species was based on the consideration that this species was the dominant species in the study area.

Limited information about the rate of decomposition of mangrove leaf litter has resulted in people not being concerned about the importance of the benefits of mangroves and the presence of litter which can increase nutrient content. This study aims to estimate the rate of decomposition of *Avicennia marina* leaf litter and to analyze the macronutrient content of N, P, K, and C-organic in *Avicennia marina* leaf litter during the decomposition process.

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MATERIALS AND METHODS

Location and Time Period of Research

This research was conducted from September 2022 to January 2023 in the Angke Kapuk Protection Forest area, Jakarta. Dry weight was measured at the Forest Ecology Laboratory, Analysis of macro nutrients N, P, K and C-organic was carried out at the Agronomy and Horticulture Laboratory, Faculty of Forestry and Environment, Bogor Agricultural University.

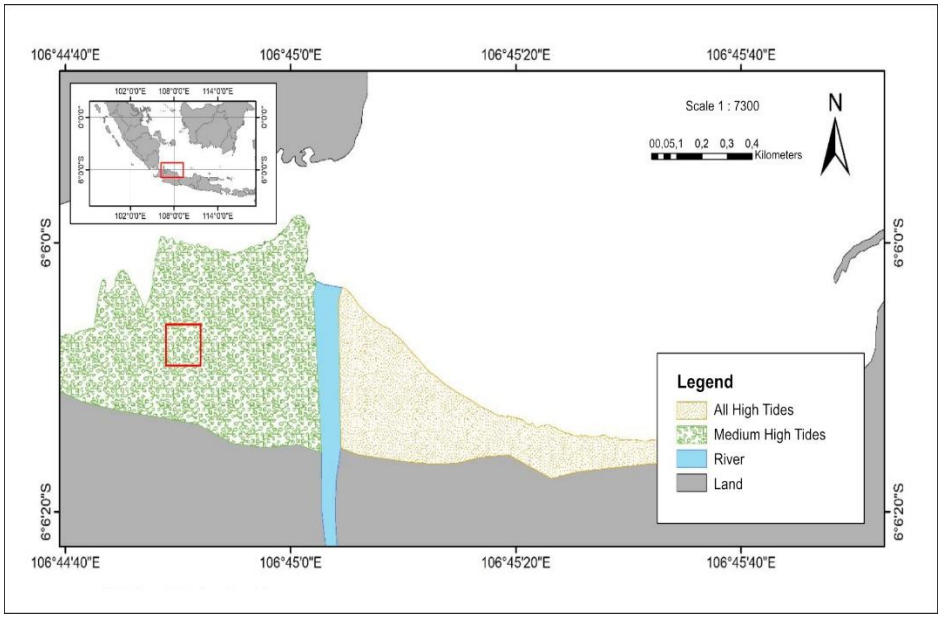

Figure 1: Research area

Tools and materials

The tools used in this research were litter bags made of nylon with a mesh size of 1 x 1 mm, aluminum foil, permanent markers, hand refractometers, ovens, analytical scales, sewing needles, sewing thread, cutters, ropes, digital cameras, plastic samples, bottles samples, paper envelopes, stationery, hagameter, GPS, compass, tally sheet, thermohygrometer, DO meter, pH meter. The materials used in this research were *Avicennia marina* leaf litter and bamboo stakes.

Research Methods

Field observations in this study used the permanent plot method modified by Hurst and Allen's (2007) method. The location has been determined, namely in the area of medium high tides, a permanent plot measuring 100 x 100 meter was made. The permanent plot was divided into several sub-plots with an area of 20x20 meter.

