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Chemical content analysis of substrates around lantebung mangrove ecotourism site, Makassar city, Indonesia

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Abstract
The study aims to determine the chemical aspects of the substrate around the Lantebung mangrove ecotourism in Makassar City. The study used a survey method by taking substrate samples in the waters. We collected soil substrate samples from three different locations. Substrate sample analysis was conducted in the laboratory. The parameters analyzed were pH, nitrogen, organic matter, ammonia, nitrite, and soil substrate texture. The data obtained were then analyzed using descriptive analysis. The results of the study showed that the pH of the substrate at 3 observation stations (ST) had acidic to neutral properties in the range of 5.90–7.34; the nitrogen of the substrate at the three research locations was in the range of 0.297–0.555%; the organic matter of the substrate at the three research locations was in the range of 0.37–2.34 ppm; the ammonia content of the substrate at the three research locations was in the range of 0.0175–0.2497 ppm; and the nitrite content of the substrate at the three research locations was in the range of 0.0096–0.0183 ppm. While the substrate texture was generally sandy clay loam, except for ST 1, which had a dusty clay substrate.

Keywords: Substrates, Lantebung, Mangrove, Ecotourism, Chemical

Introduction

Mangrove forests are plant communities that live in coastal or estuary areas that are directly and intensely influenced by the ebb and flow of seawater [1]. Each type of mangrove has different physiological and morphological adaptations to the type of substrate. Substrate is a place for mangroves to grow, either in the form of sand, mud, soil, or coral rock fragments that can be a limiting factor for distribution, growth, and zoning determinants in the mangrove ecosystem [2]. According to [3], the type of substrate on a beach will affect the growth of mangroves; this is because the type of substrate has a significant impact on the growth and density of mangrove vegetation. Substrate is the main factor supporting the regeneration process of mangrove plants, which greatly influences the level of mangrove vegetation density in an area [4]. The substrate in the mangrove ecosystem consists of several types, where each type of substrate has a different composition; this also causes the density in each area of the substrate type to have a different level [5].

In general, mangrove forests are defined as a type of forest that grows in tidal areas (especially protected beaches, lagoons, and river estuaries) that are inundated at high tide and free from inundation at low tide, where the plant community is tolerant of salt [6]. The word mangrove can be interpreted as an intertidal area, which is an area under the influence of the tides along the coastline, such as lagoons, estuaries, beaches, and riverbanks [7]. Mangroves are a type of vegetation found in coastal areas and are regularly influenced by the ebb and flow of seawater [8]. Mangroves are a specific ecosystem that is generally only found on beaches with relatively small waves or even those protected from waves, along deltas and estuaries that are influenced by the input of water and mud from the mainland [9].

Ecologically, the mangrove ecosystem functions as a spawning ground and nursery ground for various aquatic biota such as fish, shrimp, shellfish, and others [10]. Mangrove areas are areas with high primary productivity. Primary productivity greatly influences mangrove growth [11]. Human activities in coastal areas make this area the area most easily affected by human activities. The result is a decline in the quality of coastal waters [12]. Various community activities here will ultimately affect the environmental carrying capacity [10]. The decline in the quality of the mangrove environment will affect the distribution of organic material content in the sediment, which will affect the fertility of the mangroves [13].

The increasing population growth living in coastal areas and development activities that utilize coastal ecosystems can result in changes to the ecosystem. This utilization should be renewable (renewable resource) so that coastal and coastal areas that provide various natural resources can be managed properly [14]. Pollutants entering coastal and marine areas can come from various sources [15]. Around the Lantebung mangrove in Makassar City, currently, in addition to being used to overcome the negative effects in coastal areas, mangroves are also used as an ecotourism destination. This is thought to affect the quality of the substrate around the mangrove. Therefore, research has been conducted on the condition of the substrate around the mangrove forest.

