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NUTRIENTS FROM *Avicennia alba* AND *Rhizophora mucronata* IN MANGROVE AND CRAB CONSERVATION AREA, TARAKAN CITY

Nutrient Dari *Avicennia alba* Dan *Rhizophora mucronata* di Kawasan Konservasi Mangrove Dan Kepiting Kota Tarakan

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ABSTRACT

Mangrove ecosystems exhibit high productivity resulting from the decomposition of litter, which contains various nutrients such as carbon, nitrogen, and phosphorus that benefit both the mangrove plants themselves and the surrounding aquatic ecosystems. This study aims to determine the nutrient content (carbon, nitrogen, and phosphorus) of decomposed litter from *Avicennia alba* and *Rhizophora mucronata*. The study was conducted in the Tarakan City Mangrove and Crab Conservation Area, North Kalimantan, from April to June 2026, using a quantitative method with a descriptive-exploratory approach, taking into account the characteristics of the dominant mangroves at three study sites. The results showed that the decomposition rate of *A. alba* mangrove litter ranged from 0.22 to 0.64 grams/day and that of *R. mucronata* ranged from 0.25 to 0.67 grams/day; furthermore, no leaf litter from either *A. alba* or *R. mucronata* decomposed 100%. The carbon content of *A. alba* ranged from 9.45% to 13.45%, nitrogen from 0.64% to 0.72%, and phosphorus 0.25% to 0.29%, while the carbon content of *R. mucronata* ranged from 21.50% to 22.45%, nitrogen from 0.58% to 0.83%, and phosphorus from 0.06% to 0.009%. The values of the physical and chemical parameters of the water still support the decomposition process of litter.

Key words: Nutrient, mangrove litter, *Avicennia alba*, *Rhizophora mucronata*

ABSTRAK

Ekosistem mangrove memiliki produktivitas yang tinggi berasal dari dekomposisi serasah yang mengandung berbagai nutrient seperti karbon, nitrogen dan fosfor yang bermanfaat bagi tanaman mangrove itu sendiri dan ekosistem perairan sekitarnya. Penelitian ini bertujuan untuk mengetahui kandungan nutrient (karbon, nitrogen dan fosfor) dari serasah *Avicennia alba* dan *Rhizophora mucronata* yang terdekomposisi. Penelitian dilakukan di Kawasan Konservasi Mangrove dan Kepiting Kota Tarakan, Kalimantan Utara, Indonesia pada bulan April sampai dengan Juni 2026 menggunakan metode kuantitatif dengan pendekatan deskriptif eksploratif dengan mempertimbangkan karakteristik mangrove yang dominan pada tiga titik lokasi. Hasil penelitian didapatkan laju dekomposisi serasah mangrove jenis *A. alba* berkisar 0.22 - 0.64 gram/hari dan *R. mucronata* berkisar 0.25 - 0.67 gram/hari serta tidak ada serasah daun yang terdekomposisi 100% baik dari jenis *A. alba* maupun *R. mucronata*. Kandungan karbon *A. alba* berkisar 9.45% - 13.45%, nitrogen 0.64% - 0.72%, dan fosfor 0.25% - 0.29% sedangkan kandungan karbon *R. mucronata* berkisar 21.50% - 22.45%, nitrogen 0.58% - 0.83%, dan fosfor 0.06% - 0.009%. Nilai paremeter fisika dan kimia perairan masih mendukung untuk proses dekomposisi serasah.

Kata Kunci: Nutrient, Serasah mangrove, *Avicennia alba, Rhizophora mucronata*

INTRODUCTION

Mangrove ecosystems accumulate nutrients in coastal environments derived from the decomposition of leaf litter and contribute to aquatic productivity (Selviani et al., 2024). One of the main mechanisms in the nutrient cycle in mangrove ecosystems is through the production and decomposition of litter, which consists of leaves, twigs, flowers, fruit, and bark. Mangrove litter contains various organic nutrients such as carbon, nitrogen, phosphorus, potassium, and other micronutrients that are essential for the growth of aquatic organisms and the growth of the mangroves themselves (Rahman *et al*., 2024).

