Estimation of carbon stocks in mangrove sediments in Ruyung Village, Mesjid Raya District, Aceh Besar Regency

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Abstract. Exploration related to blue carbon has increased recently. As one of the blue carbon ecosystems, the mangrove ecosystem is one of the coastal ecosystems that can absorb and store carbon. This research aims to calculate mangrove density and estimate carbon stocks in sediments in the mangrove ecosystem in Ruyung Village, Mesjid Raya District, Aceh Besar Regency. Mangrove density was calculated at three stations within 10 x 10 m transects. Sediment samples were also taken compositely, and carbon analysis was carried out in the sediment using the LOI (loss on ignition) method. There were two species of mangroves found at the research location, namely *Rhizophora apiculata* and *Avicennia officionalis*. The research results show that the average mangrove density at the research location is 0.20 ind/m^2. The average soil density and sediment carbon stock at all research stations is 1.24 g/cm^3 and 271.66 MgC/ha respectively. The mangrove ecosystem, both biomass and surrounding sediment, can store carbon, which is one of the ways to mitigate global warming.

1 Introduction

Global warming occurs due to increasing carbon emissions into the atmosphere and will ultimately result in climate change. Apart from the ecological functions that we generally know, namely as feeding, nursery and spawning ground, mangroves play an important role in mitigating the effects of greenhouse gases generated by anthropogenic activities such as deforestation, agriculture, and industrial processes [1]. Mangrove forests have the same role as other forests, namely to absorb and sequester carbon dioxide (CO_2) so that they can help prevent climate change [2]. Various studies have confirmed that mangroves have a faster carbon sequestering capacity than other ecosystems such as grasslands or tropical rainforests [3]. Mangrove stored carbon in the biomass and in the soil/sediment below. Soils/sediment in mangrove rich of carbon that extend from 0,5 m to 3 m in depth and accomodate 49%-98% of the carbon stored at the mangrove ecosystem[4,5].

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The mangrove forest area in this research is in Ruyung Village. Ruyung Village is one of the villages in Mesjid Raya District, Aceh Besar Regency. This mangrove area is located between human activities such as community settlements and shrimp ponds. Research related to carbon stocks in mangrove sediments has been carried out several times, including research in Ayah District Kebumen Regency [6], Baturapa Village Bolaang Mongondow District [7] and the Ngurah Rai Grand Forest Park, Bali [8]. In Aceh Besar district, there was research related to carbon uptake in mangrove vegetation (not in the sediment below) specifically in Beureunut village [9]. However, research regarding the estimation of carbon stocks in mangrove sediments in Mesjid Raya District, Aceh Besar Regency has not yet been carried out, so this research aims to analyze carbon stocks in mangrove sediments in this area.

2 Methods

This research was carried out in the mangrove forest of Ruyung Village, Mesjid Raya District, Aceh Besar Regency in March 2023 (Fig. 1).

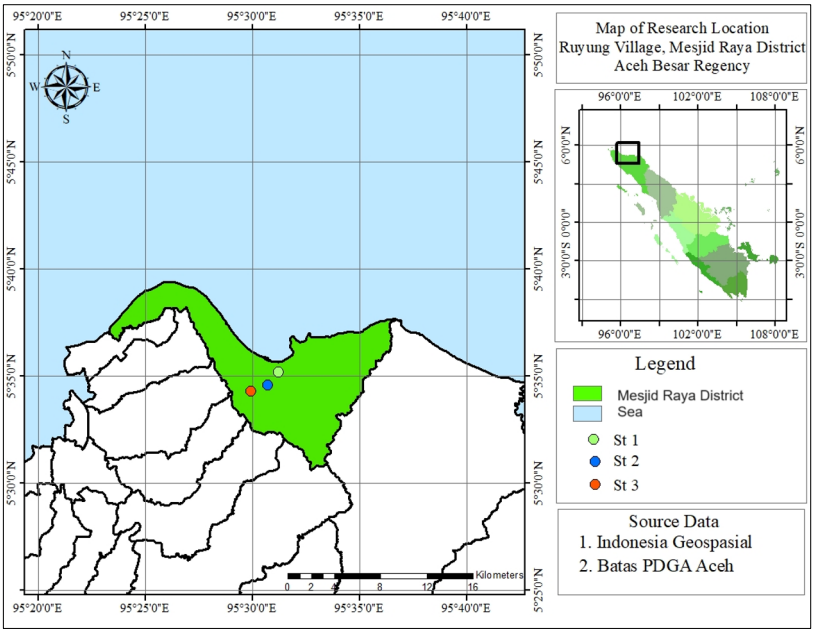

Fig. 1. Map of research location.