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DOI 10.17605/OSF.IO/9NZHC

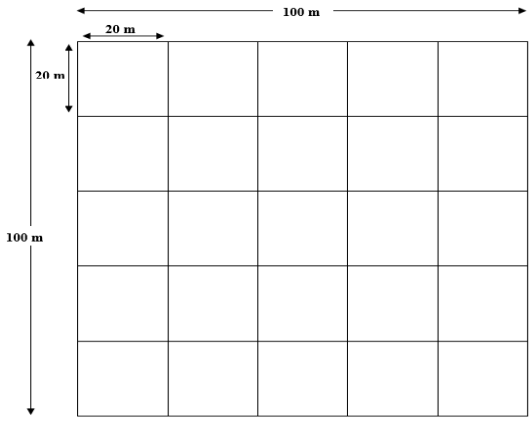

Figure 2: Layout of a permanent plot at the research site based on modification of permanent plot in Hurst and Allen (2007)

Decomposition Rate

As much as 200 grams of dried *Avicennia marina* leaf litter was put into a 40 x 30 cm litter bag made of nylon with a mesh size of 1 x 1 mm. Totally 40 litter bags are tied spreadon within the sample plot. The permanent plot measuring 100 x 100 meter is divided into 20 x 20 meter sub-plots of 25 sub-plots and then the litter bags are placed systematically and spread throughout the plots. To avoid being washed away by the tide sea water, a rope is attached to the end of the bag and tied to the roots or trunk of a mangrove tree, if there are no roots or stems to tie the bag of litter, the rope is tied to a bamboo stake with a length of 1 – 1.5 meters or adjusting to the depth sludge at the study site. A complete of five containing litter bag were taken from each area every 15 days for up to four months of observation. At each sampling, data were taken for measuring temperature, humidity and also light intensity on the soil surface in the litter. The decomposed leaf litter that has been taken will be cleaned of silt and then air-dried to obtain wet weight data. After taking the wet weight data, it is then dried in the oven at 65℃ for 72 hours until the weight is constant (Kamruzzaman et al., 2019). The litter that has been baked is placed in a desiccator and then weighed as dry weight, where the moisture content of the decomposed litter is obtained from the difference between the wet weight and dry weight. Except that, the dry weight of the decomposed leaf clutter can be entered to look the charge of decomposition of *Avicennia marina* leaf muddle the use of the method from Olson (1963).

Nutrient Levels N, P, K dan C-organic

Measurement of nutrient levels N

About 0.2500 g of the litter sample positioned it within the digest tube. Added 1 g selen mixture and 3 mL concentrated sulfuric acid. Destructed at 350℃ for 3-4 hours, the digestion is complete while white steam comes out and a clear extract is obtained (approximately 4 hours). The tube changed into removed, cooled and then the extract changed into diluted with ion-free water until exactly 50 mL, stirred till homogeneous, left in a single day for the debris to settle.

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The extract is used for N measurement by means of distillation. Pipette 10 mL of clear extract right into a vapodest tube, add 10 mL of 40% NaOH. prepare a field for the liberated NH3, particularly an Erlenmeyer containing 10 mL of 1% boric acid plus 3 drops of Conway's indicator (red color), vicinity it in a vapodest. Distilled until the volume of the box reaches 50-75 mL (inexperienced). The distillate become titrated with 0.050 N H_2SO4 to a pink color. Then report the sample titar quantity (Vc) and blank (Vb).

Measurement of nutrient levels P

Pipette each 1 ml of sample extract and general collection right into a take a look at tube. Add 9 ml of deionized water and shake (10x dilution). Pipette 1 ml each of the aqueous extract of the sample and standard series right into a response tube and add 9 ml of coloring reagent P. Shake with a tube shaker until blanded and depart for half-hour. P in solution became measured the use of a UV-VIS spectrophotometer at a wavelength of 889 nm.

Measurement of nutrient levels K

Pipette each 1 ml of sample extract and standard series into a test tube. Add 9 ml of 0.25% La solution. Stir with tube stirrer until homogeneous. K in the extract was measured by AAS with a general collection as a comparison.

Measurement of nutrient levels C-organic

The ash content or residual glow is determined by means of ashing at a temperature of 550–600 ℃, so that the organic matter becomes CO_2 and the metal becomes the metal oxide. The weight of the lost material is organic matter which can be converted into C-organic content after multiplied by a factor of 0.58. Samples of decomposed *Avicennia marina* leaf litter that had been dried at 105 ℃ were put into the furnace and incinerated at 300 ℃ for 1.5 hours. Then continued heating with a temperature of 550–600 ℃ for 2.5 hours. After 2.5 hours the furnace was turned off and left overnight. After one night, the sample which had turned into ash was removed and cooled in a desiccator and then weighed.