Carbon is largely derived from mangrove litter and contributes significantly to the accumulation of organic carbon in the mangrove substrate. Leaf litter from species such as *Rhizophora apiculata* contains over 50% carbon, emphasizing the importance of litter dynamics in the carbon cycle (Das *et al*., 2021). The decomposition process of mangrove litter can release nitrogen back into the ecosystem, indicating that mangrove leaf litter contains measurable levels of nitrogen, thus increasing the nutrient content of the surrounding soil and waters (Destiana & Darwati 2021). Phosphorus availability is equally important, albeit at lower levels, as it significantly impacts the growth and reproductive success of marine organisms that depend on water fertility. The release of phosphorus from decomposing mangrove litter contributes to improved nutrient conditions in the marine environment, thereby increasing aquatic biodiversity (Purnobasuki *et al*. 2023).

Kawasan The Mangrove and Crab Conservation Area (KKMK) is a mangrove ecosystem that has experienced changes in community structure due to degradation. Before being designated as a mangrove conservation area in 2002, the dominant mangrove species found was *Avicennia alba*, while currently the dominant species has changed to *Rhizophora mucronata* (Yulma & Wijayanti, 2024). Changes in mangrove community structure can disrupt the function of mangroves as coastal protectors, biodiversity, and nutrient cycles derived from litter decomposition. This also changes the flow of nutrients to other surrounding coastal ecosystems such as coral reefs and seagrasses because variations in tree height and density can affect nutrient retention and cycle dynamics in coastal areas (Castañeda-Moya *et al*. 2020). Based on this, it is necessary to conduct research on the nutrient content (carbon, nitrogen, and phosphorus) of decomposed mangrove leaf litter *A. alba* and *R. mucronata*.

RESEARCH METHODS

Time and Place of Research

The research was conducted in the Mangrove and Crab Conservation Area (KKMK) of Tarakan City, North Kalimantan, Indonesia from April to June 2026 (Figure 1).

