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THE RELATIONSHIP BETWEEN MANGROVE DENSITY AND SEDIMENTATION RATE IN COASTAL KUALA JAMBI DISTRICT TANJUNG JABUNG TIMUR JAMBI PROVINCE

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ABSTRACT

This research was carried out from March to April 2021 in the coastal area of Kuala Jambi District, Tanjung Jabung Timur Regency, Jambi Province. The samples were processed at the Marine Biology and Marine Chemistry Laboratory, Faculty of Fisheries and Marine, Universitas Riau, which aims to examine the density of mangroves, analyze the sedimentation rate, and know the relationship between mangrove density and sedimentation rate. A survey method was used in this study. The results showed that the dominant mangrove species in the coastal waters of Kuala Jambi was *Sonneratia alba* with an Important Index Value (INP) of 103.5%. Mangrove density in the coastal waters of Kuala Jambi was included in good criteria with moderate and very dense mangrove cover. The bottom sediment of the coastal waters of Kuala Jambi was dominated by the type of sandy mud with a percentage of 42.23 - 55.63%. The value of the sedimentation rate in the coastal waters of Kuala Jambi at station I ranged from 94.401 to 141.602 mm/year. At station II, the sedimentation rate was between 98.692 and 168.778 mm/year, while at station III the sedimentation rate was from 100.122 to 145.893 mm/year. Mangrove density had a very close relationship with the sedimentation rate, where the higher the mangrove density, was followed by the higher the sedimentation rate.

Keywords: Mangrove Density, Sedimentation Rate, Kuala Jambi Coast

I. INTRODUCTION

Tanjung Jabung Timur Regency is one of the regencies on the east coast of Jambi Province. This area is a coastal area that has extensive sea waters with a coastline of 191 km and has a fairly good ecological condition. Through Regional Regulation of Tanjung Jabung Timur Regency Number 8 of 2014, this area was designated as a coastal border zone conservation area with an area of 452.90 ha covering Mendahara District, Kuala Jambi District, Muara Sabak Timur District, Nipah Panjang District, and Sadu District.

According to Kustanti[1] the physical function of the existence of mangrove forests is to maintain the shoreline and riverbanks from erosion/ abrasion to remain stable, accelerate land expansion, control seawater intrusion, protect the area behind the mangrove forest from waves and strong winds and treat waste organic. As a coastal protector from the abrasion/erosion process, mangroves can withstand the energy of seawater abrasion waves or energy from erosion. The expansion of land that occurs in mangrove forest ecosystems occurs with the adsorption of mud by the roots of mangrove vegetation. As a result of this mud trapping, there is an addition of land protruding into the sea.

Ship traffic in Kuala Jambi waters causes waves to erode the shores of the land. Eroded land bank material is one of

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the sources of the sedimentation process. Sedimentation is the process of depositing organic and inorganic materials which are suspended in water and transported by water so that deposition occurs in a place where water is no longer able to carry these suspended particles[2]. Sedimentation is the deposition of sediment grains from the water column to the bottom of the waters[3].

Sedimentary deposits are widespread on land, on the coast, and in the sea. Sediment characteristics such as grain size, grain shape, texture, sorting, and mineral composition of sediment will differ from one place to another. The characteristics of these sediments are very dependent on the type and location of origin of the rock source and the characteristics of the sediment process[4].

Problems regarding mangroves that occur in Kuala Jambi District are the conversion of mangrove land into plantations and settlements as well as uncontrolled illegal logging. Mangrove wood is often taken for staking buildings (cerucuk), supporting fishing nets on the beach (jajar), for party tents, and some people who make mangrove wood a trading commodity, if this continues to happen it will certainly cause the density of mangrove forests to decrease and of course, there will be many impacts, one of which is the sedimentation rate. For this reason, the author is interested in conducting a research entitled the relationship between mangrove density and sedimentation rate on the Kuala Jambi Coast, Tanjung Jabung Timur Regency, Jambi Province.