There were three research stations in the mangrove ecosystem of Ruyung Village. Each station is 10 meters from the water flow. Each station has a 10 x 10 m plot to calculate mangrove density [8]. Sediment samples were taken 3 times in the plot using a modified pipe with a diameter of 5 cm and a length of 50 cm. The analyzed samples were taken from a depth of 20-30 cm from the sediment surface in each plot at the station. Apart from sediment samples, data on water quality and sediment texture were also analyzed.

Analysis of sediment carbon content was carried out using the LOI (Loss on Ignition) method [10]. Sediment samples were taken and dried in an oven at 60°C for 48 hours. After drying, the sample was ground, and 3 grams was taken to be burned in a muffle furnace at 450°C for 4 hours and the final weight of the sample was recorded. Calculations and data

analysis include soil density, dry ash, % C, and total soil carbon content using the following formula:

a) Soil density/ Bulk density

$$\text{Soil density (BD)} = \frac{oven-dry\ masa\ (g)}{sampel\ volume\ (cm^3)} \quad (1)$$

b). Lost on Ignition

$$\%\ \text{BO} = \left(\frac{Wo-Wt)}{W0} x100\right) \quad (2)$$

% BO = Percentage value of sediment organic matter lost in the combustion process; Wo: Size Initial weight (3 grams); Wt = Final weight after burning (grams).

c). Carbon percentation

$$\%\ \text{C} = 1/1{,}724 \times \%\text{BO} \quad (3)$$

d). Total Soil carbon

$$\text{Soil C (Mg/ha)} = \text{BD} \times \text{SDI} \times \%\text{C} \quad (4)$$

Soil C= Estimation of carbon stocks; BD: Soil Density (g/cm³) SDI = Sample depth interval (cm); % C = Percent carbon content of organic sediment material.

3 Results and discussion

3.1 Mangrove Density

The mangrove species found at this research location consist of two species, namely *Rhizopora apiculata* and *Avicennia officinalis*. At station 1 dominated by *Rhizopora apiculata*, at station 2 they are dominated by *Avicennia officinalis* and there are several dead mangroves found, and at station 3 only one type of mangrove was found, namely *Rhizopora apiculate* (Table 1).

Tabel 1. Mangrove density

Station	Mangrove (individu)		*Di*(Ind/m^2)
	Rhizopora apiculata	***Avicennia officinalis***	
1	23	2	0,25
2	5	10	0,15
3	35	-	0,35

The highest mangrove density is at station 3 with a value of 0.35 ind/m^2, followed by station 1 (0.25 ind/m^2 and station 2 (0.15 ind/m^2). The average mangrove density in Ruyung village is 0, 25 ind/m^2. When compared in Banda Aceh and Aceh Besar [11], the types of mangroves found are more abundant with higher densities, namely *Rhizophora mucronata, Rhizophora apiculata, Bruguiera parviflora, Bruguiera cylindrica*, and *Avicenna lanata* with an average of The density at tree level was 0.82 ind/m^2. This is thought to be because the sampling stations were in two locations, namely Banda Aceh and Aceh Besar, so the type and density of mangroves were also greater.

3.2 Sediment texture and water quality parameters

The water quality parameters observed were pH, salinity and temperature. Based on Table 2, it is known that each station is in the range 7 which is neutral pH. According to [12], a pH value in the range of 7-8 is still in the range of good conditions for mangrove vegetation. pH also has a small effect on mangrove growth but is closely related to decomposer activity. If the pH is low, it will make decomposer activity very low so that the process of changing organic material into inorganic will be slow. The higher the pH, the activity of organisms in decomposing organic matter will increase.