Materials and Methods

This research was conducted from April to June 2024 and was located in the Lantebung ecotourism area of Makassar City, where the substrate/sediment sampling process was carried out at 3 different locations, namely Station 1 (ST 1), located in the southern part of the ecotourism area, where this station has facilities such as toilets and there are also tourist spots, and currently many new mangroves have been planted as a result of collaboration between students and local residents. Station 2 (ST 2) is located in the northern

part of the Lantebung mangrove ecotourism and is the main spot for tourism because the area is larger than the spot area at station 1. Furthermore, Station 3 (ST 3) is located on the outside of the Lantebung Mangrove Ecotourism, which is the main road to access the tourist spot, and along this station it is very common to see the activities of local residents, especially in the morning and evening when residents who work as fishermen do a lot of activities. The study used a survey method by taking substrate samples in the waters at the station (ST) of the research location. Soil substrate samples were taken at the three locations. Furthermore, soil sample analysis was carried out in the Chemistry and Water laboratory of the Pangkep State Agricultural Polytechnic. Determination of substrate quality refers to the chemical and physical properties of each location. The parameters analyzed were pH, nitrogen, organic matter, ammonia, nitrite, and soil substrate texture.

a. pH

Soil pH measurement was carried out by weighing 10 grams of soil sample, which was put into a shaker bottle. Then 50 ml of ion-free water was added to the bottle and then shaken with a shaker for 30 minutes. Then the soil suspension was measured with a pH meter that had been calibrated using a pH buffer solution of 7.0 and 4.0; then the pH value was reported in 1 decimal [16].

b. Nitrogen (%)

The method of determining total nitrogen uses the Kjeldahl method. First, 0.5 grams of soil is weighed and put into a 100 mL Erlenmeyer flask, then 0.5 grams of a mixture of selenium and 15 mL of concentrated H_2SO_4 are added to the soil. The solution was then heated on the destruction device, initially with a small flame for 15 minutes, then the flame was increased until the solution was clear for ± 3-4 hours. After the solution had cooled, distilled water was added to a 50 mL measuring flask, 1 mL of the solution was taken, put into a small container, and 2 pipettes of 40% NaOH were added and then shaken. The pH of the solution was measured until it was alkaline and then diluted with distilled water to 25 mL in a measuring flask, then 3 drops of seignette salt and 0.5 mL of Nessler were added until it was yellowish. The solution was then transferred to a cuvette and tested with a spectrophotometer. The spectro reading was recorded at a wavelength of 490 nm [11].

c. Organic material (%)

Total organic matter analysis was carried out using the high temperature loss on ignition (LOI) combustion method. The LOI method aims to determine the total organic matter (organic carbon) content in sediment. The formula used [12] is:

$$Li = \frac{W2 - W3}{W1 - W0} \times 100 \times FKA$$

Where:
Li = Organic material (%)
W0 = Cup weight (g)
W1 = The weight of the cup filled with sediment sample is 5 g.
W2 = Weight after the water content is lost
W3 = Weight after incandescence

The criteria for total organic matter content in sediment are described into several categories [17], namely:

Table 1: Criteria for organic material content in the substrate

Organic Matter Content (%)	Criteria
> 5	Very high
3.01 – 5.00	High
2.01 – 3.00	Medium
1.00 – 2.00	Low
< 1	Very low

d. Ammonia (NH_3)

Ammonia measurement begins with the process of extracting ammonia from sediment samples. This process is carried out by taking a sediment sample of 2.5 grams, which is then added with 7.5 ml of 1M KCl solution. After that, the mixture was agitated using a Vortex until homogeneous. Take 2 ml of the vortex results into a tube for centrifuge. Next, the ammonia measurement process will be carried out on the suspension resulting from the agitation. The suspension (1 ml) is mixed with the reagent solution from the Salifert Ammonia Test Kit, and waited for 2 minutes. Then, the absorbance value will be measured using a spectrophotometer using a light wavelength of 400 nm [18].

e. Nitrite (NO_2)

Determination of nitrite levels is carried out using a spectrophotometer method (SNI 06-6989.9-2004). In an acidic environment (pH 22.5), nitrite will react with sulfanilamide (SA) and N-(1-naphthyl) ethylene diamine dihydrochloride (NED dihydrochloride) to form a purplish red azo compound that can be measured at a wavelength of 543 nm [19].

f. Substrate texture

The method used to see the soil fraction is to provide a 100 mL beaker; soil samples are taken with a depth of 30 cm as needed; soil samples are put into the beaker; given enough water until it approaches the mouth of the bottle; and then homogenized. Placed on a flat place. After 1 minute, observations and measurements are made on the first layer (sand layer), then the results of the observations are recorded. The sample was left again for 2 hours; after 2 hours, observations and measurements were made on the second layer (mud layer) and the third layer (clay layer). The results of the observations were then recorded, and the percentage of sand, mud, and clay fractions was calculated [11]. The data obtained from the laboratory test results were then processed and analyzed using descriptive analysis.