The problems raised in this study are how the mangrove density is on the Kuala Jambi Coast, how big the sedimentation rate is the relationship between mangrove density and sedimentation rate. The aims and benefits of this research are to examine mangrove density, analyze sedimentation rates, and examine the relationship between mangrove density and sedimentation rates with the benefits. The benefits of this research are expected to provide information regarding the effect of mangrove density on sedimentation rates.

2. RESEARCH METHOD

Time and Place

This research was carried out in March-April 2021 in the mangrove forest area of Kuala Jambi waters, Tanjung Jabung Timur Regency, Province. Analysis samples were taken at the Marine Biology Laboratory and Marine Physics Laboratory, Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau (Figure 1). The method used in this study is a survey method, where observations and sampling are carried out.

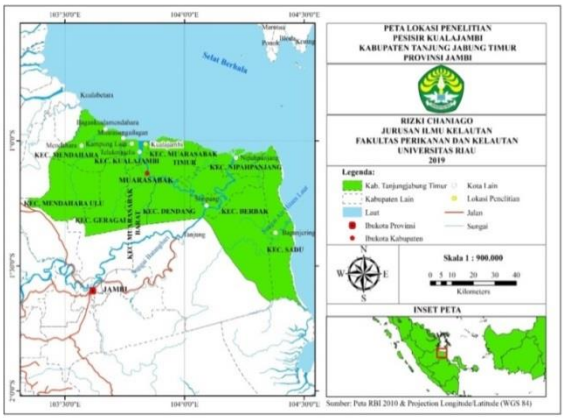

Figure 1. Map of research locations

Method

The method used in this study is the survey method, where observations and sampling are carried out.

Research Procedure

Sampling Location Determination

Determination of the sampling point was carried out by purposive sampling which was divided into 3 observation sampling points that were considered to represent the research area. Namely the selection of subjects based on certain population characteristics that are already known, namely the following characteristics: Station I describes a mangrove area with anthropogenic activity that is not too high and far from human settlements. Station II describes the mangrove area around the river mouth with

a moderate anthropogenic level and not far from human settlements. Station III describes the mangrove area around the estuary with a high anthropogenic level and is in the vicinity of community settlements.

Retrieval of Mangrove Density Data

Density data was taken using the line transect plot method. Data was taken in 3 observation stations. Each observation station has 3 transects, each transect has 3 plots, and each plot has 3 sizes, namely 10x10m² for the tree category (trunk diameter at breast height is more than 4 cm), 5x5m² size for the samplings category (trunk diameter at breast height less than 4 cm), and plots with a size of 2x2m² for the seedling category (starting from sprouting on propagules up to 1 meter high). Identification of mangrove species refers to guidelines for introducing mangroves in Indonesia.

The measurement of trunk diameter is taken at breast height or called DBH (diameter of breast height), namely the diameter of a tree trunk which is measured at the height of an adult human chest (1.3 meters).

Retrieval of Sedimentation Rate Data

Retrieval of sedimentation rate data using sediment trap. Sediment traps used 5 cm in diameter, 20 cm long, and made of PVC pipe[5]. Sediment traps are installed as many as 2 units at each station at a distance of 20 cm from the bottom of the waters. Sampling was carried out in Kuala Jambi waters with sediment sampling intervals for 5 days after installation of the tool, 3 repetitions for 15 days. Trapped sediment samples are put into sample plastic, then analyzed in the laboratory.

Data Analysis

Community Structure

Analysis of mangrove community structure data includes species density (K), Relative Density (KR), Species Frequency (Fi), Relative Frequency (FR), Type closure or Domination (D), Relative Domination (DR)[6], namely as follows:

The density of Type (K)

The density of species (K) is the number of individuals of type i in a unit area). Determination of density using the formula[7]:

$$K=\frac{ni}{A}$$

Description:
K = Density of type i (ind/ha)
ni = total number of individuals of type i
A = Total area of sampling (m²)

Important Value Index (INP)

The Important Value Index (INP) is the sum of the values of the type relative density (RDi, and the type relative frequency (RFi).