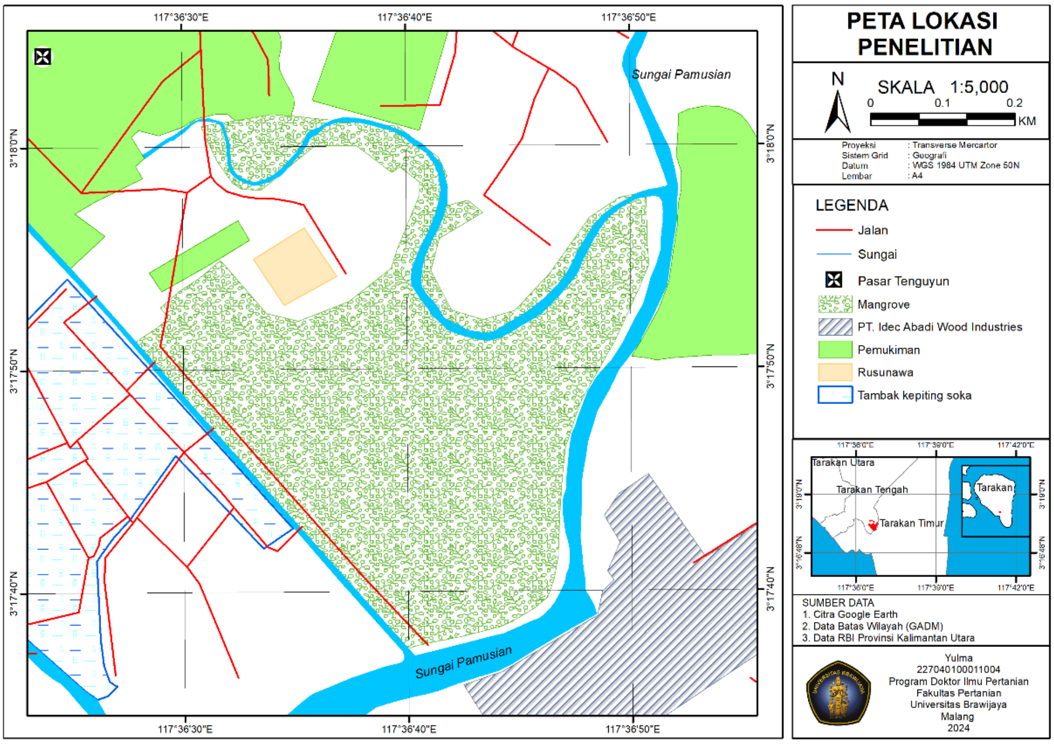

Figure 1. Research Location Map

Research Methods

This study used a quantitative method with a descriptive exploratory approach. Mangrove leaf litter sampling was carried out using a purposive sampling method by considering the dominant mangrove characteristics at three locations. Mangrove leaf litter of *A. alba* and *R. mucronata* was collected using a litter container measuring 2 x 2 m. Next, the leaf litter was dried at a temperature of 105°C until its weight was constant and put into 144 litter bags measuring 30 x 30 cm with a weight of 20 grams per bag. Litter bags were installed at each point, each with 48 bags and tied to the roots or stems of *A. alba* and *R. mucronata* mangroves. Measurements of decomposition rates and nutrient content were observed at intervals of 14, 28, 42, and 56 days.

Data Analysis

The decomposition rate value is calculated using the formula (Olson, 1963):

$$Xt = X0.\ e^{-kt}$$

$$\text{So: } \ln (Xt/X0) = -kt$$

Information :
Xt : litter weight after the t-th observation period
X0: initial litter weight
e: natural logarithm (2.72)
k: decomposition rate value
t: observation period

Carbon Analysis

The method for carbon testing uses the Walkey and Black method with the formula:

C- organic (%) = ppm kurva x ml ekstrak/1.000 ml x 100/mg sample x fk

Information:
ppm curve = sample concentration obtained from the relationship curve between series levels standard with its reading after correction for blanks.
100 = conversion to %
Fk = water content correction factor = 100 / (100 – % water content).

Nitrogen Analysis

The total nitrogen testing method uses the Kjeldahl method with the formula:

$$\% N = \frac{(V_2 - V_1) \times F}{10 \times S} \times 1.4$$

Information:
V_1 = Volume of H_2SO_4 used to titrate the blank solution (0)
V_2 = Volume of H_2SO_4 used to titrate the sample
F = dilution factor (1)
S = Sample weight (2 g)
1.4 = Constant
10 = Titration volume

Phosphorus Analysis

The method of testing organic phosphorus in organic materials uses UV-Vis spectrophotometry with the formula:

$$P\% = \text{ppm curve} \times 0{,}04 \times \frac{142}{62} \times fp \times fk$$

Information :
P% = Organic matter elements
ppm curve = sample content obtained from the relationship curve between the standard series content and the reading after blank correction
Fp = Dilution factor (10)
Fk = Water content correction factor
142/62 = conversion factor from P to P_2O_5

RESULTS

The Mangrove and Crab Conservation Area (KKMK) shows a decrease in area due to community activities such as fish farming, settlements, expansion of traditional markets, transportation routes, and river widening, resulting in a change in the dominant community structure from *Avicennia alba* to *Rhizophora mucronata*. Damage to the mangrove ecosystem will affect the KKMK's function as a mangrove protection area, nutrient producer, and as a protected habitat for mangrove crabs (*Scylla serrata*).

Litter decomposition rate

The results of observations of the decomposition rate of leaf litter from the A. alba species ranged from 0.22 to 0.64 g/day while R. mucronata ranged from 0.25 to 0.67 g/day (Figure 3), these results also show that no leaf litter has experienced 100% decomposition (Figure 4).

