Perennial, 2024
Vol. 20 No. 2: 73-83
p-ISSN: 1412-7784

Available Online:
http://dx.doi.org/10.24259/perennial.v20i2.35755
e-ISSN: 2685-6859

# ENVIRONMENTAL QUALITY IN MANGROVE STANDS IN MONDULAMBI FOREST BLOCK, MANUPEU TANAH DARU NATIONAL PARK

*Kualitas Lingkungan pada Tegakan Mangrove di Blok Hutan Mondulambi, Taman Nasional Manupeu Tanah Daru*

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## ABSTRACT

Mangrove ecosystems are dynamic and vulnerable to external factors such as temperature, pH, and salinity. Changes in the quality of the environment and external conditions of the mangrove ecosystem can affect the arrangement of vegetation, species diversity, and the health and vulnerability of an ecosystem. The research aims to determine the environmental quality of external factors in the mangrove ecosystem by incorporating supporting data such as biota associations and pollutants. Measurement of environmental quality is carried out on plots of systematically dispersed samples representing ecosystems. The quality of the environment is measured using several parameters, such as temperature, salinity, pH, substrate thickness, and stagnation height, and the data is analyzed using observational and quantitative descriptive methods. The environmental quality conditions of the mangrove ecosystems in the Mondulambi Block, RPTN (National Park Management Resort) Kambatawundut, SPTN (Section of National Park Management) II Lewa, Manupeu Land Daru National Park cover salinity values ranging from 20-30 ‰ (ideal), soil pH ranges from 5-6.5 (tends to be more acidic), water pH ranges from 6-7.5 (optimal), the soil temperature ranged between 25-28°C, the water temperature ranging between 26-29°C (tendered to be lower), the lowest substrate thickness of about 2 cm and the highest thickness of 80 cm, the highest standoff height of about 9 cm, and the lowest standoff heights of around 2 cm. The results of this study describe the conditions of an ecosystem intended to be ideal.

Keywords: Environmental Quality; Mangroves; National Park

## ABSTRAK

Ekosistem mangrove merupakan ekosistem yang dinamis dan rentan dipengaruhi oleh faktor eksternal seperti suhu, pH, dan salinitas. Perubahan pada kualitas lingkungan dan keadaan eksternal pada ekosistem mangrove dapat memengaruhi susunan vegetasi, keanekaragaman jenis, hingga kesehatan dan kerentanan suatu ekosistem. Penelitian ini bertujuan mengetahui kualitas lingkungan dari faktor eksternal pada ekosistem mangrove dengan menyertakan data penunjang berupa biota asosiasi dan pencemar. Pengukuran kualitas lingkungan dilakukan pada plot sampel yang tersebar secara sistematik mewakili ekosistem. Kualitas lingkungan yang diukur menggunakan beberapa parameter diantaranya suhu, salinitas, pH, ketebalan susbtrat, dan ketinggian genangan adapun data tersebut dianalisis dengan metode observasi dan deskriptif kuantitatif. Kondisi kualitas lingkungan pada ekosistem mangrove di Blok Mondulambi, RPTN (Resort Pengelolaan Taman Nasional) Kambatawundut, SPTN (Seksi Pengelolaan Taman Nasional) II Lewa, Taman Nasional Manupeu Tanah Daru meliputi nilai salinitas berkisar 20-30 ‰ (ideal), pH tanah berkisar 5-6.5 (cenderung lebih asam), pH air berkisar 6-7.5 (ideal), suhu tanah berkisar 25-28°C, suhu air berkisar 26-29°C (cenderung lebih rendah), ketebalan substrat terendah sekitar 2 cm dan ketebalan tertinggi 80 cm, ketinggian genangan air tertinggi sekitar 9 cm dan ketinggian genangan air terendah sekitar 2 cm. Hasil dari penelitian ini menggambarkan kondisi ekosistem mangrove tersebut dalam keadaan yang cenderung ideal.

Kata kunci: Kualitas Lingkungan; Mangrove; Taman Nasional

Submitted: 28 June 2024; Accepted: 6 August 2024

## A. INTRODUCTION

A mangrove ecosystem is a type of ecosystem located at the confluence of tidal pathways, woody plants dominate its vegetation. Mangroves can grow well on coral beaches or reef lands with thin sand or on beaches with alluvial soil types. This causes mangroves to be referred to as beach, tidal, and brackish plants (Sipahelut *et al.* 2019). The area of mangrove ecosystems in Indonesia reaches 75% of the total mangroves in Southeast Asia, or about 27% of the world's mangrove area (Widiawati 2021).

Mangrove ecosystems have complex physical, ecological, economic, and socio-cultural functions. The physical function of mangrove forests is to keep the coastline stable, protect the coast from abrasion, reduce storms and waves, and capture sediment and mud. (Prinasti *et al.* 2020). Ecological functions include spawning, nursery, and feeding grounds for specific marine biota (Prinasti *et al.* 2020; Widiawati 2021). As for the economic function as a source of livelihood, a source of fuel (wood), building materials (boards), textile materials, medicines, and food (Sipahelut *et al.* 2019) to the development of research, culture, conservation, and education.

According to Jalaludin (2020), mangroves are forests with unique plants and ecology. The mangrove ecosystem is labile, dynamic, and complex (Mughofar *et al.* 2018). It is said to be dynamic because it is adaptive to environmental conditions. Still, it is unstable because it is vulnerable to damage and requires a long time to restore ecosystem function (Imamsyah 2020). Mangrove ecosystems are vulnerable to changes in external factors in the form of environmental quality. According to Setyawan *et al.* (2002) mangroves are resulted from ecosystem change and ecosystem reactions derived from external factors such as salinity levels, sea level, soil type, and tidal processes. This ecosystem condition will then affect the diversity of species in the mangrove.

Onrizal (2010) states that one of the factors that influence mangrove growth is soil or substrate. Mangroves grow well on muddy soils, especially in areas of accumulated silt. Substrate characteristics are a limiting factor for mangrove life. The type of substrate greatly influences the species composition and density of mangrove vegetation living on it. The more suitable the substrate is for a specific kind of mangrove vegetation can be seen from how densely the vegetation covers its living area (Prinasti *et al.* 2020). The water quality of mangrove ecosystems affects mangrove health conditions. Mangroves are vulnerable to changes in water quality, such as temperature and pH. The instability of water quality parameters will affect the water quality and even cause the death of mangroves (Schaduw 2018). High salinity (>35%) can affect mangrove conditions due to negative osmotic pressure. Besides that, it can affect the biota associated with mangrove ecosystems.