Sedimentation Rate Analysis

The calculated sediment accumulation is the volume and weight of sediment deposited per unit volume of sediment trap per time with the following procedure[8]:

1. Sediment samples retained in the sediment trap are transferred to the sample plastic.
2. The sample is analyzed in the laboratory to determine its volume and weight.
3. The volume was measured by sifting the sediment with the finest sieve of 0.063 mm to separate the silt from the other fractions.
4. The volume of the fraction retained in the sieve is calculated (ml), after which it is dried and weighed (g).
5. The sediment that passes through the sieve is left for 3 days to settle, after which the settled volume (ml) is measured and weighed (g).

Sediment accumulation is calculated with the following[3]:

$$KA=\frac{v/V}{t}$$

KA = Sedimentation Rate (ml/cm^3 /day) or (ml/cm²/day)

v = sediment volume (ml)
V = trap sediment volume (cm^3) or trap sediment area (cm^2)
t = sed install time traps (days).

In addition, the calculated sediment accumulation is the weight of sediment deposited per unit area per time with the following calculation[3]:

$$KA = \frac{W/V}{t}$$

KA = Accumulation rate (g/ cm^3/day) or (g/cm^2/day).
W = the dry weight of sediment (g)
V = trap sediment volume (cm^3) or trap sediment area (cm^2).
T = sediment trap installation time (days).

3. RESULTS AND DISCUSSION

Oceanographic Parameters

The results of measuring Oceanographic Parameters in the coastal waters of Kuala Jambi can be seen in Table 1.

Table 1. Oceanographic parameter measurement

Parameter	Station I	Station II	Station III
Salinity(‰)	30	30	28
pH	7	7	7
Current Speed (m/s)	0.20	0.17	0.23
Brightness(cm)	26	28	23
Temperature (°C)	30	31	31
Depth (cm)	106	113	95

Table 2. Mangrove species identified at the study site

Family	Mangrove type		Presence		
	Latin name	Local name	ST I	ST II	ST III
Avicenniaceae	*Avicennia alba*	Api-api	√	√	√
	A. Marina	Api-api	√	√	√
Sonneratiaceae	*Sonneratia alba*	pedada	√	√	√

Table 3. Table of calculation of the average important value index (%) for each type of mangrove

Type	ST I	ST II	ST III	Average
A.alba	91.8	98.9	97	95.9
A.marina	98.2	105.7	98.1	100.7
S.alba	110	95.5	104.9	103.5
Total				300.0

Table 4. Mangrove density at each station

Station	Density (Ind/ha)	Criteria*	Condition
I	1455.56 ± 168.08	Good	Meeting
II	1777.78 ± 309.83	Good	Meeting
III	1433.33 ± 168.08	Good	Meeting

Identification and Dominating of Mangrove Types

From three observation stations, existing mangrove species have been found in the Kuala Jambi Coast in Table 2.

Determination of the type of mangrove that dominates is assessed from the highest important value index, the important value index is the lowest value indicates the level of importance or ecological value of a species in a

community. The following is the percentage of INP obtained from 3 observation stations (Table 3).

Mangrove Density

The density of mangroves between stations depends on the number of mangroves found. The results of this study showed that the average mangrove density was 1433 - 1778 ind/ha. Based on the Decree of the Minister of State for the Environment Number 201 in 2004, the density of mangroves at each station was classified as good with moderate and very dense densities. The results of calculating the density of mangroves at each station on the Kuala Jambi Coast can be seen in Table 4.

The highest density value is found at station II with a density of 1,778 trees/ha which means it is in good condition and is included in the very dense density category, the station I with a density value of 1,455 trees/ha in good condition is included in the medium density category, and at station III the average density is 1,433 trees. /ha is in good condition and is still in the medium-density category. Density data processing can be seen in Appendix 7 and a comparison graph of density levels at stations I, II, and III can be seen in Figure 2.

