Available online at IJMARCC, Website: http://ejournal.undip.ac.id/index.php/ijmarcc
International Journal of Marine and Aquatic Resource Conservation and Co-existence
Research Article, 2 (1): 38-45, October 2017

ESTIMATION CARBON STOCK ON MANGROVE VEGETATION AT MANGROVE AREA OF UJUNG PIRING JEPARA DISTRICT

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ABSTRACT

Mangrove forrest is an coastal ecosystem which has so many advantages and usages. Mangrove forrest has ecological functions as carbon sink. This function becomes very important because of the increased greenhouse gas (GHG) emissions in the atmosphere causing climate change. Climate change raises the temperature on the surface of the earth, thus threatening the existence of humans and other living things. The purpose of this research was to determine the amount of biomass, carbon reserve, CO_2 absorption and soil organic carbon in mangrove vegetation Ujung Piring, Jepara.The method used in this research was descriptive and location determined by purposive sampling, which is divided into three locations, in each location used 2-3 x sampling. The data were collected using a 10 x 10 m plot. Determination of stored biomass in stands using non-destructive sampling by measuring stem diameter (Dbh) and allometric equation on each mangrove species. Carbon stock was determined using the results of biomass determination, whereas CO_2 absorption was determined using carbon stock. Soil organic carbon is determined using the results of organic matter measurement.The result showed that 6 mangroves species were found in the research plots: *Rhizophora apiculata, Rhizophora mucronata, Ceriops tagal, Lumnitzera racemosa, Sonneratia alba,* and *Sonneratia caseolaris*. The largest carbon stock value is in Location I with the dominance of *R.apiculata*. The carbon stock of mangrove vegetation has a linear relationship with soil organic carbon. Ujung Piring has amount of biomass 16,69 ton/ha, carbon stock 7,85 ton/ha, CO_2 absorption 28,76 ton/ha and soil organic carbon 1706 ton/ha.

Key words: Biomass, Carbon Stock, CO2 Absorption, Mangrove forrest, Soil Organic Carbon

INTRODUCTION

Global warming is one of the most important issues in the world, marked by rising temperatures on the earth's surface. The cause of global warming is due to increased greenhouse gas (GHG) concentrations such as carbon dioxide (CO_2) and methane (CH_4) gases (Manuri *et al.*, 2011). GHG concentrations can increase as a result of land management, such as large-scale logging and forest fires (Hairiah and Rahayu, 2007). Mangrove deforestation can lead to an increase of 20% (CO_2) emissions of carbon dioxide (Stern, 2007).

One effort to overcome the phenomenon is by increasing the function of forest as an absorber of carbon dioxide gas. These efforts can be supported by adding information about the potential for forests as carbon sinks.

Mangrove forest is a coastal vegetation that is able to grow and develop in tidal areas of sea water (Bengen, 2001). One of the functions of mangrove forest is as a carbon store, derived from photosynthesis and store it as biomass (Soemarwoto, 1998).

Mangrove vegetation in Ujung Piring is one of the remaining mangrove vegetation in Mlonggo Sub-district, Jepara. The existence of human activities such as diversion of mangrove land into aquaculture area can damage the surrounding environment. Research about the estimation carbon stock is important to know how much mangrove vegetation in this location is able to absorb carbon in the air, so that it can support the activities of sustainable area management in relation to reduce the impact of global warming.

The purpose of this research is to determine biomass, carbon stock, CO_2 absorption, soil organic carbon, to know the species of mangrove with the highest carbon store and to know the relation between carbon stock and soil organic carbon in mangrove vegetation Ujung Piring, Jepara.

MATERIAL AND METHOD

This research was conducted in Ujung Piring mangrove area, Jambu village, Mlonggo sub-district, Jepara regency, Central Java. The material in this research is mangrove vegetation analysis (density, dominance, tree biomass, carbon stock, and CO_2 absorption), sediment (soil organic carbon and grain size), as well as environmental parameters (substrate temperature, sediment temperature, salinity and pH).

Sampling method

Data collection for vegetation sampling using transect and plot methods (Muller-Dombois and Ellenberg, 1974). The plot used in this study amounted to 24 plots divided into 3 locations with 10 x 10 m transects. The division of this location is because researchers want to know the results of carbon stock based on the difference of dominance between locations.

