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Estimation of Biomass and Carbon at Mangroves Tapak in Semarang City, Province of Central Java, Indonesia

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Abstract: ***The increasing of greenhouse gases as a result of various human activities that can cause global warming become one of the issues in the world today. The increasing of greenhouse gases causing global warming has a direct impact on climate change and sea level rise. Mangrove ecosystems that are widely available in coastal areas have a very effective ability to reduce the concentration of carbon dioxide (CO^2) in nature. The objective of study is to determine the potential of carbon stored in mangrove stands in the Tapak Area, Semarang City at Central Java Province, Indonesia. The method used is non-destructive test with allometric equations in mangrove stands and survey. Data collection was done by purposive sampling. The results showed that there were 3 types of mangroves in Dukuh Tapak, namely Rhizophora mucronata, Avicennia marina, and Rhizophora apiculata. Mangrove in Dukuh Tapak has a biomass content of 503.87 tons / ha equivalent to 231.78 tons C / ha with a total of 469 trees.***

Keywords: biomass, carbon stock, climate change, greenhouse, global warming, manggrove ecosystem, mangrove stands

1. Introduction

The coastal area has a strategic meaning because it is an interface area between terrestrial and marine ecosystems (Ward et al., 2020), and has very rich potential for natural resources and environmental services (Susantoro et al., 2019). In this shallow sea area, there are several productive marine ecosystems such as mangroves, estuaries, coral reefs and seagrass beds (Kathiresan, 2011).

Mangrove forests are found in almost all islands in Indonesia in 30 provinces (Daulat et al, 2018). Mangrove forests are a form of ecosystem that plays an important role in the coastal areas of Indonesia (Malik et al., 2019) which are scattered in several provinces in various archipelagic groups (Miron, 2018). The uniqueness of the mangrove ecosystem in Indonesia is that it has the highest species diversity in the world.

Mangrove ecosystems play an important role in global mitigation efforts by reducing CO^2 concentrations (Kibria, 2013). According to (Iksan, 2019) the value of carbon contained in mangrove vegetation is the potential for mangroves to store carbon in the form of biomass. Calculation of carbon stock in a mangrove ecosystem can be used to see the ability of the mangrove ecosystem to absorb gases that can be operated globally (Putra, 2019).

Some Efforts being made to control the concentration of carbon in the atmosphere can be used to reduce the amount of CO^2 in the atmosphere (Jaikishun, 2017), especialy in the Northen region of Java.

The character of the Northern region of Java is a major area in the development of industrial areas and is the main area of land transportation routes on the island of Java (Handayani et al., 2020). High population density and industrial activities can have an impact on increasing the use of natural resources and the volume of waste (Pimentel, 2015; Ray, 2011). All of these activities have an impact on coastal areas which can affect the environmental quality of coastal areas, especially in decreasing the quality of coastal ecosystems (Visbeck, 2013).

Ecological damage to the utilization of mangrove forests in coastal areas that is not managed properly will reduce the function of the mangrove forests which will have a negative impact on the potential and function of other forest ecosystems as habitat (Rudianto et al., 2020). Whereas mangroves can absorb and store large amounts of organic carbon in sediments and biomass of plants, trees and leaves which makes them an important natural 67 carbon sink (Putra, 2019).

Research on carbon in mangroves in Tapak, Semarang City is important to pay attention to all mangrove areas that are capable of carbon from the air. These results can support sustainable and sustainable conservation area management activities in their management with global impact.

2. Material and Method

2.1 Research Location

The research was conducted in March 2 - May 15, 2020 at Mangove Tapak Tugurejo Village, Semarang City Province of Central Java. The boat lift net size used in this research is 6 GT. Location of the research presented in Figure 1.