Mondulambi block is the only mangrove ecosystem in Manupeu Tanah Daru National Park, with an area of 16.25 ha. Manupeu Tanah Daru National Park is one of two areas managed by the Matalawa National Park Office. The Matalawa National Park Office manages 2 National Park areas: Manupeu Tanah Daru National Park and Laiwangi Wanggameti National Park. The Matalawa National Park Office area is administratively located in East Nusa Tenggara Province in three districts: East Sumba Regency, Central Sumba Regency, and West Sumba Regency, with approximately 1,869 $km^2$. The built ecosystem types include dry coastal vegetation or sandy areas, wet coastal vegetation or mangroves, field and savanna vegetation, and lowland hilly forest vegetation (dry tropical forests and semi-evergreen forests).

In the mangrove ecosystem in Mondulambi Block, RPTN (National Park Management Resort) Kambatawundut, SPTN (National Park Management Section) II Lewa, Manupeu Tanah Daru National Park is assumed to have an ecosystem with an ideal environment and minimal disturbance. This is due to the condition of the ecosystem, which is located in a conservation area with access to a remote location. It tends to be difficult, so humans rarely visit it. The background for this research is the absence of references regarding the quality of mangrove ecosystems in this region.

Mangrove ecosystems are influenced by the quality of their environment with indicators such as water and soil temperature, salinity, water and soil pH, water level, and substrate thickness. Azkia *et al.* (2013) defined mangrove environmental quality as the state of the mangrove environment that can provide optimal carrying capacity for mangrove survival. Mangrove environmental quality is measured by parameter indicators based on the natural baseline conditions of various environmental variables that affect changes in environmental quality.

Research on environmental quality conditions is needed to describe the health and vulnerability of an ecosystem. Ecological quality indicators directly affect the state of mangrove ecosystems, species diversity, and mangrove vegetation composition. Knowing the value of environmental quality indicators can be the basis and analytical material for assessing the condition of a mangrove ecosystem, identifying external factors that affect mangrove ecosystems, and becoming a consideration in making decisions related to mangrove ecosystem management. This study aims to determine environmental quality as an external factor affecting mangrove ecosystems in Mondulambi Block, Kambatawundut RPTN, SPTN II Lewa, Manupeu Tanah Daru National Park.

## B. METHODS

This research was conducted in March-April 2023 in Mondulambi Forest Block, Kambatawundut National Park Management Resort, Lewa National Park Management Section II, Manupeu Tanah Daru National Park, East Nusa Tenggara Province. The tools used in this research are a thermometer, pH meter, refractometer, meter, soil tester, camera, rope, and stationery.

### Research Methods

This study used the observation method through a quantitative descriptive approach. The observation method is carried out by observing the object and recording the situation systematically regarding the elements that appear in data collection activities (Sudjana 2010; Widoyoko 2014). The quantitative descriptive approach uses a method that aims to describe a phenomenon or situation using numbers and numerical (statistics) starting from collection and interpretation, to the final result objectively (Arikunto 2006).

### Data Retrieval Technique

Data collection was conducted in sample plots scattered throughout the ecosystem. The construction of sample plots follows a combination of the path method and measuring plots (Poedjirahajoe *et al.* 2017), which was placed systematically. The number of sample points in this study was 24, and the determination of sample points was carried out using ArcGIS software. The sampling line is made perpendicular to the mainland, cutting the mangrove community from the foremost formation to the rearmost formation. Sample points are evenly distributed in the ecosystem to represent environmental quality data on the entire ecosystem.

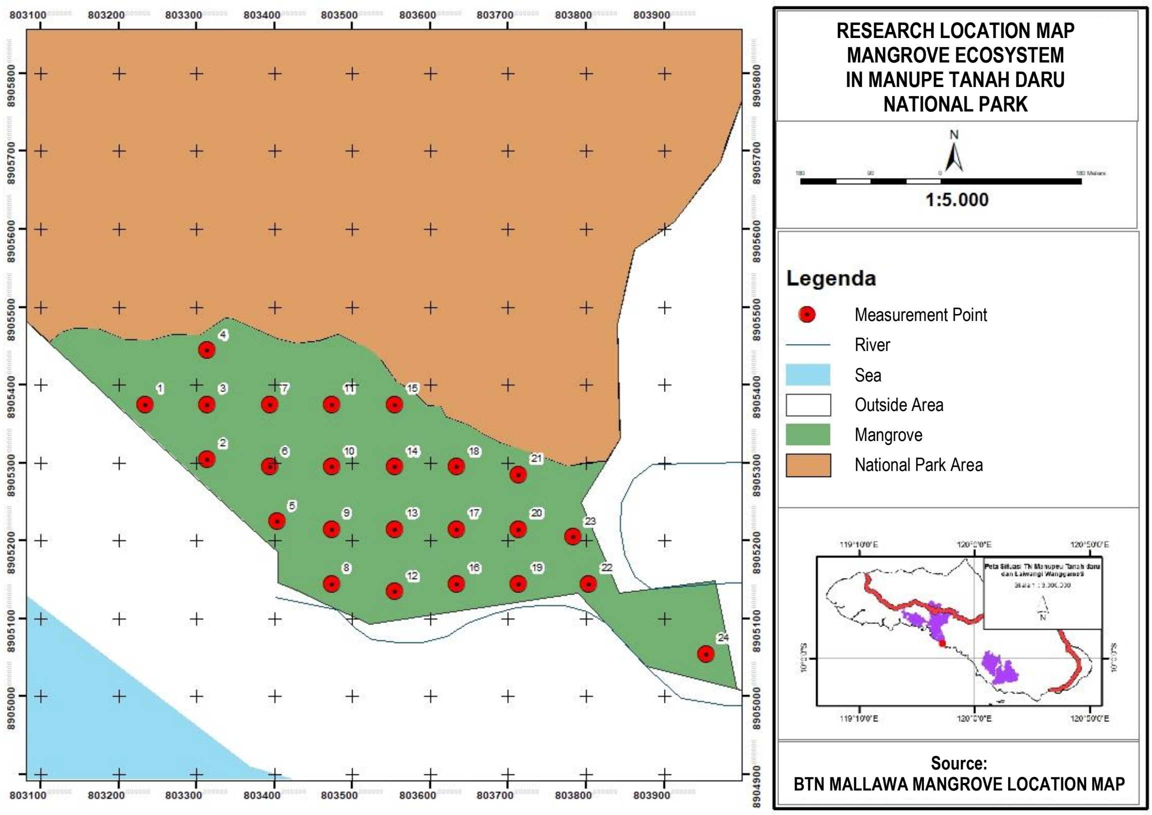


**Figure 1.** Map of sample placement

Environmental quality index measurements were conducted on seawater level, mud depth, water and soil pH, water and soil temperature, and water salinity.