DATA ANALYSIS

Decomposition rate

Measuring the average value of the rate of decomposition of litter can be calculated using the formula from Olson (1963) as follows:

$$X_t = X_o . e^{-kt}$$

$$Ln \frac{X_t}{X_o} = -kt$$

Note:

Xt: litter dry weight after the t-th observation time (g)

Xo: initial litter weight (g)

e: natural logarithmic number (2.72)

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k: litter decomposition rate

t: observation time (days)

Nutrient levels of N

Nitrogen Content (%) = (Vc-Vb) x N x bst N x 100/mg example x fk

= (Vc-Vb) x N x 14 x 100/500 x fk

= (Vc-Vb) x N x 2.8 x fk

Note:

Vc, b = mL of titar sample and blank

N = normality of H_2SO4 solution

14 = Nitrogen equivalent weight

100 = convert to %

fK = moisture content correction factor = 100/(100-% moisture content)

Nutrient levels of P and K

Levels of P, K, (%) = ppm curve x ml extract/1000ml x 100/mg sample x fp x fk

= ppm curve x 50 ml/1000ml x 100/500 x fp x fk

Note:

Ppm curve = sample rate obtained from the curve of the relationship between the standard series with the reading after correcting the blank.

Fp = Dilution factor

fK = moisture content correction factor = 100/(100-% moisture content)

100 = conversion to % (in % units)

Nutrient levels of C-organic

Leaf organic C content (%) = (W – W2) / W x fk x 0.58 x 100

Note:

W2 = weight of ash in grams

W = sample weight in grams

fk = moisture content correction factor = 100/(100 – % moisture content)

0.58 = conversion factor of organic matter to carbon

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RESULTS

Decomposition Rate

Every 15 days the rate of decomposition of *Avicennia marina* leaf litter was observed for 120 days. *Avicennia marina* leaf litter that undergoes decomposition shows different physical changes (Figure 3).

Figure 3: Physical changes of *Avicennia marina* leaf litter during process of decomposition from 15th to the 120th days: (a) 15th days, (b) 30th days, (c) 45th days, (d) 60th days, (e) 75th days, (f) 90th days, (g) 105th days, and (h) 20th days

It is noticed that the longer the observation time, the greater or increase in the percentage (%) of leaf litter weight loss. The average remaining litter of *Avicennia marina* leaves for 120 days can be seen on Figure 4.

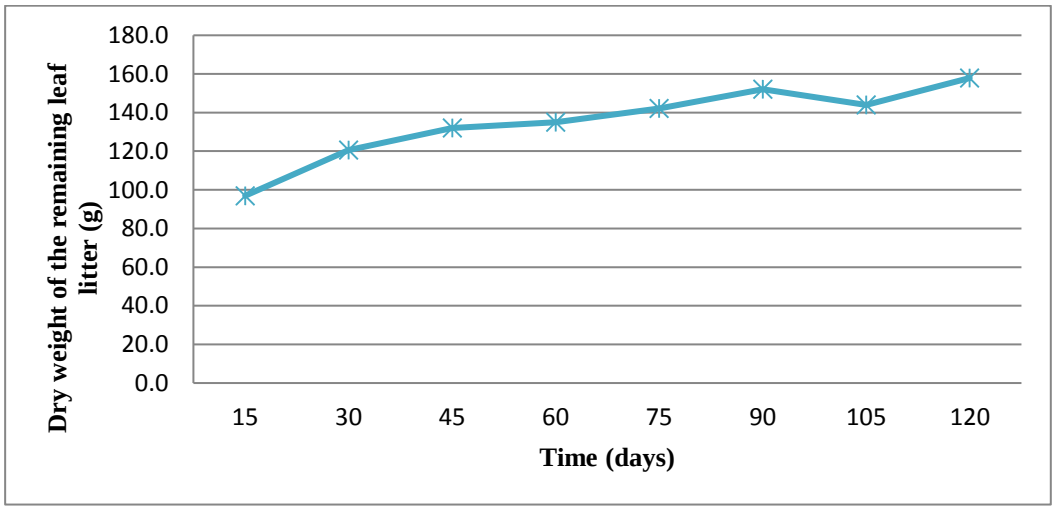

Figure 4: Remaining leaf litter during the time of decomposition

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ISSN 1533-9211
DOI 10.17605/OSF.IO/9NZHC

Based on Figure 4, the average dry weight of litter decreased drastically on the 15th day at the start of the observation. The longer the litter decomposed, the greater the weight loss percentage of litter. The decrease in the remaining litter weight observed on the 120th days was 157.887 g.

