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Carbon Stock Analysis in Mangrove Vegetation in Selat Baru Village, Bengkalis Regency, Riau Province

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ABSTRACT

Mangrove forests play a crucial ecological role in coastal ecosystems. One of its ecological functions is that mangroves absorb and store carbon, thereby reducing carbon emissions. The increase in atmospheric CO_2 levels is a result of human activities, both directly and indirectly. This study aims to assess mangrove stand density, determine differences in mangrove stand density and carbon stocks between stations, and examine the relationships between mangrove stand density and biomass, carbon stocks, and CO_2 absorption in the mangrove area of Selat Baru Village, Bengkalis Regency, Riau Province. This research was conducted in November 2024 in Selat Baru Village, Bengkalis Regency, Riau Province. The method used in this study was a survey. To determine the relationship between mangrove tree density and carbon stock, a regression test was performed. Mangrove Stand Density ranged from 877.78 - 1,211.11 ind/ha. Mangrove biomass ranged from 22.62 to 30.16 tons/ha. Carbon Stock ranges from 10.63-14.19 tons/ha. CO_2 absorption ranges from 38.98-51.98 tons/ha. The density of mangrove stands and carbon stocks show a moderate relationship, as indicated by the correlation coefficient (r) of 0.736.

Keywords: Mangroves, Carbon Stock, Selat Baru Village

1. INTRODUCTION

Mangrove forests have the potential to sequester CO_2 from the atmosphere, commonly known as blue carbon (McLeod et al., 2011). Mangroves' carbon storage capacity is greater than that of all terrestrial forests in general. Mangroves can reduce atmospheric carbon dioxide levels by absorbing it through photosynthesis. Mangroves store carbon in their biomass, such as branches, stems, roots, and leaves. Each mangrove species has a different biomass value, influenced by its density, tree diameter, and height (Kepel et al., 2017). One effort to combat global warming is to increase forests' role as carbon dioxide absorbers.

The mangrove forests in Selat Baru Village not only act as a buffer against ocean currents, but are also utilized by the local community for economic purposes. The condition of the mangrove forests in Selat Baru Village is potentially threatened, partly due to ongoing routine clearing for economic purposes.

2. RESEARCH METHOD

Time and Place

This research was conducted in November 2024. Data collection was located in the Mangrove Area of Selat Baru Village, Bengkalis Regency, Riau Province.

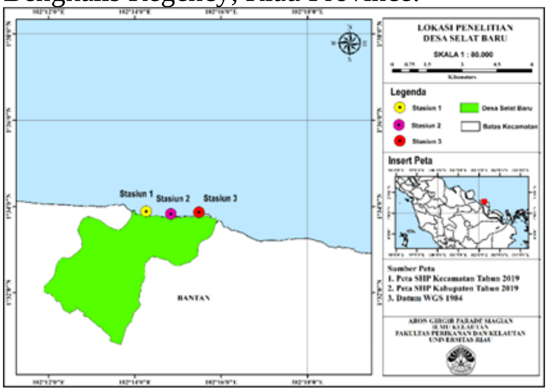

Figure 1. Research Location Map

Method

The method used in this research was a survey. Data obtained from the research locations were then processed for analysis.

Procedures

Measurement of Water Quality Parameters

The procedures used in this study included determining research stations, selecting data collection techniques, measuring environmental quality parameters, measuring mangrove density, measuring biomass, measuring carbon stocks, and measuring CO_2 absorption.

Determination of Research Stations

The research location was determined using a purposive sampling method. The stations in this study were divided into Station I, located near residential areas and tourist destinations (Selat Baru Beach), Station II, located in the mangrove ecosystem, and Station III, located near the Bandar Sri Setia Raja Bengkalis International Port.

Water Quality Measurement

Water quality measurements were conducted at three stations. The water quality parameters measured were temperature, salinity, and pH, collected during in situ sampling.

Mangrove Stand Density

Sampling was conducted using the quadrant or transect plot method. Each transect consisted of three 10 x 10 m^2 plots or quadrants, with Station I, Station II, and Station III each having three plots or three replications.

Data collection used a 10 × 10 m^2 transect to observe trees with a trunk diameter≥ 10 cm and a height> 1.5 m. A 5 x 5 m^2 plot size was used to observe saplings with a diameter of < 10 cm and a height of 1.5 m. While for observing seedlings with a height of < 1.5 m, a 2.5 x 2.5 m^2 plot size was used.