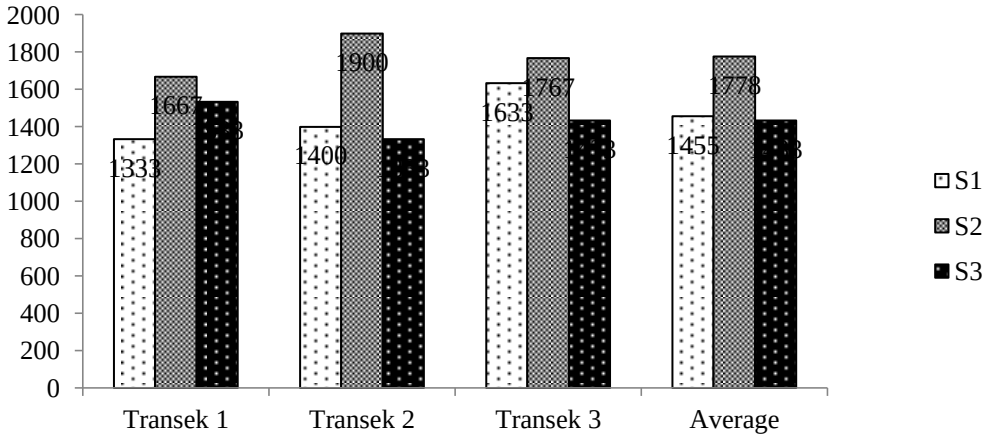

Figure 2. Mangrove density at stations I, II, and III

Mangrove species density is the number of types it stands in an area. Mangrove density at 3 observation stations ranged from 1,433-1,778 trees/ha, based on Decree of the Ministry of Environment No. 201 of 2004[9] states that densities of <1,000 trees/ha include damaged mangroves with sparse densities, densities between 1,000-1,500 trees/ha are included in good conditions with moderate densities, and densities >1,500 trees/ha are included in good conditions with dense densities.

Mangrove density at station I is 1,456 trees/ha including good mangrove conditions with medium density category Usman et al.[10] at this station found 3 types of mangroves from 2 different families *A.alba*, *A. marina*, and *S. alba*. The pH of the waters at this station is 7. The quality standard for good seawater pH for marine biota is 7-8.5 in this pH range, meaning that the quality of the waters from a pH level is still in good condition. Each station obtained a pH level of 7. There was no variation in the pH level at each observation station.

The density of mangrove species shows the number of tree stands in the area[10]. The highest mangrove density is at station II with a density of 1,778 trees/ha showing good conditions with a very dense category[9], this is because the mangroves at station II are far from human settlements and a muddy sand substrate that supports optimum mangrove growth following the opinion of Akbar et al.[11] states that the

existence of a suitable substrate for mangrove growth, low community activity, and mangroves being allowed to grow and develop due to an understanding of the importance of the existence of mangroves as a habitat for fish and other natural resources causes mangroves to grow optimally. This was also coupled with the local community's agreement not to carry out fishing activities using circular trawls (slats) which would use mangroves as stakes in the area around station II because this area had been mutually agreed to be used as a breeding ground for clams and all communities could take them. The local people only use the traditional way, which is taken by hand. At station II, III types of mangroves from 2 different families were found including *A. alba*, *A. marina*, and *S. alba*.

The lowest mangrove density level is station III with a density of 1,122 trees/ha but still in good condition with the criteria of medium density[9]. The low level of density of mangroves at station III compared to other stations is thought to be due to the high anthropogenic activity at station III compared to other stations, station III is in an area close to residential areas and is often used as a place to pick up cigars by the local community. At this station, 3 mangrove species were found from 2 different families *A. alba*, *A. Marina*, and *S. alba*.

Achmad et al.[12] Stated that most of the mangrove forests in Jambi Province in 2018 were at medium density. From the image interpretation, it can be seen that in Mendahara (Mendahara Ilir), Kuala Jambi, Muara Sabak Timur (Simbur Naik) and Sadu (Sungai Sambal, Sungai Sayang, Remaobakutuo) districts are in the Meeting density class. The subdistricts of Sebrang, Tungkal Ilir, Betara, some of the sub-districts of Mendahara (Pangkal Duri and Sungai Ayam), Nipah Panjang and Sadu (Sungai Lokan) are in the Medium density class. The Rare density class is in the Districts of Muaro Sabak Timur (Alang-Alang, Sungai Ular, Lambur), and Sadu (Sungai Cemara).