Based on the depreciation of the dry weight of the remaining *Avicennia marina* leaf litter above, it can be seen that the average value of the leaf litter decomposition rate for 120 days can be seen in Table 1.

Table 1: Average value of *Avicennia marina* leaf litter decomposition rate for every 15 days of measurement starting from the 15th day to the 120th day of observation

Time (Day)	Decomposition rate
15	0.044
30	0.031
45	0.024
60	0.019
75	0.017
90	0.016
105	0.012
120	0.013
Average	0.022

Based on the Table 1, the highest rate of litter decomposition occurred on the 15th days and then decreased with increasing time until on the 120th days. The average value of the decomposition rate for 120 days is 0.022.

Nutrient Levels N, P, K and C-organic

The value of N, P, K and C-organic nutrient analysis in decomposed leaf litter for 120 days can be seen in Table 2.

Table 2: Analysis of N, P, K and C-organic nutrients in leaf litter for 120 days

Days	Nutrient levels (%)			
	N-total	P	K	C-org
0	1.22	0.07	0.75	32.11
15	1.67	0.05	0.04	46.33
30	1.86	0.08	0.07	44.59
45	2.06	0.09	0.06	46.83
60	2.12	0.10	0.06	48.06
75	1.97	0.10	0.06	46.80
90	2.09	0.09	0.05	49.32
105	2.09	0.10	0.05	43.29
120	2.09	0.10	0.04	48.90

Based on Table 2, the highest N nutrient content (2.12%) was found in leaf litter that had decomposed for 60 days. The lowest N content of *Avicennnia marina* leaf litter was (1.22%), found in leaf litter that had not undergone decomposition. The highest P content (0.10%) and

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the lowest (0.05%). The highest K nutrient content (0.75%) was found in leaf litter that had not undergone decomposition. The highest levels of C-organic nutrients were found in litter that had decomposed for 90 days (49.32%) and the lowest (32.11%), in leaf litter that had not been decomposed.

DISCUSSION

The results showed that the highest decomposition rate occurred in the first 15 days. Highest litter decomposition in the first 15 days is thought to be due to the loss of litter organic matter due to the abundance of bacterial decomposition (decomposers) that occurred when the litter was first laid. This study shows results that are in accordance with research conducted by Setiawan (2013) that the remaining dry weight of leaf litter at various levels of salinity from the beginning today 15 experienced the greatest decomposition process. The speed of the process of changes in the rate of decomposition occurred in the first week of observation. The leaf litter decomposition process took place faster in the first week because the organic matter leaching process was fast, but the longer the observation time, the slower this was in accordance with Farooqui et al (2014) statement which stated that the leaching process of organic matter contained in leaf biomass will take region extra slowly as the period of time of commentary. Pradisty et al (2021) stated decomposition includes the sequential breakdown of organic matter into diverse inorganic nutrients through physical, biological and chemical pathways.

The reduction in litter weight that experienced drastic decomposition at the beginning of the observation on the 15th days was 96.949 g. The decrease in leaf litter weight was caused by the activity of macrobenthos which acts as a chopper to eat leaves. Related to this, Gultom (2009) stated that litter which decomposes during the decomposition period is assisted by macrobenthos that live on the mangrove floor. Macrobenthos is one of the early decomposers which crushes or chops the rest of the leaves are then removed again as dirt and then followed by microorganisms such as bacteria and fungi to decompose organic matter into proteins and carbohydrates.