The next step is to identify all types of mangroves in the plot, then count the number of tree stands and the number of seedlings in the plot, and measure the circumference of the trunk of each tree, where the measurement of the tree trunk diameter is carried out at the chest height of an adult (DBH = diameter at breast height = 1.3 m from the ground surface).

Each stem was measured with a tape measure, then numbered or marked, and its species recorded. Measurements were made by wrapping the tape around the tree trunk, keeping it parallel in all directions, to obtain the trunk's circumference. Determining the DBH of mangroves.

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

Information:

K : Density of a type (individual/m^2)

ni : Number of individuals

A : Total plot area (m^2)

The standard criteria for mangrove damage are based on the Ministry of Environment (2004).

CO_2 absorption

Absorption calculation: CO_2 can use the formula referring to Bismark et al. (2008), namely:

$$S\ CO_2 = x\ Kc \frac{Mr.CO2}{Ar\ C}$$

Information:

S CO_2	:	Carbon gas absorption dioxide (CO_2)
Mr CO_2	:	Relative molecular weight C atom
Kc	:	Carbon content, expressed in kg
Ar. C	:	Relative atom C

Parameters include temperature (thermometer), pH (pH meter), salinity (refractometer), brightness (Secchi disk), and current (current meter).

Data Analysis

Data were analyzed using ANOVA in SPSS (Statistical Package for the Social Sciences) to compare biomass, carbon stock, and CO_2 absorption between stations. Regression analysis was also conducted to determine the relationship between mangrove density and carbon stock. This regression analysis was conducted only for the mangrove species that dominate the study area, namely *Rhizophora apiculata*, *Sonneratia alba*, *R. mucronata*, and *Avicennia marina*.

3. RESULT AND DISCUSSION

Water Quality Parameters

Water quality parameters are crucial for all organisms to carry out life processes, including those in mangrove forests located in areas affected by both land and sea. Water quality parameters measured include temperature, pH, and salinity, as shown in Table 1.

Table 1. Results of Water Quality Measurements

Parameter	Unit	Station		
		I	II	III
Temperature	℃	31	27	30
pH	-	6.9	6.68	6.73
Salinity	‰	25	22	23

The research results identified 4 mangrove species at the three research stations: *R. apiculata*, *S.alba*, *R.mucronata*, and *A.marina*. The types of mangroves and their densities at each station are shown in Table 2.

Table 2. Mangrove Density in Selat Baru Village

Station	Mangrove Density (Ind/ha)	Criteria	Condition
I	1,022.22 ± 69.39	Good	Currently
II	1,211.11 ± 69.39	Good	Currently
III	877.78 ± 183.59	Damaged	Seldom
Average	1,037.04	-	-

Mangrove ecosystems significantly influence atmospheric CO_2 concentrations. The greater the number of mangroves stands, the better they are at absorbing CO_2. The highest density is found at Station II, namely 1,211.11 ind/ha, while the lowest density is found at Station III, namely 877.78 ind/ha. The density at Station II is higher than at Stations I and III due to the different characteristics of the three areas, where Station II is a mangrove forest undergoing rehabilitation. Station I is close to residential areas and the Selat Baru tourist beach, which causes seedling growth to be disturbed by local community activities. Station III is close to the Bandar Sri Setia Raja International Port, Selat Baru Village, which results in mangroves in this area experiencing abrasion from sea waves and those generated by ship activities. Based on the standard quality criteria for mangrove density set by the Ministry of Environment No. 51 of 2004, namely very dense density ≥ 1,500 ind/ha, moderate ≥ 1,000 – 1,500 ind/ha, and rare < 1,000 ind/ha, then the density at each station I and II is in good condition with a moderate density level, while at station III it is in a damaged condition with a rare density level.

According to Susanto et al. (2013), the low density of mangroves in an area is due to the large anthropogenic influence that changes the mangrove habitat for other purposes, such as clearing land for settlements and fish farming, as well as logging for building materials and charcoal, so that the mangrove ecosystem experiences pressure and its condition experiences decline. The substrate at the location where mangroves grow is also a factor supporting their success. The mangrove root system is a form of mangrove adaptation to environmental conditions (Prakoso et al., 2017).