The substrate texture at the research location, namely around the Lantebung mangrove forest, can be seen in Table 2.

Table 2: Texture of the substrate at the research location

Research Location	Substrate texture
ST 1	Dusty clay
ST 2	Sandy clay loam
ST 3	Sandy clay loam

Results

The results of substrate chemical measurements at the research location around the Lantebung mangrove forest can be seen in Fig. 1 to Fig 5.

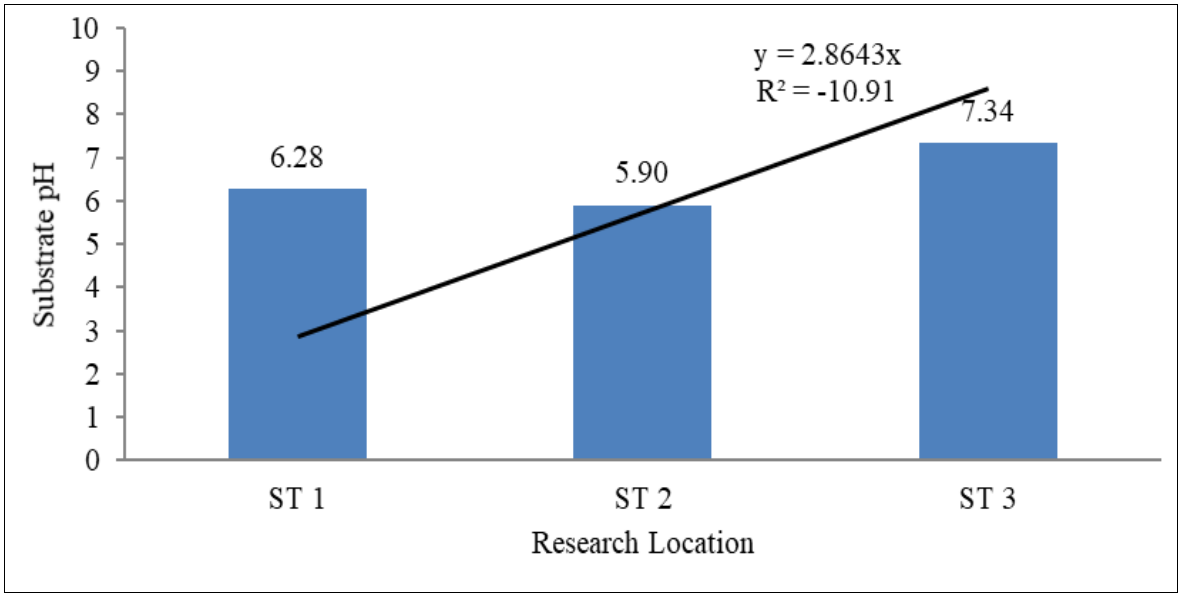

Fig 1: pH of the substrate at the research location

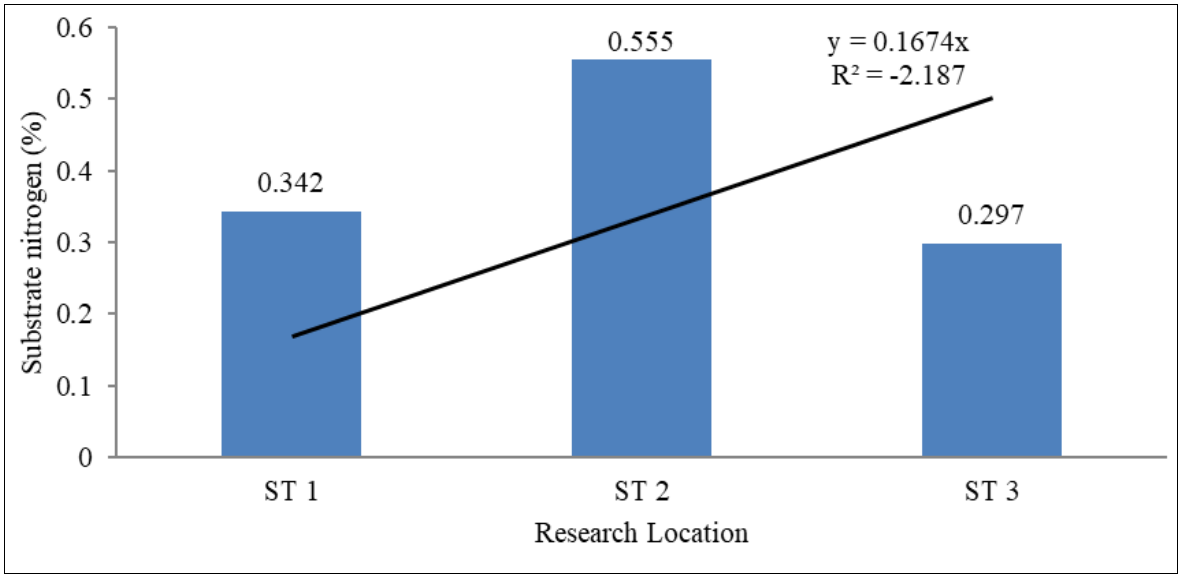

Fig 2: Nitrogen substrate of the research location

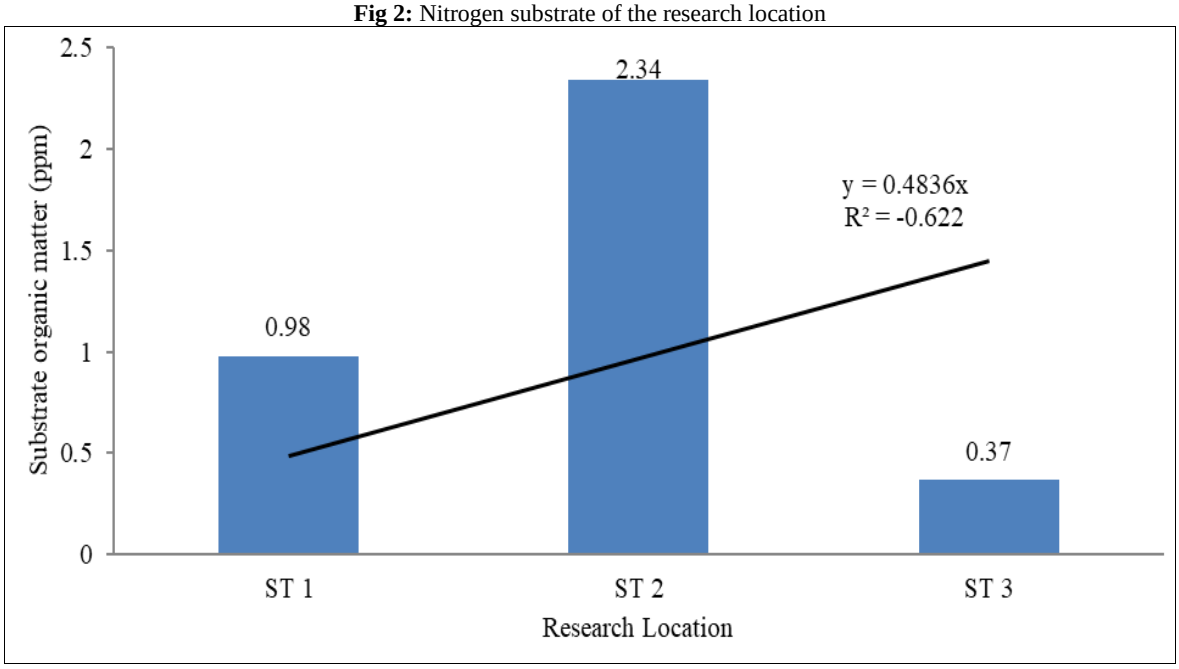

Fig 3: Organic material of the substrate at the research location

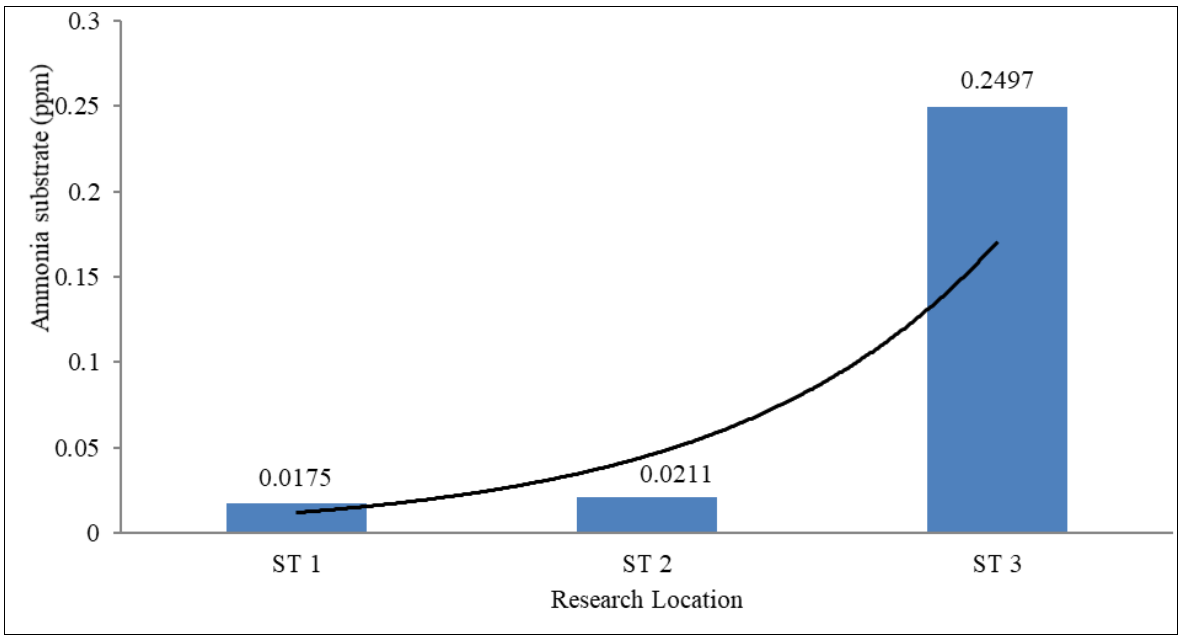

Fig 4: Ammonia substrate at the research location

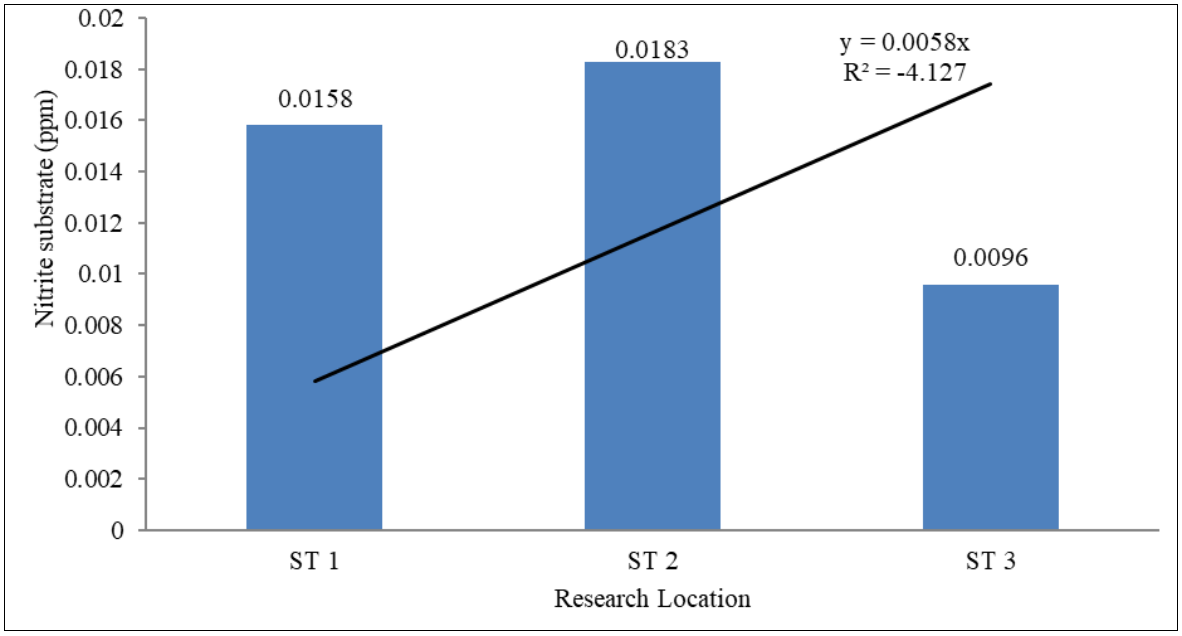

Fig 5: Nitrite substrate at the research location

Discussion

Fig 1 shows that the substrate pH at the research location is in the range of 5.90–7.34, with the lowest substrate pH at ST 2, which is located in the northern part of Lantebung mangrove ecotourism and is the main spot for tourism, namely 5.90, and the highest substrate pH at ST 3, which is located on the outside of Lantebung mangrove ecotourism, which is the main road to access the tourist spot. The substrate pH at all three research locations is relatively low. According to [10], a good pH tolerance range for mangrove ecosystems is around 6.0–9.0, and the optimal pH is around 7.0–8.5. Mangroves will grow and develop well in the pH range of 6.2–8 [20]. Soil pH with a value range between 6–7 is the appropriate pH for mangrove growth. According to [21], soil pH with a range of values between 6 and 7 is the appropriate pH for mangrove growth. The most optimal pH level is neutral, with a value of 6.6 to 7.5 [21]. In neutral pH conditions, it is easy for plants to absorb nutrients [22]. If the pH is low, decomposers will occur, which results in the process of breaking down organic materials into inorganic materials being slow, and vice versa; if the pH is high, the process of breaking down into inorganic materials is fast [23]. Total nitrogen content at three different ages of mangroves shows an increase in value, namely, the older the mangrove, the higher the nitrogen content. This can be caused by the presence of a stronger root system so that plants can precipitate mud that contains a lot of nutrients, especially nitrogen [11]. Nitrogen in sediment is an essential element for plants that plays a role in the process of photosynthesis and stimulates growth [24]. Fig 2 shows that the nitrogen substrate at the three research locations is in the range of 0.297-0.555%, with the lowest nitrogen at ST 3, which is located on the outside of the Lantebung Mangrove Ecotourism, which is the main road to access tourist spots,