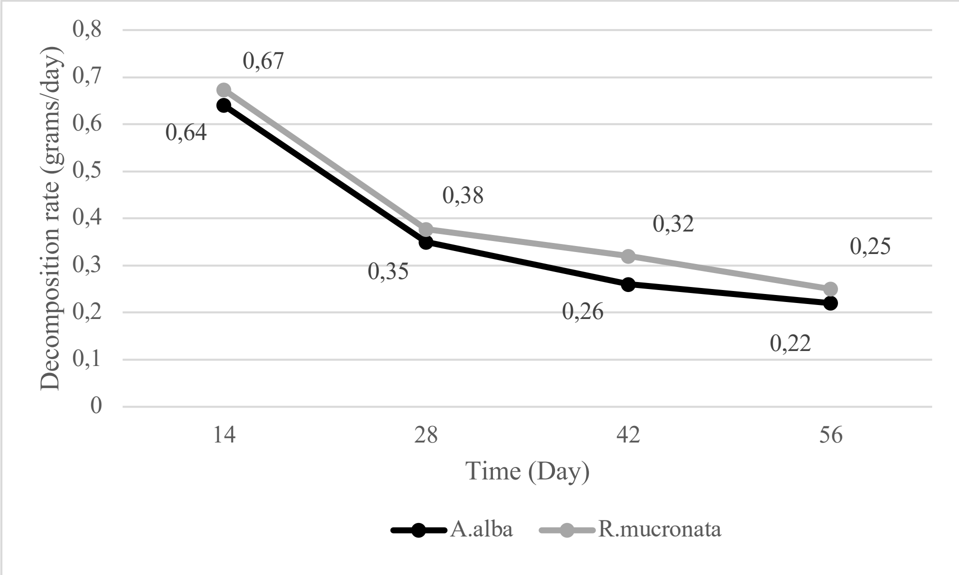

Figure 3. Decomposition rate of mangrove leaf litter *A. alba* and *R. mucronata*

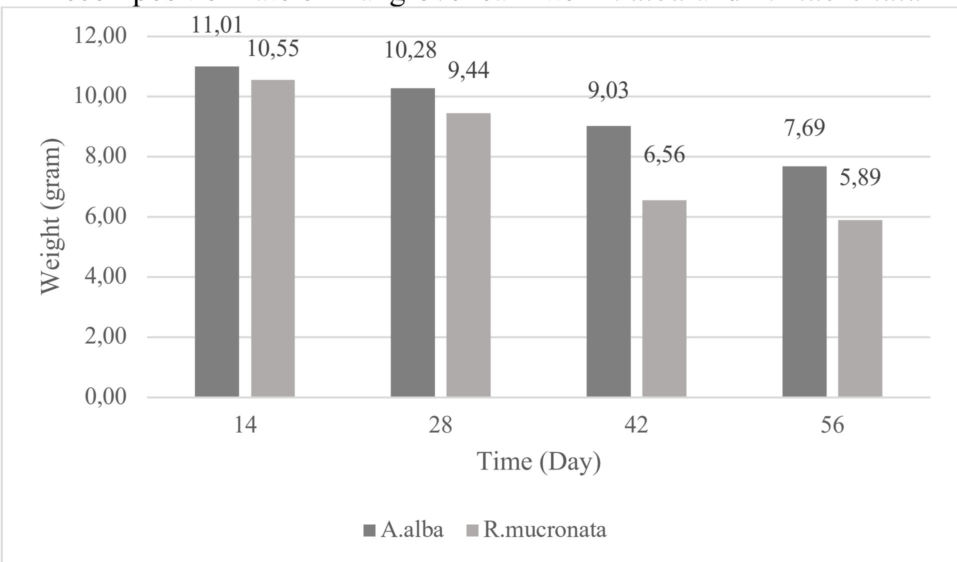

Figure 4. Remaining dry weight of mangrove leaf litter *A. alba* and *R. mucronata*

The nutrient content of mangrove leaf litter *A. alba* and *R. mucronata* is shown in Figure 5 and Figure 6, while the physical and chemical parameters of the water are shown in Table 1.