Biomass, Carbon Stock, and CO_2 Absorption

Based on the research conducted, the results for biomass, carbon stock, and mangrove CO_2 absorption are shown in Table 3.

Table 3. Biomass, Carbon Stock, and CO_2 Absorption of Mangroves at Each Station in Selat Baru Village

Station	Biomass (tons/ha)	Carbon Stock (ton/ha)	CO_2 absorption (ton/ha)
I	27.08± 7.80	12.73± 3.67	46.68± 13.45
II	30.16± 12.70	14.19± 5.67	51.98± 21.89
III	22.62± 9.17	10.63± 4.31	38.98± 15.81
Average	26.62 ± 9.89	12.52± 4.65	45.88± 17.05

Based on the biomass calculation results, the highest biomass was found at station II with a biomass content of 30.16 tons/ha. The lowest biomass content was at station III with a value of 22.62 tons/ha. This is because the mangrove density at station II is higher than that at station III. According to Mandasari et al. (2017), differences in biomass are caused by tree density and diameter.

According to Dharmawan et al. (2008), the high or low biomass produced by a mangrove ecosystem is determined by soil fertility and tree density. High biomass contributes to the mangrove forest's capacity to store carbon, which is important for mitigating climate change.

The results of carbon stock calculations at the three research stations showed that Station II had the highest total carbon content, at 14.19 tons/ha. Meanwhile, the lowest carbon stock was found at Station III, with 10.63 tons/ha. This difference in mangrove carbon stock values occurred because the mangrove density at Station II was greater than that at Station III.

This explains that carbon and biomass have a positive relationship anything that increases or decreases biomass will increase or decrease carbon stock. Compared with other areas, the estimated mangrove carbon stock in Selat Baru Village is relatively low. This indicates that the mangrove ecosystem in the area is less effective at storing carbon. According to research (Heriyanto et al., 2012), the carbon content of plants reflects the extent to which they can bind CO_2 from the air.

Based on the research results, the highest CO_2 absorption was at Station II, with 51.98 tons/ha, while the lowest was at Station III, with 38.98 tons/ha. This difference in CO_2 absorption occurs because the mangrove density at Station II is greater than the mangrove density at other stations. According to Oktaviona (2017), CO_2 absorption also shows a positive relationship with total biomass, carbon stock, and CO_2 absorption content. So, CO_2 absorption will be large if the total biomass is also large, so the carbon content will also be large, and vice versa.

The Relationship Between Mangrove Density and Carbon Stock

The relationship between mangrove stand density and mangrove carbon stock in Selat Baru Village is evident from the correlation coefficient (r) of 0.737. Thus, the relationship between mangrove stand density and carbon stock is moderate. This moderate relationship is also influenced by many other factors, including individual tree biomass (e.g., diameter and height), stand age, mangrove species, and soil carbon content. Carbon storage in plantation forests is influenced by several factors not included in this study, including plant age, sediment fertility or habitat, and plant spacing or density.

The relationship between mangrove stand density and mangrove carbon stocks in Selat Baru Village is shown in Figure 2.

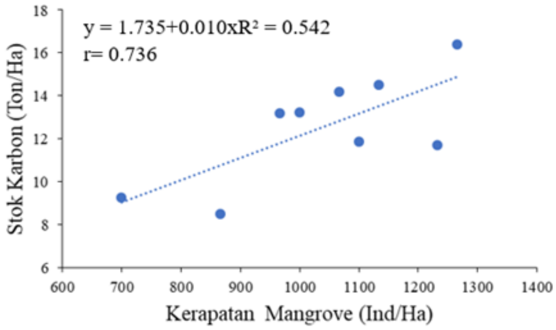

Figure 2. The Relationship between Mangrove Stand Density and Carbon Stock

4. CONCLUSION

Based on the research conducted, it can be concluded that the mangrove stands at stations I and II are in good condition, with moderate density. However, at station III, it is in a damaged condition with a low density. The highest mangrove stand density, biomass, carbon stock, and CO_2 absorption were found at station II; the lowest were found at station III. The correlation between mangrove stand density and carbon stock values was moderate. The mangrove carbon stock between stations was not significantly different (p-value ≥ 0.05).

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