Environmental quality parameters of mangrove waters and soils include:

1. Measuring water and soil temperatures using a *thermometer* (°C) and *soil tester* (°C).
2. Measuring water salinity using a refractometer with units of per mil (‰).
3. Measuring soil pH using a *soil tester*.
4. Measuring the pH of the water using a pH stick.
5. Measuring the water level at the surface of the mangrove (cm) and the mud thickness (cm) using a tape measure.

**Table 1.** Reference Environmental Quality Parameters

| Parameters | Ideal Condition | Reference |
|---|---|---|
| Water temperature | 28-32 °C | Annex to Kepmen LH No.51 year 2004 |
| Soil temperature | ≥ 20 °C | (Noor 2012; Mughofar 2018) |
| Salinity | ≤ 34‰ | Annex to Kepmen LH No.51 year 2004 |
| pH of water | 6.5-8.5 | Annex to Kepmen LH No.51 year 2004 |
| pH of substrate | 6-7 | (Cyio 2008). |

## C. RESULTS AND DISCUSSION

### Ecosystem Overview

The Manupeu Tanah Daru and Laiwangi Wanggameti (Matalawa) National Park Office manages two National Park areas, namely Manupeu Tanah Daru National Park and Laiwangi Wanggameti National Park since 2016 following the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.7/Menlhk/Setjen/OTL.0/1/2016 concerning Organization and Work Procedures of National Park Technical Implementation Units (Matalawa National Park Office 2020).

This mangrove ecosystem is located in the southern part of Sumba Island, with inadequate and unsafe infrastructure conditions for mobilization, minimal pre-facilities, and limited transportation access around the area. Hence, Mondulambi Beach, with its mangrove ecosystem, rarely gets tourist visits. The distance of the village or community house from the location is around 10 km. This protects the mangrove ecosystem area from human activities.

In the mangrove ecosystem area, 9 types of mangroves are dominated by *Sonneratia alba* species or Lar by the local community. The species in question include *Sonneratia alba* (Lar), *Bruguiera gymnorrhiza* (Tuangal), *Rhizophora mucronata* (Black Lar), *Excoecaria agallocha* (Kabuta), *Lumnitzera racemosa, Acanthus illicifolius, Terminalia catappa* (Ketapang), *Acrostichum aureum*, and *Derris trifoliata.* Mangrove forests in this area are directly adjacent to lowland forests, and there are significant differences in vegetation between the two ecosystem types.

Based on their location, Manupeu Tanah Daru National Park mangroves do not intersect directly with the sea. The mangroves are separated by an estuarine stream that crosses the coastline horizontally in front of the mangrove ecosystem and then turns to the sea. Based on zoning in the ecosystem, there are only 2 zones: the mangrove zone and the nipah zone. This zone is divided based on the constituent plants influenced by the condition of the plant substrate.

This ecosystem starts with a mangrove zone with a muddy soil substrate and a bit of sand at the front of the ecosystem, which is directly opposite the estuary because it is not in direct contact with the sea. In this zone, main mangrove species such as *Sonneratia alba, Rhizophora mucronata, Bruguiera gymnorrhiza, Excoecaria agallocha*, and *Lumnitzera racemosa* are found, as well as associated mangroves such as *Terminalia catappa, Derris trifoliata*, and *Acrostichum aureum*. According to Hotden (2014), the mangrove zone is dominated by *Rhizophora* sp. and sometimes *Bruguiera* sp. Meanwhile, according to Mughofar (2018), ecosystems with muddy substrates, such as in the mangrove zone, are suitable for *Rhizophora mucronata* stands. Meanwhile, according to Jalaludin *et al.* (2020), *Sonneratia* sp. is categorized as a clan with the ability to tolerate a wide range of salinity compared to other genera, so the location where this clan is found is more flexible on various types of substrates and growing locations. Mughofar *et al.* (2018) stated that the edge of the estuary is occupied by *Rhizophora* sp., followed by a mixed zone of *Rhizophora* sp., *Bruguiera* sp., *Sonneratia* sp., *Ceriops* sp., and *Excoecaria* sp., which is following the conditions of the area where the study was conducted.

The next zone in this mangrove ecosystem is the Nipah zone. In this zone, species of *Sonneratia alba, Rhizophora mucronata, Bruguiera gymnorrhiza*, and *Excoecaria agallocha* are found, which are then associated with *Acrostichum* sp. In addition, there are *Terminalia catappa* and *Acanthus illicifolius*. The nipah zone is the transition zone between the mangrove and lowland forests. This zone generally has low salinity with sandy substrates and is very little influenced by tides (Hotden *et al.* 2014).

Based on Watson's Immersion Class, the inundation class of this ecosystem belongs to medium-high tides and exceptional or equinoctial tides. Because it is separated by a horizontal estuary that separates the mangroves from the sea, the front of the mangrove ecosystem is inundated if the tide is relatively large (medium-high tides). Meanwhile, the middle part of the mangrove forest area to the back is classified as exceptional or equinoctial tides or areas sometimes inundated by the highest tides.

### Environmental Quality Parameters

Soerianegara & Indrawan (2002) state that the environment is a very influential aspect of an ecosystem. In mangrove ecosystems, environmental quality is measured based on soil quality, water quality, and the types of pollutants in the ecosystem. For soil quality measurements, the parameters measured are soil temperature, acidity (pH), and substrate thickness. As for water quality measurement, the parameters measured are water temperature, acidity (pH), and salinity.

**Table 2.** Environmental Quality Index values

| Parameters | Range | Average | Ideal Condition | Description |
|---|---|---|---|---|
| Water temperature (°c) | 26-29 | 27.7 | 28-32 °C | Slightly lower |
| Soil temperature (°c) | 26-29 | 27.7 | ≥ 20 °C | Ideal |
| Water ph | 6-7.5 | 6.4 | 6.5 - 8.5 | Slightly more acidic |
| Soil ph | 6-7.5 | 6.1 | 6 - 7 | Ideal |
| Salinity (%) | 20-30 | 23.9 | ≤34‰ | Ideal |

**Temperature**

Temperature plays a role in photosynthesis and respiration, controlling the condition of mangrove ecosystems and regulating organisms' life processes and distribution. Temperature change is one of the factors that can affect mangrove ecosystems (Syahrial *et al.* 2020). In general, the temperature of the mangrove environment has its range. According to Noor (2012), mangroves cannot grow well when temperatures are below 19ºC. Meanwhile, according to Idrus & Kusmana (2021), a suitable temperature for mangroves is not less than 20°C. Mughofar (2018) states that some mangrove plant species require ideal temperatures to grow, including *Excoeraria agallocha* and *Luminitzera racemosa*, which achieve the highest fresh leaf growth at 26-28°C, while *Avicennia marina* grows well at 18-20°C.