Table 2. Sediment texture and water quality parameters

Station	pH	Salinity (ppt)	Temperature (°C)	Texture
Station 1	7,6	31	30	Sandy loam
Station 2	7,6	31	30	Sandy loam
Station 3	7,8	30	29	Sandy clay loam

The salinity and temperature values at the research station range between 30-31 ppt and 29-30 °C. Based on the decision of the Minister of Environment and Forestry No. 51 of 2004, the optimal temperature and salinity in the mangrove ecosystem are 28 – 32 °C and ~34‰ respectively, so it is still within sea water quality standards for mangroves. The types of sediment textures obtained in the research were sandy loam and sandy clay loam sediments. The difference between these two types of sediment is that the sandy loam sediment type has a rather clear rough feel, forms rather hard balls, and is easily crushed, while the sandy clay loam sediment type feels smooth with a few parts that are a bit rough, somewhat sticky, can be formed when pressed. and can be rolled easily.

3.3 Soil density/ Bulk Density

Soil density is the weight of soil in oven/dried conditions per unit volume. From the results of the analysis that has been carried out, it is known that the soil density value at each station has a different value. The sample volume is obtained from the results of measuring the height of the sample interval and the diameter of the corer. Soil density values at each station can be seen in Figure 2.

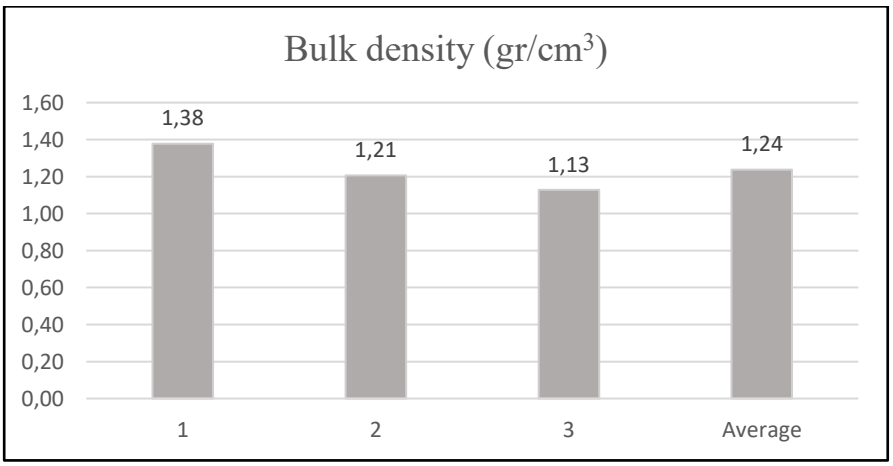

Fig. 2. Bulk density

The highest soil density value was at station 1, namely 1.38 g/cm³, the lowest value was at station 2, namely 28.4 g/cm³. The average value of soil density obtained from this research is 33.8 g/cm³. The results of this research are greater than the soil density value obtained from the results of research on carbon stocks in mangrove sediments carried out by [7] namely 0.39 g/cm³ and from the results of stock research soil carbon carried out by [13] was 0.58 g/cm³. This is thought to be due to the texture of the sediment at the research location being sandy loam and sandy clay so that it has a higher density.

3.4 Percentage of carbon organic sediment

Organic carbon in sediment is one of the factors that make up organic compounds in waters. According to [14], organic carbon is the main factor for improving soil quality and for storing carbon. The organic carbon percentage value is obtained from the results of the LOI (Loss on Ignation) method to determine organic material and its conversion to organic carbon. The average value of organic carbon percentage for all stations can be seen in Figure 3.