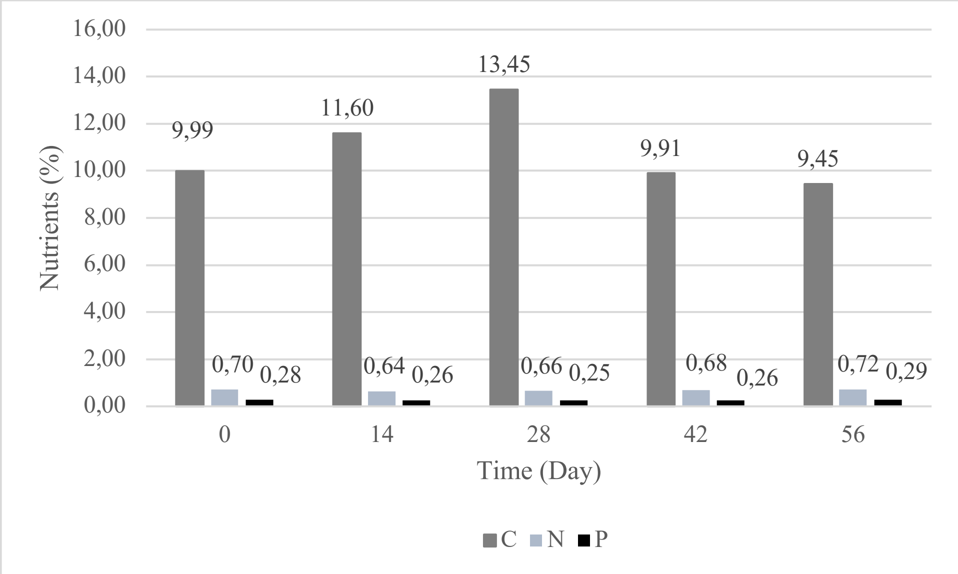

Figure 5. Nutrient content of *A. alba* mangrove leaf litter

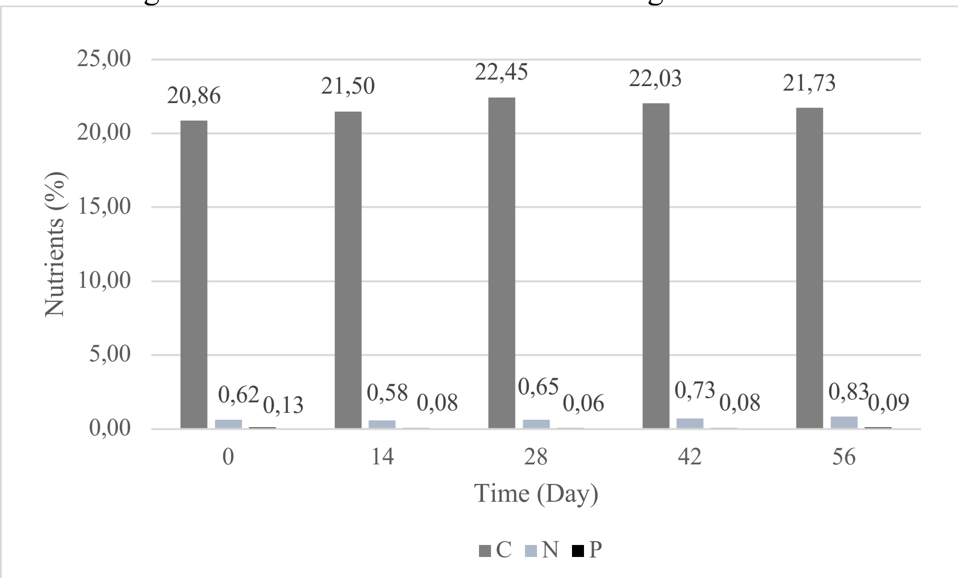

Figure 6. Nutrient content of *R. mucronata* mangrove leaf litter

Table 1. Values of physical and chemical parameters of water

No.	Parameter	Units	Mark
1.	Temperature	^{0}C	27-29
2.	Salinity	ppm	25-33
3.	pH	-	5.80-8.21
4.	DO	mg/L	3.00-5.40