at 0.297%, while the highest nitrogen is at ST 2, which is located in the northern part of the Lantebung mangrove ecotourism and is the main spot for tourism, at 0.555%.

The sandy substrate has the lowest tree level density and organic matter content, while the highest density and organic matter content are found in the sandy mud substrate. Substrates with a high mud fraction can be a good habitat for mangrove growth [4]. Fig 3 shows that the organic matter content of the substrate at the three research locations is in the range of 0.37–2.34 ppm, with the lowest organic matter content at ST 3, which is located on the outside of the Lantebung Mangrove Ecotourism and is the main road to access the tourist spot, at 0.37 ppm, and the highest organic matter content at ST 2, which is located in the northern part of the Lantebung mangrove ecotourism and is the main spot for tourism, at 2.34 ppm. The organic matter content in the substrate is influenced by several factors, one of which is the type of substrate [4]. The decomposition of organic matter in mangrove land is greatly influenced by the frequency and duration of soaking and particle size distribution of the substrate [25]. Mud particles have low porosity so that mud is better at holding organic material compared to sand particles, which are larger in size and have higher porosity so that organic material is easily released [26].

The levels of ammonia in seawater vary greatly and can change rapidly [15]. Ammonia in water is an indication of the decomposition of organic matter, especially protein [27]. [28] states that if the concentration of ammonia in water is too high, then water pollution can be suspected. The increasing levels of ammonia in the sea are closely related to the entry of easily decomposed organic materials (both those containing nitrogen and those not containing nitrogen) [29]. Waste is one of the problems that must be handled properly because waste can contain hazardous and toxic chemicals [15]. One of the chemicals commonly contained in waste is ammonia [30]. Fig 4 shows that the ammonia content of the substrate at the three research locations is in the range of 0.0175–0.2497 ppm, with the lowest ammonia content at ST 1, which is located in the southern part of the ecotourism where this station has facilities such as toilets and also tourist spots, namely 0.0175 ppm, while the highest ammonia content is at ST 3, which is located on the outside of the Lantebung Mangrove Ecotourism, which is the main road to access tourist spots, and throughout, this station is very commonly seen with the activities of local residents, especially in the morning and evening when residents who work as fishermen do a lot of activities of 0.2497 ppm.