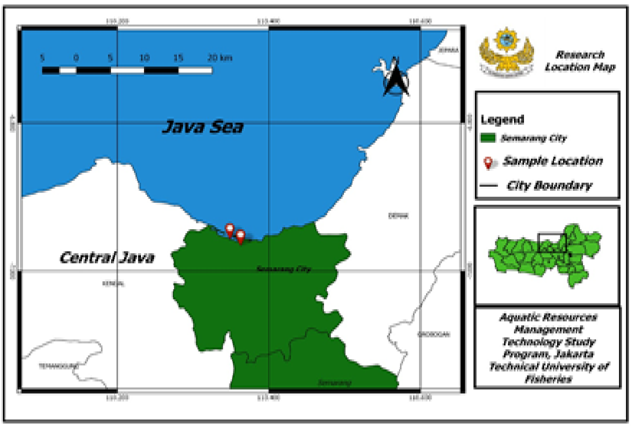

Figure 1: Research location

2.2 Tools and Material

The tools used in this research are GPS used to determine the coordinate point, camera used to record activities during research, stationery used to record the results of the interview, transect rope used to transect boundary, roll meter used to measure distances between transects, plots rope used to define mangrove boundaries that will be identified in the form of seedlings, saplings and trees, cloth meter used to measure the diameter of mangrove tree trunks, wooden stakes used to be a pole for transect lines and plots, mangrove identification table used to assist in identifying mangrove species in the field, plastic sample used to store leaf, stem and fruit samples in mangroves, mangrove worksheets used to be data entry sheet, compass used to make the rope pulled perpendicular to the shoreline, PH meter used to measure water pH, thermometer used to measure temperature and refractometer used to measure the salinity of waters.

2.3 Research Methods

The method used is a non-destructive test with allometric equations method in mangrove stands and also survey method by conducting direct operations in the field. The non-destructive test with allometric equations method is the method done by measuring the height or diameter of the tree and using allometric equations to extrapolate the biomass. The survey method is an investigation carried out to obtain facts from the symptoms that exist and look for factual information, both about social, economic, or political instutions of a group or region in the form of primary and secondary data. Primary data obtained by direct observation to obtain data, conduct interviews to dig up information, in this case the interviewees are mangrove stakeholders. Documenting by taking pictures directly using the camera to support and visualize the results associated with this research. While secondary data is obtained through supporting data obtained through Internet, books and others references. The research station was determined by using a purposive sampling technique. The procedure for measuring biomass and mangrove carbon stock was carried out by means of a non-destructive test (NDT) where the allometric formula was known to be measured. The total biomass in mangrove trees is calculated using allometric equations by calculating the aboveground biomass. The carbon concentration in organic matter is usually around 50% (Iksan et al. 2019), therefore the estimated amount of carbon stored per component can be calculated by multiplying the total weight of the biomass by the carbon concentration. The analysis includes vegetation index, biological index, associated biota, mangrove biomass, carbon and total carbon stock as well as water quality parameters.

2.4 Data Analysis

The analysis used in this research is an analysis of spesies and relative density, species and relative frequencies, importance value index, diversity index, index of evenness, dominance index, environment parameter of waters, calculation of carbon biomass and measurement of total carbon stock.

1) **Spesies Density (Di)** → Di = ni/A → (Di = i-species density; ni = number of individual boxes of species-I; A = total area of sampling) (Akhrianti, 2020)
2) **Relative Species Density (RDi) →** RDi = ni/Σn x 100% → RD_i = Relative Density; ni = = total number of individuals of species-i (ind); Σn = total number of individuals of all species**. (ind** (Akhrianti, 2020)
3) **Species Frequencies (Fi) → Fi = pi/ ΣP →** Fi = Frequency of the ith type; pi = Number of sample plots where species of i_n is found; ΣP = The total number of sample plots created(Akhrianti, 2020)
4) **Species Relative Frequency (RFi) → RFi = Fi/ ΣF x 100% →** RFi = Relative frequency (%); Fi = Frequency of the i^n species (ind); ΣF = total frequency of all species (ind) (Akhrianti, 2020)
5) **Closure of Species (Ci) → Ci = ΣBA/A →** BA = $\pi d^2/4$, π = 3,14; A = The total area of the sampling area (m²)(Akhrianti, 2020)
6) **Relative Closure of Species (RCi) → RCi = Ci/ΣC x 100% →** RCi= closing relative type; Ci= area of species cover; ΣC = total area of closure for all species. (Akhrianti, 2020)
7) **Species Important Value Index (IVI) →** IVI = Important values of a species range from 0- 300%. This important value provides an overview of the influence or role of a type of mangrove in the mangrove community. (Akhrianti, 2020)
8) **Diversity Index (H') → H' = (ΣPi Ln Pi) →** H '= Shannon-Wiener diversity index; **Σ** is summation**;** Pi is the proportion of individuals found in the ith species**;** Ln= Natural logarithm; (Shannon, 1949)
9) **Index of Evennes (E) → E = H^1/H^1max →** E = Evennes index; H' = Shannon-Wiener diversity index; Ln = Natural logarithm; S = Number of species; H'maks = Maximum value/ ln S; (Odum, 1993)
10) **Dominance Index (D) → D = Σ_i^s ni (ni-1)/N(N-1] →** D = dominance index – Simpson; ni = number of individual in the i^{th} species; N total number of entities in the dataset; (Simpson, 1949)
11) **Water Environment Parameters**