Idrus & Kusmana (2021) stated that surface waters generally have a temperature of around 28-31°C. Meanwhile, the water temperature for mangroves based on the Appendix to Kepmen LH No. 51 of 2004 is around 28-32°C. The value of soil temperature in the mangrove ecosystem is not regulated in the Appendix to Kepmen LH No. 51 of 2004.

Based on these measurements in Table 2, water temperature values ranged from 26-29°C, with the lowest value at 26°C and the highest at 29°C. The average of all research plots was 27.7°C. The water temperature values at these locations are mostly lower than the temperature criteria for mangrove waters stipulated in Kepmen LH No. 51 of 2004. This is probably because the research was conducted during prolonged rainy weather, so the temperature in the ecosystem was also influenced by rainwater. In addition, the low water temperature is thought to be due to the mangrove ecosystem, which is not directly adjacent to the sea, where the seawater surface temperature is directly exposed to sunlight. The tidal flow at this research location comes from the estuary, which is the meeting of seawater and river flow that passes through lowland forests and is protected from exposure to sunlight. Therefore, the temperature at the location tends to be lower than the sea surface temperature. In addition, the lowland forest behind the mangrove ecosystem is thought to influence the ecosystem's microclimate. Based on the study's results, the range of water temperatures did not show significant differences. This happened because each research station's mangrove density was relatively the same. The difference in water temperature can also be caused by the high and low density of mangroves because it also affects the intensity of sunlight received by the waters. In an open ecosystem area, the temperature becomes high due to the sun's intensity entering the water (Imamsyah 2020).

Soil temperature values based on the measurements in Table 2 ranged from 25-28°C, with the lowest value at 25°C and the highest at 28°C. The average of the entire research plot was 26.5°C. According to Hambran *et al.* (2014), the high and low temperature of the soil is influenced by solar radiation and mangrove vegetation. In line with the water temperature, vegetation density also affects the soil temperature due to the influence of light intensity entering the ecosystem. Efendi *et al.* (2018) revealed that an increase in soil temperature can stimulate the metabolic activities of microflora to accelerate the mineralization process.

At another location in the same district in Kahi's research (2022) in the Pakonjawai Protected Area, East Sumba Regency, the environmental temperature in the ecosystem ranged from 24-28°C. This value is not much different from this research location's water and soil temperatures. This is because both places are within the scope of the same district area, where the average temperature in East Sumba district is between 22.5-31.7°C, with a short rainy season of about 4 months and a long dry season of about 7 months (Watuwaya 2022).

**Degree of Acidity (pH)**

Factors that affect the mangrove ecosystem environment are pH or acidity. pH or concentration of hydrogen ions indicates the acidity or basicity of seawater (Wailisa *et al.* 2022). Similarly, the soil's pH shows the size of the number of hydrogen ions in a solution in the soil (Kusuma *et al.* 2014).

According to Wijayanti (2009), the water pH range suitable for mangrove growth is 6-8.5. Appendix Kepmen LH No. 51 of 2004 shows that the pH supporting mangrove growth is around 6.5-8.5. Meanwhile, the pH of the substrate suitable for mangrove growth ranges from 6-7 (Cyio, 2008).

Based on the measurements in Table 2, the water's pH value ranged from 6-7.5, with the lowest value being 6 and the highest being 7.5. The average of the entire research plot was 6.4. This value shows a number that is suitable for mangrove growth. The presence of mangrove litter is one factor affecting the water pH in mangrove areas. Microorganisms decompose the fallen mangrove litter, producing detritus, which makes the waters acidic (Imamsyah *et al.* 2011).

Meanwhile, soil pH describes the soil's balance of acids and bases. From the measurement of soil pH or mangrove substrate in Table 2, the soil pH value ranged from 5-6.5, with the lowest value of 5 and the highest of 6.5. Meanwhile, the average of the entire research plot amounted to 6.1. According to Cyio (2008), from a pH value of 6-7, soil pH can drop to below 5 due to the high content of organic matter in the substrate. (Usman *et al.* 2013). This statement follows the opinion of Imamsyah *et al.* (2020), where the pH of the substrate becomes acidic because decomposing bacteria destroy mangrove litter on the substrate, which produces organic acids, which reduce the pH of the substrate.

The pH value at this location tends to be lower than the research of Kahi (2022) in the Pakonjawai Protected Area, East Sumba Regency, or the same region. At the Kahi (2022) research site, soil pH ranged from 7-8, and water pH ranged from 7.7-8.4. These lower values are thought to be due to the decomposition process of debris occurring more at this research location, compared to the Kahi (2022) research location. This pH value is thought to be influenced by the density of vegetation, considering that in the Kahi (2022), the density at the tree, sapling, and seedling levels was 0.066 ind/ha, 0.191 ind/ha, and 0.141 ind/ha, respectively. This value is much different from the results of this study, where the density values at the tree, sapling, and seedling levels were 491.7 ind/ha, 1,900 ind/ha, and 35,416.6 ind/ha, respectively. Litter production is influenced by density (Zamroni & Rohyani 2008). This is in line with the research of Aida *et al.* (2014), which states a high-density value will affect the higher mangrove litter production and vice versa. Thus, the smaller amount of vegetation causes less leaf litter to decompose into residue, so water conditions tend to be alkaline at the research site Kahi (2022). However, the location is still included in the Kepmen LH No. 51 of 2004 criteria for mangrove growth.

**Salinity**

Salinity is a component that directly affects mangrove vegetation. Salinity is closely related to the level of tidal inundation, making it one of the controlling factors of mangrove ecosystems (Noor *et al.* 2006). Any mangrove species can grow in high-salinity environments, but growth is usually poor or short, and some species are not even resistant to high salinity (Mughofar 2018). Mangrove species are generally less competitive under freshwater conditions, so saline or saline environments are necessary for the stability of mangrove ecosystems. Factors such as tides, rainfall, evaporation, precipitation, and water topography affect water salinity. Therefore, the salinity of a body of water can be the same or different from that of other bodies of water, such as inland, marine, and brackish waters. The salinity of seawater ranges between 30 and 35%, estuaries range between 5 and 35%, and freshwater ranges between 0.5 and 5% (Mughofar 2018). Based on Kepmen LH No. 51 of 2004, the appropriate water salinity levels for mangrove ecosystems do not exceed a value of 34%.