Sediment Fraction

Based on the analysis of sediment samples, it was found that the type of sediment that dominates the mangrove forest substrate is sandy mud. In more detail, the results of fraction analysis Sediments are shown in Table 5, that the types of sediment (substrate) that dominate in the Kuala Jambi Coastal Waters are as follows.

Table 5. Sediment fraction

Station	% Sediment Fraction			Sediment Type
	Gravel	Sand	Mud	
I	1.32	45,28	53,40	Sandy Mud
II	0.96	56,81	42,23	Muddy Sand
III	1.00	43,37	55,63	Sandy Mud

From the results of Table 5 it is known that on the coast of Kuala Jambi, 3 types of sediment fractions were found, namely gravel, sand, and silt. The type of sediment that dominates in this study area is the silt fraction, while the type of fraction that is least encountered is the gravel fraction. The sediment type in the coastal waters of Kuala Jambi that dominates is the sediment type sandy mud, from 3 stations there is one station that has a Muddy sand sediment type, namely at station II.

The gravel fraction was found to be between 0.96-1.32%. The highest gravel fraction was found at station I with a value of 1.32%, while the lowest gravel fraction was found at station II with a value of 0.96%. The sand fraction with percentages

ranges from 43.37 to 56.81%. The highest sand fraction was found at station II with a value of 56.81%, while the lowest sand fraction was found at station III with a value of 43.37%. The sludge fraction with values ranging from 42.23% -55.63%. The highest mud fraction was found at station III with a value of 55.63%, while the lowest mud fraction was found at station III with a value of 42.23%.

Based on the results of sampling in the field and analysis of samples at the Marine Chemistry Laboratory, the types of sediment particles in the Kuala Jambi Coastal waters were found in gravel, sand, and silt sediment fractions. The percentage of gravel fraction ranges from 0.96% - 1.32%. The lowest gravel fraction was obtained at station II with a value of 0.96% and the highest gravel fraction was found at station I with a value of 1.32%. The sand fraction ranged from 43.37% - 56.81%. The lowest sand fraction was obtained at station III with a value of 43.37% and the highest sand fraction was obtained at station II with a value of 56.81%. The percentage value of the sludge fraction ranged from 42.23% - 55.63%. The lowest mud fraction was obtained at station II with a value of 42.23% and the highest mud fraction was obtained at station III with a value of 55.63%.

Sediment types in the coastal waters of Kuala Jambi are grouped into two types of sediment based on the Sephard triangle analysis, namely silty sand and sandy mud. The type of sediment (substrate) that dominates the Kuala Jambi Coastal Waters is sandy silt with a percentage value of 42.23-55.63%. This is because the currents in the study area tend to be weak so that suspended sediments will easily settle. This is to the statement of Wisha & Aida[8], in areas with high current velocity, the transport mechanism is also high so that abrasion tends to occur in the region, while in areas with weak current velocity suspended sediments will easily settle, due to lack of transport energy by currents and tides.

In addition, high human activities such as ship traffic as a means of public transportation cause the erosion of river banks and carries sediment particles, and the influence of sediment from the mainland also affects the type of sediment on the Kuala Jambi Coast. This is following Rifardi[5], that in addition to waves and currents, the process of sediment formation is also determined by artificial (human) activities on land. Artificial influence around the coast affects the distribution of sediment fractions because this activity supplies poorly sorted sediment.

Sediment Accumulation and Sedimentation Rate

The sediment accumulation value can be seen in Table 6.