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Table 1: Standard criteria for aquatic environtment parameters (minister of Environment Decree of Indonesia, Number 51/2004)

No	Water Environment Parameters	Quality Standards
1	Potential Hydrogen (Ph)	7-8,5
2	Temperature (°C)	28-32
3	Salinity (‰)	30-34

12) Calculation of Carbon Biomass

Table 2: Alometric models of above-ground biomas of several mangrove species (Rustam et al., 2015)

No	Species type	Model of allometrik	Source
1	Avicennia alba	$B = 0{,}079211 * D^{2{,}470895}$	(Tue et al., 2014)
2	Avicennia marina	$B = 0{,}1848 * D^{2{,}3524}$	(Dharmawan & Siregar, 2008)
3	Rhizophora apiculata	$B = 0{,}043 * D^{2{,}63}$	(Amira, 2008)
4	Rhizophora mucronata	$B = 0{,}1466 * D^{2{,}3136}$	(Dharmawan, 2013)
5	Sonneratia alba	$B = 0{,}3841 * \rho * D^{2{,}101}$	(Kauffman & Cole, 2010)
6	Scyphiphora hydrophyllacea	$B = 0{,}251 * \rho * D^{2{,}46}$	(Komiyama et al., 2005)
7	Bruguiera gymnorhiza	$B = \rho * 0{,}0754 * D^{2{,}505}$	(Kauffman & Donato, 2012)
8	Bruguiera cylindrica	$B = 0{,}251 * \rho * D^{2{,}46}$	(Komiyama et al., 2005)
9	Ceriops tagal	$B = 0{,}251 * \rho * D^{2{,}46}$	(Komiyama et al., 2005)
10	Xylocarpus granatum	$B = 0{,}1832 * D^{2{,}21}$	(Tarlan, 2008)
11	Lumnitzera littorea	$B = 0{,}251 * \rho * D^{2{,}46}$	(Komiyama et al., 2005)
12	Lumnitzera racemosa	$B = 0{,}251 * \rho * D^{2{,}46}$	(Komiyama et al., 2005)

Information:
B = Biomass (kg); D = Diameter at breast height (cm); ρ = wood density (gr/cm^2)

13) Measurement of Total Carbon Stock

The carbon concentration in organic matter is usually around 50% (Macías, 2017), therefore the estimated amount of carbon stored per component can be calculated by multiplying the total weight of the biomass by the carbon concentration with the following formula (Hetland, 2016): **Carbon stock = Biomass per unit area × 0.50**

Based on the calculation of carbon stock, the amount of CO^2 absorption by mangroves will be obtained using the formula:
CO^2 absorption = (Mr CO^2) / (Ar C) × Content C → Mr CO^2 = Molecular weight of the compound (44) and Ar C = Relative molecular weight of atom C (12)

3. Result and Discussion

3.1 Identification of Mangrove Species

The research which was conducted at the Mangroves of Dukuh Tapak, Tugurejo Village, Semarang City, found 3 species of mangrove trees. The mangrove species consist of Rhizophora mucronata, Avicennia marina, and Rhizophora apiculata. It is line with previous research conducted by (Martuti et al., 2017). The distribution of mangrove species can be seen in Table 3

Table 3: Distribution of mangroves site

Station	Mangrove Types		
	Rhizophora mucronata	Avicennia marina	Rhizophora apiculata
1	121 stands	43 stands	21 stands
2	140 stands	47 stands	-
3	7 stands	90 stands	-
Total	268 stands	180 stands	21 stands

3.2 Identification of Mangrove Areas

The area of mangroves in the coastal area of Semarang City is 84.47 ha and the largest area is in the Tugu District which has an area of 52.4 ha of mangrove. This situation tends to show a decrease in the area of mangroves and this is due to the change in land use for industry and the presence of coastal abrasion due to sea level rise (Nugroho et al., 2020). Mangrove in Tapak village itself has an area of mangrove vegetation in 1999 was 20.37 ha, then in 2003 it was 19.12 ha, and in 2015 it was 19.27 ha (Perdana et al., 2016). This mangrove is located on the northern coast of the sea and close to the industrial area of the city of Semarang

3.3 Identification of Mangrove Vegetation

The results of observations of mangrove vegetation at station 1 in the mangroves of Dukuh Tapak, Tugurejo Village, Semarang City used an identification book (Noor, 2008). The mangrove vegetation analyzed by calculating the density (Di), relative density (DRi), relative frequency (FRi), closure relative (Ci), and important value index (IVI) (Ismail et al., 2017) can be shown at figure 2 and 3.