Based on the measurements obtained in Table 2, salinity levels ranged from 20-30%, with the lowest value at 20% and the highest at 30%. The average of all research plots was 23.9%. In general, the salinity value of the ecosystem is suitable for mangrove growth. This is because the value does not exceed 34%, which can disrupt mangrove growth. The salinity value is not the same as the salinity of seawater, generally 30-35%, according to Mughofar (2018), due to the position of the ecosystem in the estuary area, which is not in direct contact with seawater. The average value of about 23.9% is thought to be because when the research was conducted, the weather at the location was rainy for one month, thus affecting the salinity in the ecosystem. In addition, at the edge of the mangrove ecosystem, there is a freshwater stream flowing from a spring in the lowland forest behind the mangrove ecosystem, so some plots at the edge of the ecosystem are also affected by salinity levels.

This salinity level is lower than in the research of Kahi (2022) in the Pakonjawai Protected Area, East Sumba Regency, or in the same district, with salinity values ranging from 25-35%. This is thought to be due to the location of Kahi's research, where the mangrove ecosystem is directly adjacent to the sea. In addition, data collection activities were carried out from June to October 2022, when the East Sumba region experienced the lowest rainfall in 2022. In the East Sumba region, the dry season lasts from April to the second week of November, with the peak of the dry season in July-September (Watuwaya 2022). According to BPS data in Figure 2, the rainfall of East Sumba district in 2022 is presented in the following graph.

The situation was different during data collection in this study, which was carried out during prolonged rainy weather. According to BMKG data (2023), the NTT region at the end of March to early April experienced high to very high category rain (> 150 mm). This condition then affects salinity levels, which tend to be low.

**Substrate Thickness and Inundation Height**

Substrate thickness and inundation height are influenced by tidal activity. The substrate comes from rock weathering, which consists of organisms, detritus, and marine chemical processes (Prarikeslan 2016). Coarse substrates (sand) are usually found in water conditions with strong currents, while fine or muddy substrates are often found in water conditions with calm currents (Imamsyah 2020).

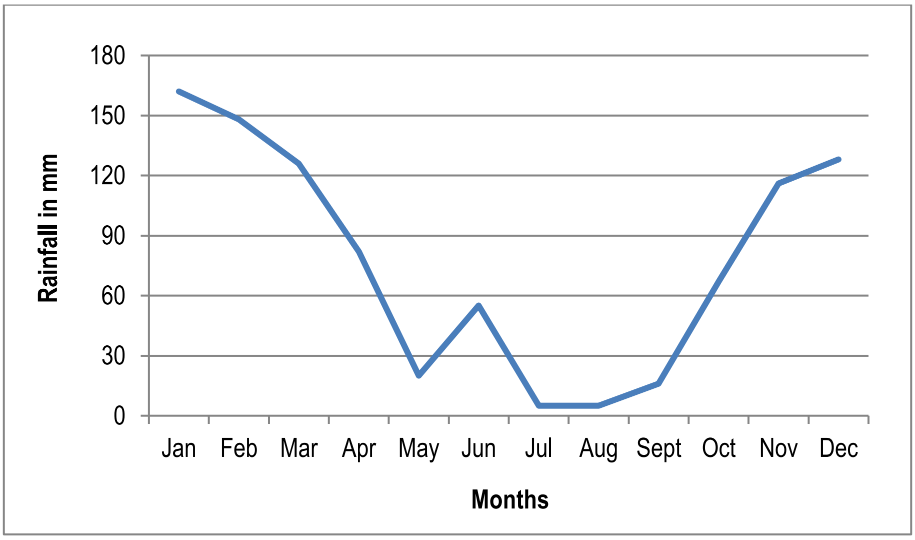


**Figure 2.** Rainfall chart (BPS NTT 2022)

The substrate thickness at the study site had varied values in each plot. The thickest substrate was as high as 80 cm, while the thinnest was as high as 2 cm. The low thickness of the substrate is thought to be influenced by the location of the plots at the front of the ecosystem, which is directly adjacent to the estuary and experiences tidal activity and strong currents. The plots in the center had a high substrate depth due to siltation and less tidal wave activity. According to Imamsyah *et al.* (2020) mud substrate grains have a fine size due to the weakened current speed in the estuary area. Meanwhile, at the back of the ecosystem, the substrate began to thin out allegedly because it bordered the soil in the lowland forest.

Tidal conditions significantly affect the inundation height in this ecosystem. The value of this inundation height varies in each plot, as the highest inundation height is about 9 cm, and the lowest is as high as 2 cm. This is because the measurements were taken during low tide so that the front ecosystem bordering the sea has a low inundation height. The substrate at the front of the ecosystem consists of sandy mud that does not absorb and retain water. The highest inundation height was in the plot in the middle of the ecosystem because the middle part has a muddy substrate with stagnant water. During a low tide, it remains inundated with water and mud.

In this study, data on substrate thickness and inundation height are only used as supplementary data following the field conditions when the research was conducted. This is because substrate thickness and inundation height conditions tend to change and are influenced by tides, terrestrial variations, weather, and research time. In addition, in this study, measurements were only taken once with no repetition. This causes a lack of supporting data to see the range and average of substrate thickness and inundation height.

**Supporting Data**

*1. Polluters*

This mangrove ecosystem is quite far from settlements and human activities, so the potential for pollution is low. Several types of inorganic waste, such as cigarette packs, plastic water bottles, plastic wraps, glass bottles, and beverage cans, were found in small quantities in this location. In addition, organic waste such as firewood residues and fruit peels were found. This waste is indicated to come from visitors traveling or fishing through the mangrove ecosystem area. In this research location, no pollutants originate from household, factory, oil, or marine transportation waste. Meanwhile, places indicated to be sources of contaminants include settlements within 10 km, tourist areas less than 1 km away, and fishing locations within about 1 km. Meanwhile, the research found activities such as tourism and logging for firewood in the mangrove area.

Mangrove ecosystems are more vulnerable to pollutants because they generally have more contact with human activities than other forest ecosystems. This is also influenced by the geographical location of mangrove ecosystems, many located on the seafront or coastal areas close to settlements, port activities or sea transportation, ponds, tourism, and industry. In addition, garbage dumped in the ocean is often caught in mangrove ecosystems, thus bringing pollutants to mangrove ecosystems. One example in the study Holik *et al.* (2022) in Cemara Beach, South Lembar Village, West Lombok Regency, NTB, the threat to mangrove ecosystems is in the form of garbage, household waste in the form of residual flow of washing water and soap. Another threat is the area's destruction due to conversion into ponds, tourism activities, and port activities near the beach. This is different from the research location, which tends to be maintained because it is located in a conservation area, in addition to the location that is difficult to reach and far from human activities that impact the ecosystem's sustainability.