DISCUSSION

Differences in the Decomposition Rate of Mangrove Leaf Litter *A. alba* and *R. mucronata*

Differences in litter decomposition rates are influenced by internal factors (the nature of the litter itself) and external factors (the environment and decomposing organisms). In this study, *R. mucronata* exhibited a faster decomposition rate (0.25-0.67 grams/day) than *A. alba* (0.22-0.64 grams/day), due to several factors such as leaf structure, chemical composition, and water content. This finding aligns with Ahmed & Shaukat (2021) who found that *Rhizophora mucronata* exhibited a higher decomposition rate compared to Avicennia marina due to similar physiological and ecological characteristics. Furthermore, the decomposition rate of R. mucronata is associated with higher nutrient release and is supported by microbial activity as litter decomposers (Selviani *et al*. 2024).

The increased litter decomposition rate of *R. mucronata* is closely related to its high nutrient content. The rapid release of N and P during decomposition encourages microbial colonization and activity, accelerating the overall degradation process. These results emphasize the importance of litter quality in the functioning of marine and coastal ecosystems, where nutrient cycling is highly dependent on the dynamics of mangrove litter decomposition (Liu *et al*. 2022).

In this study, no leaf litter from either *A. alba* or *R. mucronata* species decomposed completely. This is due to several factors, including nutrient content, environmental conditions, and the physical characteristics of the litter. High lignin content often inhibits decomposition due to its resistance to microbial breakdown (Kobayashi *et al*. 2024). Another factor, low nitrogen content, is associated with slower decomposition rates because nutrient-poor litter is metabolically less favorable for decomposers (Cissé *et al*. 2021). Furthermore, high lignin and polyphenol content in leaf litter can inhibit the decomposition process, resulting in residual litter (Ferreira *et al*. 2022). Environmental factors also significantly influence leaf litter decomposition, such as soil moisture, temperature, and microbial activity, which are integral abiotic conditions that regulate the decomposition process (Huang *et al*. 2018).

Nutrient Content of Decomposed *Avicennia alba* Mangrove Leaf Litter

The carbon content of *A. alba* ranges from 9.45% to 13.45%, nitrogen from 0.64% to 0.72%, and phosphorus from 0.25% to 0.29%, all of which can increase aquatic productivity. This finding aligns with the findings of Yunasfi *et al*. (2024) that decomposed *A. alba* leaf litter has been shown to contribute significant amounts of nitrogen to the soil, supporting mangrove diversity. *A. alba* leaf litter is generally characterized by moderate to high carbon content, typically exceeding 50% in oven-dry conditions, and contains substantial nitrogen content that can improve soil fertility (Das *et al*. 2021). Regarding phosphorus, *A. alba* demonstrates that the phosphorus contribution from mangrove leaf litter can vary significantly based on site conditions (Yunasfi *et a*l. 2024).

Differences in nutrient content, particularly nitrogen and phosphorus, during decomposition are crucial because they affect nutrient availability for plant uptake and the microbial communities that thrive in mangrove substrates (Pradisty *et al*. 2022). This nutrient cycle plays a crucial role in maintaining ecological balance, especially under various environmental conditions such as salinity and tidal influences on mangrove ecosystems. Furthermore, leaf litter quality, in terms of the carbon-to-nitrogen (C:N) ratio, plays a crucial role in determining decomposition rates and nutrient release efficiency. A balanced C:N ratio in *A. alba* litter can optimize microbial activity, facilitating the more effective transformation of organic matter into bioavailable nutrients (Mahmudi *et al*. 2021).