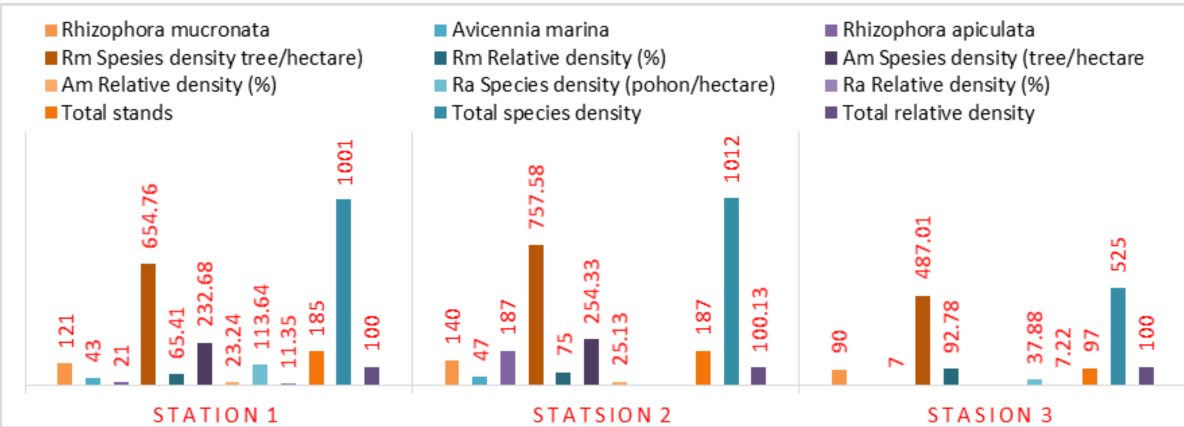

Figure 2: Species relative and density

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Based on the figure above, station 1 and 2 has criteria for medium mangrove density with a value of 1001 and 1012 trees / ha respectively, but station 3 has criteria for low mangrove density with a value of 525 trees/ha. There are three species of mangrove plants at station 1 cosisting of Rhizophora mucronata, Rhizophora apiculata and Avicennia marina, two species at station 2 and 3 consisting of Rhizophora mucronata dan Avicennia marina.