*2. Biota*

As an ecosystem that protects other biota, mangroves play a very important role in ensuring the biodiversity of coastal biota. Improving mangrove quality is also reflected in increasing mangrove biodiversity and biomass. Linearly, a good mangrove ecosystem can support biomass growth and its associated biota. Mangrove biodiversity and biomass also relate to mangrove quality (Yonvitner *et al.* 2019). Mangroves are essential in maintaining environmental biodiversity (Herrera *et al.* 2015). Biota, such as fish, crustaceans, and mollusks, depend highly on mangrove ecosystems. Associated biota found directly in mangrove ecosystems are generally *sedentary* and *temporary* (Yonvitner *et al.* 2019).

The distribution of fauna inhabiting mangrove forests is classified into two types: vertical and horizontal. Vertical dispersal is carried out by types of fauna that live by attaching or attaching to roots, branches, and trunks of mangrove trees (Karimah 2017). As for the horizontal distribution, it is usually found in the type of fauna that lives on the substrate, whether it is classified into infauna, namely biota that lives in the substrate or hole, or epifauna, namely biota that lives on the substrate (Karimah 2017).

Molluscs in mangrove ecosystems generally have a significant ecological role in the food chain. Mollusks act as detritus predators and reduce or tear up fallen litter, thus accelerating the process of litter decomposition by microorganisms. Some crab fauna pull propagules into their hiding places or watery places, helping spread seedlings in mangrove ecosystems (Karimah 2017).

Mollusks and crustaceans generally dominate mangrove forests in Indonesia. Mollusks in Indonesia typically consist of about 61 species of gastropods and about 9 species of bivalves. The crustaceans generally consist of brachyuran (crabs) and macrura (shrimp) (Karimah 2017). Research Valentino *et al.* (2022), whose primary focus was on macrozobenthos in mangrove waters of Gili Lawang, East Lombok, NTB found as many as 15 species of macrozobenthos consisting of 2 phyla, namely molluscs and oligochaeta. As in the research Buwono (2015) found economically significant aquatic fauna in mangrove areas of 21 species from 15 families on the beach in the Pangpang Bay area, Banyuwangi Regency.

In this study, several aquatic biota were found in the mangrove ecosystem, such as mangrove crabs (*Scylla* spp.), silverfish (*Periothalamus* sp.), mangrove shrimp (*Thalassina anomala*), snails (*Telescopium telescopium*), mangrove clams (*Geloina coaxans*), and kaliomang (*Coenobita* sp). In addition, there was also a butterfly *Catopsilia pomona* in front of the mangrove ecosystem. The biota found in the study does not describe the entire biota in the mangrove ecosystem at that location. This is because this study's biota data collection is used as a support and general description. Because the main focus of this research is not on ecosystem biota, then the number, distribution, and other specific research are not carried out. The biota recorded only includes biota found during the study. Biota found in this ecosystem shows in Figure 3.

Gelodok fish (*Periothalamus* sp.) is part of the Oxudercinae subfamily and is often found in muddy and mangrove coastal areas. *Periothalamus* sp. or spadefish is essential as an environmental bioindicator and planting material for mangrove vegetation. Periothalamus sp. or spadefish have nests in the form of holes in the substrate around the mangrove shade with a depth of between 40-100 cm and a distance between holes of 75-200 cm. The hiding nests are made by hollowing out the soil surface, causing changes in soil structure and mixing of detritus. The mixing of detritus is thought to affect the ability to absorb and store carbon concentrations in mangrove ecosystems that have the potential to absorb atmospheric $CO_2$, which is then stored in the mangrove substrate (Sujono & Muzaki 2021).

Crabs (*Metoprogapsus* sp.) are part of the Crustacea and are found in mangrove forest ecosystems. This crab has a wide distribution area due to its high adaptability to mangrove forests and high tolerance to salinity and temperature in mangrove ecosystems (Gita, 2016). Mangrove crabs are one of the biota of mangrove ecosystems that have high economic value and are consumed by the community. The utilization of mangrove crabs for consumption is done either through direct capture in their habitat or cultivation on a large scale.

Kelomang *(Coenobita* sp.*)* is a crustacean found in mangrove forest ecosystems. *Coenobita* sp. is known as kaliomang, omang-omang, undur-undur, and kulu-kulu. *Coenobita* sp. is omnivorous and preys on tiny organisms, garbage, or decaying material (Dewiyanti & Yunita 2013).

Mangrove Shrimp (*Thalassina anomala*) is a species of crustacean commonly known as mangrove shrimp, land shrimp, mud lobster, and mangrove scorpion. *Thalassina anomala* is a type of mud shrimp that is often found in mangrove forests. *Thalassina anomala* generally makes a nest hole and forages only around the nest hole (Karimah 2017). *Thalassina anomala* is a member of the Crustacean group that digs (*Crustacean diggers*) and performs daily activities digging the ground to make burrows in specific substrates a place of life. *Thalassina anomala* burrows vertically and branches towards the water source with a depth of about 2 m and even more (Kartika 2015).

Mangrove clam (*Geloina coaxans*) is a mollusk that is part of the bivalves or shellfish. *Geloina coaxans* have a shell shape similar to a plate or saucer with a convex center and two symmetrical bilateral valves on edge. (Salim *et al.* 2018).

*Telescopium telescopium*, also known as the mangrove snail, is found in mangrove habitats. *Telescopium telescopium* lives in mangrove ecosystems, is almost found on muddy substrates, and is influenced by tides. *Telescopium telescopium* will bury itself in the mud during high tide. Natural mangroves that are the habitat of *Telescopium telescopium* will significantly impact and affect the gastropods that are the biota of the association if disturbances occur (Sibua *et al.* 2021).

Butterfly (*Catopsilia pomona*) is the typical lemon emigrant in Asia and parts of Australia. *Catopsilia pomona* belongs to the Pieridae family and is classified as a diurnal butterfly. In this study site, the *Catopsilia pomona* butterfly assemblage was found in front of the ecosystem at the estuary's edge.