The procedure to knows tree biomass using non-destructive sampling method by measuring all tree diameters of height 1.3 m above ground, then used allometric approach to estimate the potential of biomass and carbon stock. Meanwhile, to estimate the soil organic carbon and the type of substrate is taking sediment samples at a depth of 0-30 cm (Hairiah and Rahayu, 2007).

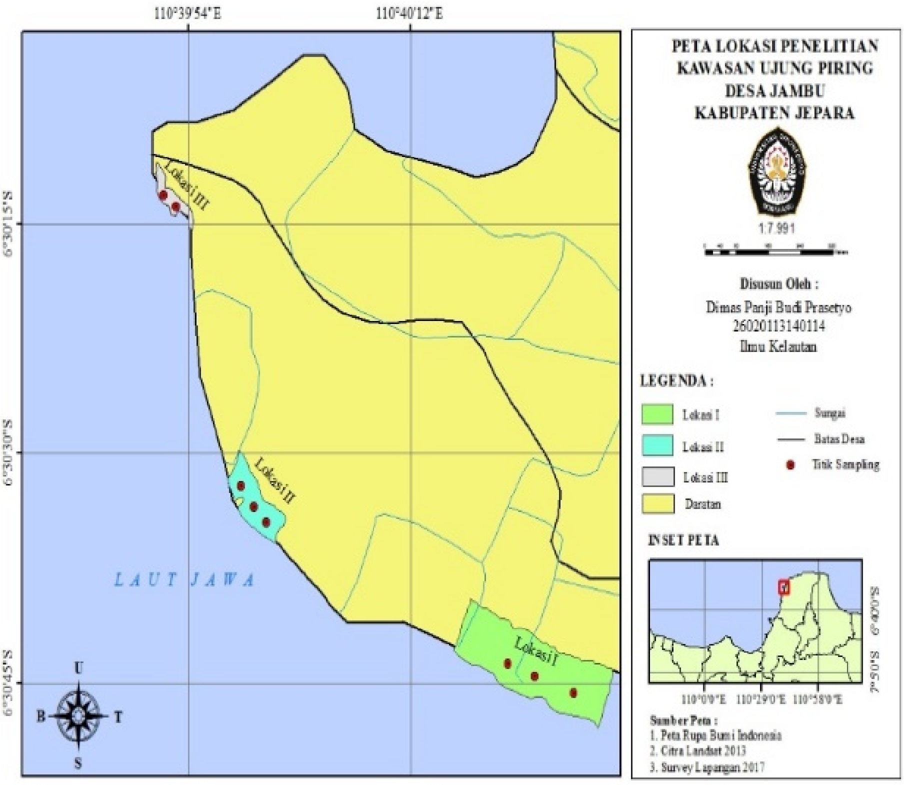

Figure 1. Map of Location Sites in Mangrove Vegetation Ujung Piring, Jepara

Density and Relative DominanceAnalysis

Density is the number of individuals per unit area (Mueller-Dumbois and Ellenberg, 1974). The value of the density calculated using the formula:

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

Where :

K : Density (ind/ha)
Ni : Number of stands
A : Wide Plot (m^2)

Basal area is the result of measurement of transverse tree trunks (Mueller-Dumbois and Ellenberg, 1974). Basal area values can be calculated by the formula:

$$BA = \frac{\pi d^2}{4} cm^2$$

Where :

BA : Basal area
π : 3,14

The relative dominance is the percentage of closure of a species to a mangrove area obtained from the basal area values for the tree category (Mueller-Dumbois and Ellenberg, 1974), using the formula:

$$DR = \frac{BAi}{BA} x\ 100\%$$

Keterangan :

DR : Relative dominance (%)
BAi : Total basal area of each species
BA : Basal area of all species

Biomass Analysis

Determination of biomass in each type of mangrove using allometric equations presented in Table 1 and Table 2.