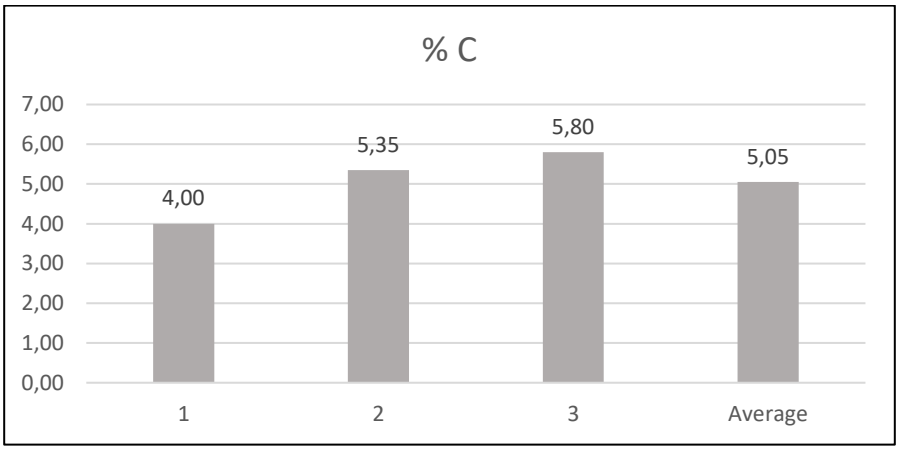

Fig. 3 Carbon organic percentation

Based on Figure 3, the lowest organic carbon percentage value is at station 1 and the highest is at station 3. This difference in carbon percentage occurs because the mangrove density level at station 3 is greater than at the other stations. The average percentage of sediment organic carbon at all stations is 5.05%C. This organic carbon percentage value is smaller than the organic carbon percentage value in the Sediment at Northern of Bunaken National Park Coast [15] where the organic carbon content at a depth of 0-30 cm ranges from 6.77-13.78%C.

3.5 Total carbon sediment

The highest soil carbon is at station 3, namely 347.67 MgC/ha and the lowest is at station 1, 177.70 MgC/ha. The average value of overall carbon content is 271.66 mgC/ha (Figure 4). The average carbon stock in this study is greater than the results of research [13] which analyzed the carbon stock in Karimun Java mangrove sediments, namely 72.75 MgC/ha and 213.12 MgC/ha at a depth of 15-30 cm. However, the carbon stock in Ruyung village is lower than the average carbon stock in Baturapa village which is 398.82 MgC/ha [7]. According to [16] there are several factors that influence carbon stores in the soil, including environmental

factors such as land use and soil physico-chemical factors such as temperature, pH, pores, soil texture, soil density and others.

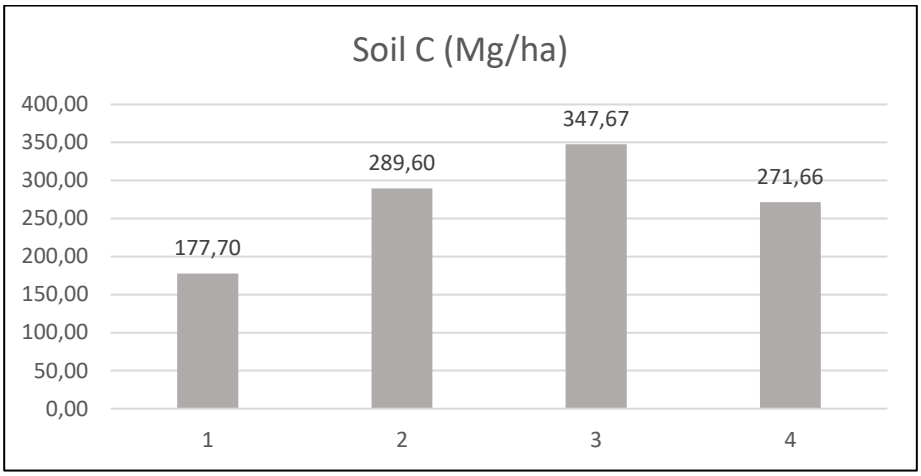

Fig. 4 Total carbon soil

4 Conclusion

The mangrove species found at the research location were *Rhizopora apiculata* and *Avicennia officinalis*, with an average density of 0.20 ind/m^2. The soil density and carbon percentage were 1.24 g/cm^3 and 5.05 %C, respectively. The total carbon content in the mangrove sediments of Ruyung village was 271.66 MgC/ha. From this research, it can be concluded that sediment in mangrove ecosystem can store carbon.

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