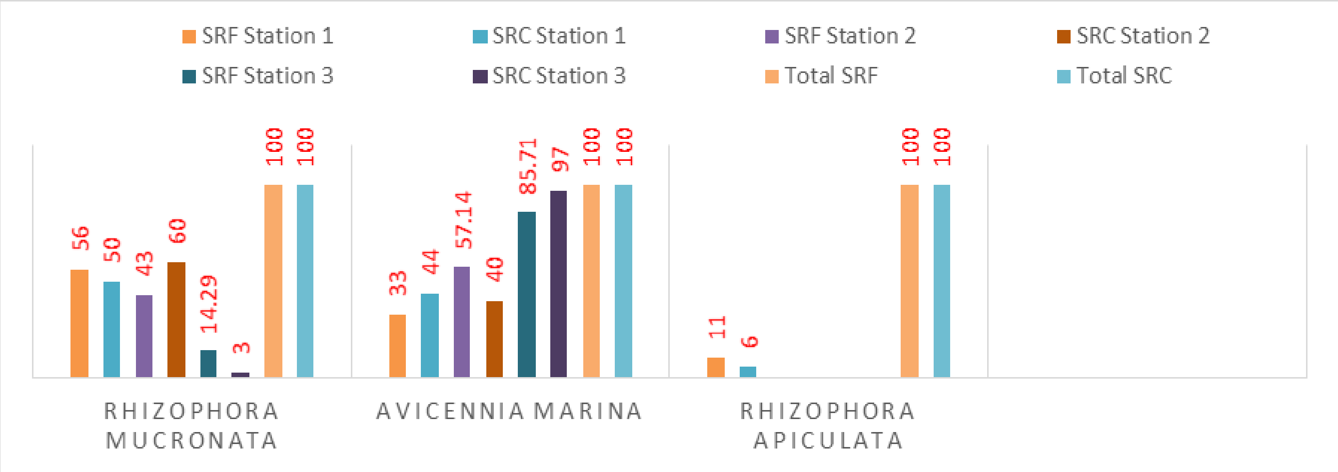

Figure 3: Species Relative Frequency and Closure

The highest relative frequency value and relative closure at station 1 was 55.56% and 50% for the species Rhizophora mucronata, indicating that Rhizophora mucronata had the most distribution in each plot. Station 2 has a smaller relative frequency value that is 42.86%, which means that this species of mangroves has less distribution in each area. However, Rhizophora mucronata had a relatively higher cover than Avicennia marina with a ratio of 60%: 40%. So it can be concluded that Rhizophora mucronata has a more important role than Avicennia marina in the area because it has characteristics and morphology that supports it to compete with other species and it can be stated that the condition of the waters in the area is good for mangrove growth. At station 3, Avicennia marina has a relative frequency value of 85.71% and a relative cover of 97.07%. This shows that the Avicennia marina has the most distribution and is evenly distributed in each compartment. Avicennia marina has a relative frequency value of 85.71% and a relative cover of 97.07%. This indicates that Avicennia marina has the most distribution and this species is evenly distributed in each plot.

3.4 Diversity, Evennes and Dominance Index Vegetation

The calculation of the diversity, evennes and dominance index is carried out to determine the level of mangrove biodiversity, the evenness level of a mangrove species and the magnitude of the mangrove species that dominates an area. The results of the calculation of the diversity, evennes and dominance index can be seen in (Table 4).

Table 4: Diversity, evennes and dominance index at research stations at Duku Tapak Mangrove

Index	Station		
	1	2	3
Diversity Index	0,9	0,6	0,3
Evennes Index	0,8	0,8	0,4
Dominance Index	0,5	0,6	0,9

Based on table 4 above, the diversity index value (H ') is obtained ranging from 0.3 to 0.9. According to Agustini's criteria (2016), this value is included in the low category (H'≤2.0). This shows that the mangrove ecosystem has less productivity, less stable water conditions and high ecological pressure. There are several possible factors causing damage to the mangrove ecosystem, namely pollution, conversion of mangrove forests that do not pay attention to environmental factors and xcessive deforestation. This is reinforced by the statement of (Ilman et al., 2020) which states that the damage to the mangrove ecosystem is caused by the conversion of functions for fishponds and housing areas, overexploitation and water pollution which triggers degradation of habitat and biodiversity in this area.

Furthermore, the evennes index value at each research station ranged from 0.4 to 0.8. In accordance with Agustini's criteria (2016), this value is included in the low category (at station 3) and classified as high (at stations 1 and 2). This shows that the species found at stations 1 and 2 tend to have evennes, it means that there is not particular species dominates a station. If the evennes index value is small, then the species evennes in the community is less, it is means that the number of individuals of each species is not the same, so there is a tendency to be dominated by certain species. Conversely, the greater the evennes index value indicates that in the community there is no particular domina species.

The dominance index value at each research station ranged from 0.5 to 0.9. The highest dominance index value was found at station 3 (0.9) and the lowest at station 1 (0.5). Based on Agustini's criteria (2016), station 3 has a high dominance value which is indicated by the presence of a dominant species, namely Avicennia marina which has more than half of the total individuals at station 3. Meanwhile, at station 1 the dominance value is low, there are not mangrove species that dominate the community. This means that the species in the mangrove community tend to be evennes and the ecological conditions are still stable. And for station 2 the dominance value is moderate as indicated by the presence of a dominant species, namely Avicennia marina which has more than half of the total individuals at the station.

3.5 Identification of Biota Types

The biota found at the sampling station were aves species such as large egrets (Egretta alba), Prenjak jawa (Prinia familiaris), and turtledoves (Geopelia striata). This biota was seen passing through the air several times when mangrove samples were taken. Then also found types of fish such as gelodok fish (Periothalamus sp.), Milkfish (Chanos chanos) and shrimp (Litopenaeus vannamei). Gelodok fish (Periothalamus sp.) are often found on riverbanks in mangroves. These fish have fast and agile movements in moving places, making it difficult for researchers to catch these fish. Milkfish (Chanos chanos) and shrimp (Litopenaeus vannamei) are found in mangrove areas located in traditional ponds. At the mangrove location Tapak milkfish and shrimp are commonly cultivated by the local community. At the sampling station, reptiles, molluscs and bivalves were also found, such as snakes (Hypsiscopus matannensis), mangrove crabs (Scylla Spp.), Snails (Achatina fulica), sea snails (Gibbula divaricata), tree snails (Amphidromus).