Carbon Sotck Analysis

According to IPCC (2006) the carbon concentration contained in organic matter is 47%, so the estimated amount of carbon stored is by multiplying 0.47 with biomass as in the following equation:

$$\mathbf{Cb = B\ x\ 0.47}$$

Where :

Cb :Carbon stock (kg)
B : Biomass (kg)

CO_2 Absorption Analysis

According to IPCC (2006) the conversion of carbon stock to total CO_2 uptake can use the relative atomic mass ratio of C (12) with the relative molecular of CO_2 (44), formulated:

$$W_{CO_2} = \frac{Mr.CO_2}{Ar.C} x\ Cn$$

Where :

W_{CO_2} :CO_2 absorption(kg)
Mr : Relative molekular
Ar : Relative atom
Cn : Carbon stock (kg)

Soil Organic Carbon Analysis

Sediment samples dried first and then analyzed in Laboratory Test, Food Technology and Agricultural Products

(TPHP) Gadjah Mada University to determine the content of organic materials. After the content of the organic material is known further determines the content of C-organic (C_{org}) is formulated:

$$C_{org} = \frac{\%\,BO}{1{,}724}$$

Where :
C_{org} : C-organic (%)
BO : Organic matters(%)

Calculation of soil organic carbon content according to Lugina *et al.* (2011) can use the equation as follows:

$$C_t = Kd \times \rho \times \%\,C_{org}$$

Where :
Ct : Soil organic carbon (g/cm^2)
Kd : Soil depth (cm)
ρ : Bulk density (g/cm^3)
% C_{org} : C-organic (%)

After the calculation of soil carbon (g/cm^2), then converted to units of ton per hectare (ton/ha) to know the potential land can use the equation as follows:

$$C_{soil} = Ct \times 100$$

Where :
C_{soil} : Soil organic carbon(ton/ha);
Ct : Soil organic carbon(g/cm^2)
100 : conversion factor from g/cm^2 to ton/ha

Biomass, Karbon Stock, andCO_2Absorption in ton per hektare (ton/ha)

After calculating the carbon stock in kilograms, according to Lugina *et al.* (2011) conducted the conversion of carbon stocks into units of ton per hectare to know the potential land can use the equation as follows:

$$C_n = \frac{Cx}{1000} \times \frac{10000}{Lplot}$$

Where :
Cn : Biomass/ carbon stock /CO_2absorption (ton/ha)
C_x :Biomass / carbon stock / CO_2absorption (kg)
Lplot : Wide plot (m^2)

Table 1.Allometric Equations for Biomass Determination

Species	Formulation	Source
Ceriops tagal	$B = 0{,}188495\ (D)^{2{,}3379}$	Clough and K.Scott.(1989)
Lumnitzera racemosa	$B = 0{,}251\ \rho\ (D)^{2{,}46}$	Komiyama *et al.* (2005)
Rhizophora apiculata	$B = 0{,}048\ (D)^{2{,}614}$	Balitbang Kehutanan.(2013)
Rhizophora mucronata	$B = 0{,}128\ (D)^{2{,}6}$	Fromrard *et al.* (2008)
Sonneratia alba	$B = 0{,}3841\ \rho\ (D)^{2{,}101}$	Klauffman & Donato. (2012)
Sonneratia caseolaris	$B = 0{,}251\ \rho\ (D)^{2{,}46}$	Komiyama *et al.* (2005)

Where :
B : Biomass (kg)
D : Diameter (cm)
ρ : Wood density (g/cm^2)

Table 2. Wood Density Value

Species	Wood Density (ρ) (*mean* ± *SD*)*
Lumnitzera racemosa	0.770 ± 0.093
Sonneratia alba	0.475 ± 0.047
Sonneratia caseolaris	0.340 ± 0.054

Source : *) Komiyama *et al.* (2005)

RESULT AND DISCUSSION

The identification of the species was conducted in an insitu based on Kitamura *et al.* (1997, conducted in Ujung Piring mangrove vegetation, found 23 mangrove species found among which, 6 species are in plot, i.e *Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba, Sonneratia caseolaris, Ceriops tagal, and Lumnitzera racemosa*. While there are 17 species of mangroves found outside the plot, i.e*Avicennia marina, Excoecaria agallocha, Xylocarpus granatum, Aegiceras corniculatum, Scyphiphora hydrophyllacea, Ipomoea pes-caprae, Terminalia catappa, Acanthus ilicifolius, Sesuvium portulacastrum, Calatropis gigantea, Clerodendrum inerme, Derris trifoliata, Panandus tectorius, Scaevola, taccada, Spinifex littoreus, Thespesia populnea* and*Hibiscus tiliaceus*. The results of vegetation analysis in this study are presented in Table 3.