**Figure 3.** Biota found in the ecosystem: mudskippers fish (a), crab (b), hermit crab (c), and lemon emigrant/common emigrant (d)

## General Ecosystem Quality Condition

Based on the values obtained in this study, the values obtained in the Mondulambi Block, Kambatawundut RPTN, SPTN II Lewa, Manupeu Tanah Daru National Park include water temperature values ranging from 26-29°C which tends to be lower which is likely influenced by the microclimate of the lowland forest behind the mangrove ecosystem, soil temperature ranging from 25-28 ° C including ideal values, Soil pH ranges from 5-6.5 which tends to be more acidic slightly likely influenced by high detrius, water pH ranges from 6-7.5 which shows ideal numbers, salinity values range from 20-30‰ which shows perfect numbers, the lowest substrate thickness is about 2 cm and the highest thickness is about 80 cm, the highest waterlogging height is about 9 cm and the lowest waterlogging height is about 2 cm. These values illustrate the environmental quality of mangrove ecosystems that tend to be ideal for mangrove growth. The low disturbance likely influences this in the ecosystem because the ecosystem is located in a conservation area far from settlements.

These idealized values of environmental quality conditions provide optimal carrying capacity for the growth and sustainability of mangrove ecosystems. The condition of the mangrove ecosystem needs to be maintained. The water temperature and pH of water, whose value is slightly less than the ideal state, have not become serious problems; various external factors can influence this in the ecosystem. The arrangement of vegetation types and vegetation diversity in a maintained state is in line with the results of the study. Sulastri (2024) shows a moderate diversity value based on the Shannon-Wiener Index in the ecosystem.

In this ecosystem, further research needs to be carried out on the value of organic C, Dissolved Oxygen (DO), substrate texture, and microclimate to complement environmental quality data on the Mondulambi Block mangrove ecosystem, Kambatawundut RPTN, SPTN II Lewa, Manupeu Tanah Daru National Park. Research on species morphometrics also needs to be done because the number of morphometric leaf populations illustrates the environmental pressure received by a population.

## D. CONCLUSION

Based on the results of this study, it can be concluded that the environmental quality conditions in the mangrove ecosystem in Mondulambi Block, Kambatawundut RPTN, SPTN II Lewa, Manupeu Tanah Daru National Park include salinity values ranging from 20-30 ‰ (ideal), soil pH ranging from 5-6.5 (tends to be more acidic), water pH ranges from 6-7.5 (perfect), soil temperature ranges from 25-28°C, water temperature ranges from 26-29°C (tends to be lower), the lowest substrate thickness is about 2 cm and the highest thickness is about 80 cm, the highest waterlogging height is about 9 cm and the lowest waterlogging height is about 2 cm. Based on index values that tend to be ideal and pollutants and interactions with humans that tend to be minimal, it can be concluded that the mangrove ecosystem in Mondulambi Block, Kambatawundut RPTN, SPTN II Lewa, Manupeu Tanah Daru National Park is ideal and suitable for mangrove growth. The management must maintain the perfect state of the ecosystem.

## ACKNOWLEDGMENTS

I would like to thank the Matalawa National Park Office for giving me the time and space to complete this research and writing.

## REFERENCES

Aida, R. G., Wardiatno, Y., Fahrudin, A., Mukhlis Kamal, M. (2014). Litterfall Production of Mangrove in Tangerang Coastal Area, Banten. *Journal of Indonesian Agricultural Sciences (JIPI), August*, 19(2), 97.

Azkia, F. A., Anggoro, S., Taruna, T. (2013). Assessment of Mangrove Environmental Quality in Dukuh Tambaksari, Sayung District, Demak Regency. In *Proceedings of the National Seminar on Natural Resources and Environmental Management* (pp. 556-563).

Matalawa National Park Center. 2020. *Matalawa National Park Strategic Plan (RENSTRA) East Nusa Tenggara (NTT) Province 2020-2024*. Matalawa National Park Office. Waingapu.

BMKG. 2023. *Analysis of Atmosphere-Sea Dynamics; Rainfall Analysis. Prediction*. BMKG. Jakarta.

BPS NTT. 2022. *East Nusa Tenggara in Figures*. BPS NTT. Kupang.

Buwono, Y. R. (2015). *Potential Aquatic Fauna of Mangrove Forest Ecosystem in Pangpang Bay Area, Banyuwangi Regency*. Udayana University.

Cyio, M. B. (2008). Effectiveness Of Organic Materials And Draining Height On Changes In Eh, Ph, And Soluted Fe, P, Al Status In Ultisol Soils. *J. Agroland*, 15(4), 257-263.

Dewiyanti, I., Yunita, Y. 2013. Identification and Abundance of Pests Causing Unsuccessful Rehabilitation of Mangrove Ecosystems. *Journal of Marine Science* 18: 150-156.

Efendi, R. A., Khairijon,. Isda, M. N. (2018). Litter Production Rate in Two Dominant Vegetation of Mangrove Forest in Bukit Batu Village, Bengkalis Regency, Riau Province. *Journal of Riau Biologia*, 3(1), 1-11. Retrieved from https://jrb.ejournal.unri.ac.id/index.php/JRB/article/view/6103/5615

Gita, R.S.D. (2016). Diversity of mangrove crab species (Scylla spp.) in Alas Purwo National Park. *Journal of Biology and Biology Learning*, 1(2), 148-161.

Hambran, Linda, R., Lovadi, I. (2014). Analysis of Mangrove Vegetation in Sebubus Village, Paloh District, Sambas Regency. *Journal of Protobiont*, 3(2), 201-208.

Herrera, R.D., Verdugo, F.F., Santiago, F.F., Farias, F.G. (2015). Nutrient Removal in a Closed Silvofishery System Using Three Mangrove Species (*Avicennia germians, Languncularia racemosa,* and *Rhizophora mangle*). *Marine Pollution Bulletin* 91: 243-248.

Holik, A., Aji, I. M. L., Hidayati, E. (2022). *Mangrove Health based on Environmental Parameters and Leaf Morphometrics in Rhizophora mucronata Species in the Coastal Area of Cemara Beach, South Lembar Village, West Lombok Regency*. University of Mataram.

Hotden, Khairijon,. Isda, M. N. (2014). Analysis of Mangrove Vegetation in the Mangrove Ecosystem of Tapian Nauli Village I Tapian Nauli District, Central Tapanuli Regency, North Sumatra Province. *Jom Fmipa*, 1(2), 1-10.

Idrus, S., Kusmana, M. R. (2021). Analysis of Environmental Quality and Suitability of Mangrove Ecotourism on Dodola Island, Morotai Island Regency. *Journal of Natural Resources and Environmental Management*, 11(1), 120-129.

Imamsyah, A., Bengen, D. G., Ismet, M. S. (2020). Mangrove Vegetation Structure Based On Biophysical Environmental Quality In Ngurah Rai Bali Forest Park. *Ecotrophic*, 14(1), 88-99.