The nitrification process is assisted by the enzyme nitrogenase, which plays a role in changing ammonium (NH_4^+) into nitrite (NO_2). There are two processes in nitrification, namely ammonium to nitrite (NO_2^-) and the process of nitrite (NO_2^-) to nitrate (NO_3^-). This process can take place chemically or biologically [31]. Figure 5 shows that the substrate nitrite content at the three research locations is in the range of 0.0096-0.0183 ppm, with the lowest nitrite content at ST 3, which is located on the outside of the Lantebung Mangrove Ecotourism and is the main road to access the tourist spot of 0.0096, while the location with the highest nitrite content at ST 2 is located in the northern part of the Lantebung mangrove ecotourism and is the main spot for tourism of 0.0183 ppm. [32] states that natural waters generally contain nitrite of 0.001 ppm and should not exceed 0.06 ppm. Nitrite is one of the key parameters in determining water quality because it is toxic when it reacts with hemoglobin in the blood, which causes the blood to be unable to transport oxygen [29]. Furthermore, [30] stated that in natural waters, nitrite is generally found in very small amounts due to its unstable nature due to the presence of oxygen. In the nitrification process and the ammonification process, it is very dependent on the presence of oxygen in the aquatic environment, because ammonification bacteria are aerobic bacteria that require oxygen to carry out their metabolic processes [33]. When oxygen in the environment is abundant, the ammonification and nitrification processes will also run smoothly [34].

If the substrate is sandy or sandy with a combination of coral pieces, the mangrove density will be low because the substrate cannot catch or hold the fallen mangrove fruit so that the regeneration process does not occur [3]. The type of sediment is a limiting component for mangrove growth. If the sediment composition is more clay and silt, the stand will be denser [35]. The existence of mangrove vegetation greatly influences the formation of sediment texture types. According to [36], mangrove roots can accumulate sediment, capture litter, and play an important role in the formation of soil transformation. Table 2 shows that the substrate texture at ST 2, which is located in the northern part of the Lantebung mangrove ecotourism and is the main spot for tourism, and ST 3, which is located on the outside of the Lantebung mangrove ecotourism and is the main road to access the spot, has a sandy clay texture. Meanwhile, ST 1 is located in the southern part of the ecotourism area, where at this station there are facilities such as toilets, and there are also tourist spots, and currently there are many new mangroves that have been planted as a result of collaboration between students and local residents, which have a dusty clay texture. Substrates with a dominant sand fraction tend to have sparse mangrove density because sand has less ability to store water so that the availability of water for mangroves is limited [37]. Particles in the form of sand will stop and settle first, while sediment in the form of softer mud can be carried further by the current. This is because sand particles are larger and heavier than mud particles [38]. Furthermore, the results of research [39] stated that productivity and nutrient transport from mangrove ecosystems are found in large quantities in mangrove sediments containing mud because they easily bind nitrogen, phosphate, and other elements. [40] found that the organic matter content was lower at high sand fraction points.

Conclusion

The pH value of the substrate at the research location was in the range of 5.90–7.34, with the lowest substrate pH at ST 2 and the highest at ST 3. Substrate nitrogen at the three research locations was in the range of 0.297–0.555%, with the lowest nitrogen at ST 3 and at ST 2. The organic matter content of the substrate at the three research locations was in the range of 0.37–2.34 ppm, with the lowest organic matter content at ST 3 and the highest at ST 2. The ammonia content of the substrate at the three research locations was in the range of 0.0175–0.2497 ppm, with the lowest ammonia content at ST 1 and the highest at ST 3. The nitrite content of the substrate at the three research locations was in the range of 0.0096–0.0183 ppm, with the lowest nitrite content at ST 3 and the highest at ST 2. The substrate texture was generally sandy clay loam, except at ST 1, which had a

dusty clay substrate. Based on the results of this study, it can be stated that all tested parameters are still suitable for fish farming activities.

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