Nutrient Content of Decomposed *Rhizophora mucronata* Mangrove Leaf Litter

The carbon content of R. mucronata ranges from 21.50% to 22.45%, nitrogen from 0.58% to 0.83%, and phosphorus from 0.06% to 0.009%. These results suggest broader implications for global nutrient cycling and carbon dynamics. The carbon and other nutrients in *R. mucronata* litter are closely linked to the mangrove food web. The presence of crabs and other detritivores, consuming leaf litter, contributes to nutrient recycling, thus influencing the growth and dynamics of primary producers in the mangrove ecosystem (Robertson, 2021).

The high nutrient content of *R. mucronata* litter is crucial for increasing decomposition rates, particularly in mangrove ecosystems. The primary components influencing this process are the concentrations of nitrogen and phosphorus in the litter. High-quality litter is characterized by a higher nutrient content, accelerating decomposition due to increased microbial activity and the availability of essential nutrients for decomposing organisms (Ndagurwa *et al*. 2020). Furthermore, the litter composition of *R. mucronata* showed a positive correlation between higher initial N concentrations and faster decomposition rates (Figure 3). Higher N content can stimulate microbial activity, thus promoting faster nutrient recycling.

The Relationship between Physical and Chemical Parameters of Water and Decomposition Rate

The relationship between water physical and chemical parameters and decomposition rate is a complex interaction influenced by various environmental factors. Fluctuations in water chemistry, such as nutrient concentrations (N and P), and physical factors such as tides, significantly impact the decomposition process. This is consistent with Das *et al.'s* (2021) statement that environmental factors and nutrient dynamics play a crucial role in determining decomposition rates. Selviani *et al*. (2024) stated that their analysis of litter decomposition in various mangrove forest zones found that *R. mucronata* exhibited high decomposition rates, related to the species' metabolic efficiency and adaptability to environmental stressors such as salinity and nutrient availability.

Decomposition rates generally correlated positively with increasing water temperature. Water temperatures ranged from 27 to 29°C, strongly supporting the decomposition process of mangrove leaf litter. Temperature parameters not only accelerate microbial decomposition but also enhance interactions between plant residues, leading to faster decomposition in warmer conditions (Seibold *et al*. 2021). Salinity at the study site ranged from 25 to 33 ppm, significantly impacting microbial activity, the primary agents in the decomposition process. Salinity affects microbial respiration and nutrient cycling, both of which are closely related to the decomposition process (Qadeer *et al*. 2024). The pH ranged from 5.80 to 8.21, consistent with Breugem et al. 2024's statement that early organic matter decomposition tends to be more effective in slightly acidic environments (around pH 6), while the overall mineralization process is enhanced in neutral to slightly alkaline conditions (pH 7-8). Furthermore, DO values ranged from 3.00 to 5.40 mg/L, and higher dissolved oxygen levels can increase the rate of organic matter decomposition. High DO concentrations in the water column contribute to the decomposition of active organic matter in the sediment, resulting in increased oxygen consumption by benthic organisms (Osaka *et al*. 2022).

CONCLUSION

The decomposition rate of mangrove litter of *R. mucronata* species is higher, ranging from 0.25 -0.67 grams/day while *A. alba* ranges from 0.22-0.64 grams/day and no leaf litter is 100% decomposed from either *A. alba* or *R. mucronata* species. The carbon content of *A. alba* ranges from 9.45% - 13.45%, nitrogen 0.64% - 0.72%, and phosphorus 0.25% - 0.29% while the carbon content of *R. mucronata* ranges from 21.50% - 22.45%, nitrogen 0.58% - 0.83%, and phosphorus 0.06% - 0.009%. The value of water physical and chemical parameters still supports the litter decomposition process.

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