The results of mangrove vegetation analysis in Ujung Piring, Mlonggo Subdistrict, Jepara have density values and different types of dominance at each location. Location I has a density value of 2233 ind / ha dominated by *Rhizophora apiculata*. Location II has the lowest density value compared to other locations of 1922 ind / ha and is dominated by *Ceriops tagal*, while in Location III has the highest density value of 2667 ind / ha and is dominated by *Sonneratia alba* type. According to the Decree of the Ministry of Environment (2004), the density value of Ujung Piring mangrove vegetation is included in the very tight category (> 1500 ind / ha). Density and dominance values are presented in Table 4.

The environmental parameters measured in this study include temperature, salinity and pH parameters. The results of environmental parameters measurements in this study are presented in Table 5

Tabel 3. Result of Mangrove Vegetation Analysis at Ujung Piring, Jepara.

Vegetation Component*	Family	Mangrove Species
Major	Sonneratiaceae	*Sonneratia alba* J. Smith
		Sonneratia caseolaris (L.) Engl.
	Rhizophoraceae	*Rhizophora apiculata* Blume.
		Rhizophora mucronata Lamk
		Ceriops tagal C. B. Rob.
	Avicenniaceae	*Avicennia marina* (Forsk.) Vierh
	Combretaceae	*Lumnitzera racemosa* Willd.
Minor	Meliaceae	*Xylocarpus granatum* Konig
	Euphorbiaceae	*Excoecaria agallocha* L.
	Primulaceae	*Aegiceras corniculatum* (L.) Bianco
	Rubiaceae	*Scyphiphora hydrophyllacea*
Association	Convolvulaceae	*Ipomoea pes-caprae* (L) Sweet
	Malvaceae	*Hibiscus tiliaceus* L.
		Thespesia populnea (L.) Sol
	Combretaceae	*Terminalia catappa* L.
	Acanthaceae	*Acanthus ilicifolius L.*
	Aizoaceae	*Sesuvium portulacastrum*
	Apocynaceae	*Calotropis gigantea* (L.)
	Lamiaceae	*Clerodendrum inerme* (L.) Gaertn
	Fabaceae	*Derris trifoliata* Lour.
	Panandaceae	*Panandus tectorius*
	Goodeniaceae	*Scaevola taccada* (Gaertn)
	Poaceae	*Spinifex littoreus* L.

Table 4. Number of Stands (Ni), and Density (K) of Mangrove Vegetation Ujung Piring, Jepara

Location	Species	Ni	K (ind/ha)	DR (%)
I	*Rhizophora apiculata*	174	1933	61,53
	Sonneratia caseolaris	15	167	22,38
	Sonneratia alba	10	111	13,36
	Ceriops tagal	2	22	2,73
Total	**201**	**2233**	**100**	
II	*Ceriops tagal*	134	1489	72,71
	Lumnitzera racemosa	34	378	15,63
	Rhizophora apiculata	5	56	11,66
Total	**174**	**1922**	**100**	
III	*Sonneratia alba*	86	1274	56,01
	Sonneratia caseolaris	9	133	8,39
	Rhizophora mucronata	80	1185	34,13
	Rhizhophora apiculata	5	74	1,47
Total	**180**	**2667**	**100**	

Table 5. The Result of Environmental Parameters at Mangrove Area of Ujung Piring, Jepara.

Location	Temperature (^{o}C)		Salinity (‰)	pH
	Substrate	Air	Water	Substrate
I	29-30	30-31	15-22	6
II	32-35	31-32	13-21	6
III	28-29	29-30	16-21	6
Quality Standards	18-30*)		10-30**)	4-9,5***)

Source :*)Usman (2013);
**)Saparinto (2007);
***)Wardoyo (1975) *in*Hasbi (2004)

The substrate temperature in the mangrove vegetation area of Ujung Piring Jepara ranges from 28-35 C and the air temperature is 29-32 C, where at Location II is the location with highest temperature. Carbon stock can be determined by calculating the tree biomass content first. The content of tree biomass is the sum of the biomass content of each tree organ which is the total of organic material from photosynthesis (Hairiah & Rahayu 2007). The results of total biomass in this study are presented in Table 6.

Table6. The Results of Biomass (B) and Diameter Range (Dbh) Mangrove at Ujung Piring Jepara.