The type of organism encountered and suspected of participating in accelerating the decomposition of *Avicennia marina* leaf litter is Nereis sp. found in *Avicennia marina* leaf litter that had decayed for 120 days. This worm is estimated to need *Avicennia marina* leaf litter as a food ingredient for its life. According to Dix and Webster (1995), the speed of litter decomposition is affected by the speed at which the litter is fragmented. This solution is mostly carried out by many soil animals such as slugs, worms, insect larvae and others. Furthermore, Kuter (1986) stated the presence of worms in the leaf litter caused the breakdown (fragmented) of the leaf litter to take place more quickly. Mamidala et al (2023) stated the role of large invertebrates in particular in breaking down clumps of mangrove leaves is that they have to change many of the decomposition mechanisms and then release vitamins into the coastal environment.

Litter contains nutrients that help establish the growth and development of plants, fish, shrimp, crabs and other microorganisms that live in mangrove forests. Litter that has a high nutrient content will experience the decomposition process faster. This is in accordance with Waring

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and Schlesinger, (1985) who stated that nutrient-rich litter tends to decompose faster than nutrient-poor litter on the same forest floor. Nitrogen content (N) is a nutrient that is donated directly or indirectly from the results of decomposition for the development of the mangrove growth itself. The increased content of N nutrients is thought to be due to N nutrients playing a role in the process of adaptation to the high salinity of the environment and relatively long tidal inundation so that the increase in time and duration of inundation provides support for increased nutrient content. According to Hardjowigeno (2003), the elements that affect the decomposition of organic matter are temperature, humidity, soil air conditioning, processing, and soil pH. These factors can also affect the total nitrogen content in the decomposition rate. The nutrient content of phosphorus (P) in *Avicennia marina* is needed for metabolic processes. The content of P nutrients increased from the 15th day of 0.05% to the 120th day of 0.10%. Handayani (2004) stated the content of nutrient P in litter is relatively low, due to the nature of P which easily moves within the plant so that if there is a deficiency of this element in a plant, the nutrient P present in the plant tissue will be released into the tissues which are still active so that the litter old ones will contain relatively small P.

One of the factors that causes the N nutrient content to increase is the role of bacteria in assisting the process of litter decomposition. This is in accordance with the statement of Steinke et al (1983) which states that the increasing of N content may be caused by the nitrogen-fixing bacteria function in the leaf litter. Whereas the increase of the phosphor content according to Wijiyono (2009) is due to the high decomposition rate that cause the release of phosphorus into the litter greater than to the environment. Mobilization of nutrients from leaf litter in tropical mangrove environments can also vary further, both in space and time, primarily based on several local elements including the frequency and intensity of tidal inundation, redox soils, and prevalence of mangrove roots, biota presence, and activity (Reef et al., 2010).

The content of C-organic nutrients with a decomposition time of 15 days was 46.33% and increased on the 120th day by 48.90%. Because at the time of observation the weather conditions were rainy so that there was a lot of carbon nutrients available. This is in accordance with the opinion Effendi (2003) which states that rain is a source of adding carbon to the waters because the rain contains carbon dioxide in the atmosphere. Carbon nutrients have increased due to the low level of salinity which makes the percentage value of carbon increase. The content of carbon nutrients from day 45 to day 120 increased because the observation area entered the rainy season so that the intensity of fresh water entering sea waters was high causing low salinity. In accordance with Gultom (2009), the nutrient content of carbon (C) at the initial conditions from day 15 to day 105 decreased at each level of salinity 0-10 ppt, 10-20 ppt, 20-30, >30 ppt. The percent value (%) of carbon decreases at high salinity >30 ppt. Effendi (2003) stated carbon dioxide levels in the waters can experience a reduction due to the photosynthesis and evaporation processes that occur. The carbon contained in the atmosphere and waters is converted into organic carbon through the process of photosynthesis.

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CONCLUSION

The highest rate of decomposition of *Avicennia marina* leaf litter occurred on the 15th day. The high litter decomposition in the first 15 days is thought to be due to the loss of litter organic matter due to the abundance of bacterial decomposition (decomposers) that occurred when the litter was first laid. The decrease in litter weight on the 15th day was 96.949 g. The increase and decrease in yield from the analysis of N, P, K and C-organic nutrients in *Avicennia marina* leaf litter.

Acknowledgements

The authors thank to the Office of Park and City Forest DKI Jakarta, for permission and supporting this research, and also thank to some forest rangers for their kind support and assistance during data collection and the field survey.

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