Table 6. Sediment accumulation value and sedimentation rate

Station	Sediment Volume (ml)	Sediment Weight (g)	ka (tonnes /ha/year)	Sedimentation rate (mm/year)
S1.1	660	350	500,611	94,401
S1.2	990	560	800,978	141,602
S1.3	750	390	557,824	107,274
S2.1	690	270	386,186	98,692
S2.2	1180	450	643,643	168,778
S2.3	900	390	557,824	128,729
S3.1	830	310	443,398	118,716
S3.2	1020	440	629,34	145,893
S3.3	700	340	486,308	100,122

Based on Table 6, the value of sediment accumulation in the coastal waters of Kuala Jambi at Station I ranges from 500,611 -800,978 tons/ha/year with sedimentation rates between 94,401-141,602 mm/year. At station II the value of sediment accumulation ranges from 386.186 -653,643 tons/ha/year with sedimentation rates between 98.692 - 168.778 mm/year. Whereas at station III the value of sediment accumulation ranged from 443.398 - 629.34 tons/ha/year with sedimentation rates ranging from 100.122 - 145.893 mm/year. Based on the results of the analysis carried out in the laboratory, the value of sediment accumulation in the waters of the Kuala Jambi Coastal waters at Station I ranged from 500,611 - 800,978 tons/ha/year with sedimentation rates between 94,401 - 141,602 mm/year. At station II the value of sediment accumulation ranges from 386.186 - 653,643 tons/ha/year with sedimentation rates between 98.692 - 168.778 mm/year. Whereas at station III the value of sediment accumulation ranged from 443.398 - 629.34 tons/ha/year with sedimentation rates ranging from 100.122 - 145.893 mm/year.

The current speed in the study area is classified as a weak current with an average speed of 0.2 m/s. According to McLusky *in* Supriharyono[13], it is explained that currents are one of the factors affecting sedimentation where sediment with a diameter of 104 µm will be eroded by currents at a speed of 150 cm/s, and carried away by currents at speeds between 90-150 cm/s, then settles at speed < 90 cm/sec. The same is true for fine sediments with a diameter of 102 µm which can be eroded at current speeds > 30 cm/s and deposited at speeds < 15 cm/s. Based on this, all sediment materials of all sizes will likely be eroded and carried away by river currents and tidal currents in estuary waters.

The Relationship between Mangrove Density and Sedimentation Rate

The results of measuring the density of mangroves at station I were 1455.56 ind/ha with an average sedimentation rate at this station of 114.43 mm/year. Whereas at station II the mangrove density value was 1777.78 ind/ha with an average sedimentation rate of 132.07 mm/year. Whereas at station III the mangrove density value was 1433.33 ind/ha with an average sedimentation rate of 121.58 mm/year.

Based on the results of the analysis using simple linear regression, the correlation value between mangrove density and sedimentation rate was 0.848 which was included in the very strong category. The coefficient of determination is 0.439 or 43.9%, which means that mangrove density can affect the sedimentation rate by 43.9%, while 56.1% is influenced by other factors. This shows that the higher the mangrove density, the higher the sedimentation rate. This is supported by the statement of Salim et al[14] which states that the physical function of mangroves is to maintain shoreline stability, prevent abrasion, and catch mud and sediment. Mangrove density contributes to the extent of accretion, sediment distribution, and surface elevation height[15]. Dense mangrove forests will cause additional land along the coast (accretion), and vice versa in areas where mangrove forests are lost it will trigger coastal abrasion. Thus, these two conditions cause changes in the coastline in the long term in an area.

4. CONCLUSION

From the results of the study, it can be concluded that the dominant mangrove species in the coastal waters of Kuala Jambi is *S.alba* with an Important Index Value (INP) of 103.5%. The density of mangroves in the coastal waters of Kuala Jambi is included in the good criteria with

moderate and very dense mangrove cover. The bottom sediments of the coastal waters of Kuala Jambi are dominated by sandy mud types with a percentage of 42.23 - 55.63 %. Sedimentation rate values in the coastal waters of Kuala Jambi at station I ranged from 94.401 - 141.602 mm/year. At station II the sedimentation rate ranged from 98.692 - 68.778 mm/year, while at station III the sedimentation rate ranged from 100.122 - 145.893 mm/year. The mangrove density has a very close relationship with the sedimentation rate, where the higher the mangrove density, the higher the sedimentation rate. It is recommended for further research to add other factors that affect mangrove density and a sedimentation rate and discuss them in more depth.

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