Jalaludin, M., Lestari, D., Andriani, M., Ulum, M., Mellenia, S. N. (2020). Corelation Between Mangrove Ecosistems Rhizophora Stylosa. To Aquatic Biota On The Pramuka Island Of Thousand Islands. *Journal of Geography*, 9(1), 38-49.

Karimah. (2017). The Role of Mangrove Forest Ecosystems as Habitat for Marine Organisms. *Journal of Tropical Biology*, 17(2), 51-58.

Kartika, W.D. (2015). Morphometric Variation of Landlocked Shrimp Thalassina anomala (Herbst) in West Tanjung Jabung Regency, Jambi. In *Proceedings of Semirata 2015 in the field of MIPA BKS-PTN West Tanjungpura University Pontianak* (pp. 179-189).

Kusuma, A.P., Hasanah Nur, R., Dachlan Soekotjo, H. (2014). DSS for Analyzing Soil Fertility pH Using Single Linkage Method. *Eeccis*, 8(1), 61-66.

Mughofar, A., Masykuri, M., Setyono, P. (2018). Zoning and Vegetation Composition of Mangrove Forest at Cengkrong Beach, Karanggandu Village, Trenggalek Regency, East Java Province. *Journal of Natural Resources and Environmental Management*, 8(1), 77-85. Retrieved from https://doi.org/10.29244/jpsl.8.1.77-85

Onrizal. (2010). Changes in Mangrove Forest Cover on the East Coast of North Sumatra from 1977-2006. *Indonesian Journal of Biology*, 6(2), 163-172.

Poedjirahajoe, E., Marsono, D., Wardhani, F. K. (2017). Use of Principal Component Analysis in the Spatial Distribution of Mangrove Vegetation on the North Coast of Pemalang. *Journal of Forestry Science*, 11, 29-42.

Prinasti, N.K D., Dharma, I.G.B.S., Suteja, Y. (2020). Mangrove Vegetation Community Structure Based on Substrate Characteristics in Ngurah Rai Grand Forest Park, Bali. *Journal of Marine and Aquatic Sciences*, 6(1), 90. Retrieved from https://doi.org/10.24843/jmas.2020.v06.i01.p11

Salim, G., Weliyadi, E., Kasmawati. (2018). Growth Traits and Condition Index of Geloina coaxans in Mangrove and Proboscis Monkey Conservation Areas of Tarakan City. *Journal of Harpodon Borneo*, 11(1), 1-13.

Schaduw, W.N.J. (2018). Distribution and Water Quality Characteristics of Small Island Mangrove Ecosystems of Bunaken National Park, 1790.

Setyawan, A.D., Susilowati, A., Wiryanto. (2002). Habitat Relics of Mangrove Vegetation on the South Coast of Java. *Biodiversity Journal of Biological Diversity*, 3(2), 242-256. Retrieved from https://doi.org/10.13057/biodiv/d030206

Sibua, J., Wahab, I., Koroy, K. (2021). Morphometric Characteristics of Mangrove Snails (Telescopium telescopium) in the Mangrove Ecosystem of Daruba Village Beach, Morotai Island Regency. *Journal of Marine Science*, 3(2), 90-98.

Sipahelut, P., Wakano, D., Sahertian, D.E. (2019). Species Diversity and Dominance of Mangroves on the Coast of Sehati Village, Amahai District, Central Maluku Regency. *Biosel: Biology Science and Education*, 8(2), 160-170. Retrieved from https://doi.org/10.33477/bs.v8i2.1145

Sujono, P. A. W., Muzaki, F.K. (2021). Correlation Analysis of Mudskipper Abundance with Soil Organic Carbon Concentration in Mangrove Forest of Labuhan Village, Sepulu District, Bangkalan Regency, Madura. *ITS Engineering Journal*, 10(2).

Sulastri, C. W., Aji, I. M. L., Wahyuningsih, E. (2024). Analysis of Species Diversity In Mangrove Stands in Mondulambi Forest Block, Rptn Kambatawundut, Sptn II Lewa, Manupeu Tanah Daru National Park Area, 12(2), 286-304.

Syahrial, Saleky, D., Samad, A. P. A., Tasabaramo, I. A. (2020). Ecology of Tunda Island Waters Serang Banten: General State of Mangrove Forest. *Indopasifik Journal of Aquatic Resources*, 4(1), 53-68. Retrieved from https://doi.org/10.46252/jsai-fpik-unipa.2020.Vol.4.No.1.103

Usman, L., Syamsuddin,. Hamzah, S. N. (2013). Analysis of mangrove vegetation in Dudepo Island, Anggrek District, North Gorontalo Regency. *Scientific Journal of Fisheries and Marine*, 1(1), 11-17. Retrieved from http://ejurnal.ung.ac.id/index.php/nike/article/view/1211

Valentino, N., Latifah, S., Setiawan, B., Hidayati, E., Awanis, Z. Y., Hayati. (2022). Characteristics of Makrozoobentos Community Structure in The Mangrove Ecosistem of Gili Lawang, East Lombok. *Journal of Belantara*, 5(1), 119-130. Retrieved from https://doi.org/10.29303/jbl.v5i1.888

Wailisa, R., Putuhena, J. D., Soselisa, F. (2022). Analysis of Water Quality in the Coastal Mangrove Forest of Amahai State, Central Maluku Regency. *Journal of Small Island Forests*, 6(1), 57-71. Retrieved from https://doi.org/10.30598/10.30598.jhppk.2022.6.1.57

Widiawati, D., Marlinsa, E., M, M., Putra, E. P. (2021). Inventory of Mangrove Plant Species in the Bhadrika Tourism Park Area, Bengkulu Province. *Biosilampari Journal: Journal of Biology*, 4(1), 13-18. Retrieved from https://doi.org/10.31540/biosilampari.v4i1.1340

Wijayanti, T. (2009). Mangrove Forest Conservation as Educational Tourism. *Scientific Journal of Environmental Engineering*, 1(2), 15-25.

Yonvitner, Wahyudin, Y., Mujio,. Trihandoyo, A. (2019). Mangrove Biomass and Association Biota in Bontang City Coastal Zone. *Indonesian Journal of Biology*, 15(1), 123-130.

Zamroni, Y., Rohyani, I. S. (2008). Mangrove Forest Litter Production in the Coastal Waters of Teluk Sepi Bay, West Lombok. *Biodiversity Journal of Biological Diversity*, 9(4), 284-287. Retrieved from https://doi.org/10.13057/biodiv/d090409