3.6 Water Environment Parameters

The following is the water quality of the Tapak mangrove sampling station, Tugurejo Village, Semarang City, obtained during the final practice (Table 5).

Table 5: Water environment parameters of Tapak's Mangrove

No	Water Environtment Parameters	Station 1		Station 2		Station 3		Quality Standars (kepmen LH/51/2005)
		T1	T2	T1	T2	T1	T2	
1	pH	8,4	8	8,1	8	7,9	7,7	7-8,5
2	Temperature (°C)	32	33	33,3	35,2	32,8	32,5	28-32
3	Salinitas (‰)	32	32	30	30,5	27	27	30-34

3.7 Water Environment Parameters

Based on the research results, the total value of biomass and carbon stock of mangrove vegetation in Dukuh Tapak, Tugurejo Village, Semarang City was shown in (Table 6).

Station	Mangrove Species	Spesies Number	Stand Biomass (tonnes / ha)	Carbon Stock (tonnes/ ha)	CO2 absorption
1	Rhizophora mucronata	121	60,92	28,02	102,74
	Rhizophora apiculata	21	5,07	2,34	8,56
	Avicennia mucronata	43	86,8	39,92	146,4
	Σ	185	152,79	70,28	257,7
2	Rhizophora mucronata	140	83,14	38,25	140,24
	Avicennia mucronata	47	88,14	40,54	148,66
	Σ	187	171,28	78,79	288,9
3	Rhizophora mucronata	7	3,23	1,49	132,47
	Avicennia mucronata	90	176,57	81,22	170,79
	Σ	97	179,8	82,71	303,26
Total Number		469	503,87	231,78	849,86

The research results showed that the biomass content was 503.87 tonnes/ha. This is equivalent to 231.78 tonnes C/ha and this condition is estimated to be able to absorb 849.86 tonnes of CO^2/ha of carbon dioxide (CO^2). The Tapak Mangrove has an area of 19.27 ha, so with the existing area it is estimated that the Tapak Mangrove has a biomass content of 9709.57 tonnes / ha, equivalent to 4466.40 ton C/ha and it is able to absorb CO^2 about 16376.80 tonnes/ha. Based on carbon storage data obtained from each research station, the highest carbon storage is at station 3 with a total of 97 trees, this allows the area to be able to store carbon of 82.71 tonnes/C, while the lowest carbon content is at station 1 with the number of 185 trees, the ability to store carbon in this area is estimated at 70.28 tonnes/C. Station 3 has the highest biomass potential (179.8 tonnes/ha) while station 1 has the lowest biomass potential (152.78 tonnes/ha). This is because station 3, which is located near the estuary, has a high density and the age of the existing stands is older than others so that the mangroves growing in this location have a relatively large diameter

4. Conclusion

The types of mangroves found in the study locations were different for each station. At station 1 there were 3 types of mangroves, while at stations 2 and 3 only 2 types were found. This condition is possible because each type of mangrove has a different survival rate and substrate.

The quality of mangrove waters in Tapak, Tugurejo Village, Semarang City for the degree of acidity or pH has a value ranging from 7 to 8.4. and the temperature at the observation location has a value ranging from 32^0C to 35.2^0C. If it is compared with the sea water quality standard, the Ministerial Decree No. 51 of 2004, the pH value indicates the state of the waters in the location has passed the specified threshold. Biota in tropical waters generally lives naturally in the upper limit of the highest temperature, if there is a change from the upper limit it will disrupt physiological processes that can cause the death of biota. The salinity of the waters in the Tapak Semarang mangrove area was found to range from 27‰ to 32‰. If it is compared with the sea water quality standard, the Ministerial Decree No. 51 of 2004, the pH value indicates that the waters in the location are fairly normal.

The mangroves in Tapak, Tugurejo Urban Village, Semarang City are able to absorb carbon from the air. The mangroves in Dukuh Tapak have a biomass content of 503.87 tonnes/ha, a carbon stock content of 231.78 tonnes C/ha with a total of 469 trees.

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