Location	Species	Dbh (cm)	B (Kg)
I	*Rhizophora apiculata*	4-15,9	1533,74
	Sonneratia caseolaris	7,5-25,2	733,79
	Sonneratia alba	7,9-14,3	298,85
	Ceriops tagal	9,2-14,6	133,18
	Total		**2699,56**
II	*Ceriops tagal*	1-3,7	160,24
	Lumnitzera racemosa	1,2-3,5	87,87
	Rhizophora apiculata	1,5-5,4	11,97
	Total		**260,08**
III	*Sonneratia alba*	4,2-11,5	1136,50
	Sonneratia caseolaris	5,2-13,6	187,21
	Rhizophora mucronata	4-10,2	978,68
	Rhizophora apiculata	4,2-6	16,18
	Total		**2318,57**

The largest Biomass are in Location I with 2699.56 kg, while the lowest result is in Location II with 260.08 kg. The biomass value at location I is also influenced by the dominance of the mangrove species. Location I is dominated by *Rhizophora apiculata* that can contribute more biomass than other species. Known *R.apiculata* has a type of stilt root that can adapt in anoxide substrate conditions (Heriyanto and Subandono, 2012). This condition causes the number of roots of the *R.apiculata* increased and higher. This adaptation can affect the mangrove biomass.

Location II is the location with lowest biomass value 260.08 kg. Low biomass value is due to the small diameter ranges of stems ranging from 1-5.4 cm. According to the formula of biomass estimation using this allometric, it is known to use the diameter of tree variables (Table 1), therefore the biomass yield is directly proportional to the diameter or the larger the diameter the greater the biomass value.

The large amount of carbon stock in a plant can illustrate how many plants can absorb carbon dioxide (CO_2) from the air. The carbon dioxide will become energy for the photosynthesis processe that enter the plant structure and become part of the plant, for example cellulose stored in stems, roots, branchs and leaves (Hilmi, 2003). The results of carbon stock calculations in this study are presented in Table 7.

The largest carbon stock value in this study is located at Location I that is 1268.79 kg, while the lowest value is in Location II that is 122.23 kg. The largest type of mangrove contributor is *R.apiculata* with 720,86 kg in Location I. This is thought to be influenced by its biomass value. Hairiah and Rahayu (2007), stated that the potential of carbon stock can be seen from existing stand biomass. Therefore, any increase in biomass will be followed by an increase in carbon stock, so that the amount of biomass affects carbon stock.

Plants have the ability to photosynthesize that absorb CO_2 in the air so as to reduce greenhouse gases in the atmosphere. CO_2 absorption value shows the ability of stands to absorb CO_2 stored as biomass. CO_2absorption (WCO) in mangrove vegetation of Ujung Piring, Jepara is presented in Table 8.

Mangrove forests have potential to absorb carbon dioxide in the air (Kusmana, 2000). The results of this study indicate that Location I is the location with the highest amount of CO2 absorption that is 4652,27 kg, while the lowest is in Location II that is 448,19 kg. These results suggest that CO_2absorptionis closely related to its biomass content. This is in accorandce with the statement of Heriyanto and Subiandono (2012), that the amount of CO_2 absorbed by trees increases with the amount of biomass.

Sediment organic matter indicates that all research sites are included in very high category according to Reynold (1971) in Adip *et al.* (2014), that the content of organic matter (BO> 35%) included in the category is very high. More data presented in Table 9.

The substrate has a role in C-organic absorption in every condition (Ariani, 2016). After obtaining C-organic percentage then calculating soil organic carbon, presented in Table 10.

The results of this study found that the highest soil organic carbon value was in Location I with that is 8.03 g/cm^2, while the lowest was in Location II that is 3.71 g/cm^2 and the third location was 7.94 g/cm^2. The high content of soil organic carbon in Location I is suspected because of the high value of organic material in there, which reached 86.86% and higher than other locations. According to Hairiah and Rahayu (2007), organic matter is the remnant of plants, animals and humans present on the surface and in the soil, partially or completely transformed by soil organisms (decomposition) to decay and merge with soil.

The difference of soil organic carbon in the three location is also due to the different types of substrates. Location II has the lowest soil organic carbon because the sediments at this location belong to the type of sand. This is because sandy sediment textures can bind fewer organic materials than mud texture (Rafni, 2004). At this location also has a higher temperature, which causes the substrate is drier and slowing decomposition process. The slow decomposition rate is also due to at least the abunandce of decomposers compared with conditions that have high humidity. Syamsurisal (2011) which states that the abunandce of microbes (decomposers) is more abunandt in the mud or silt that have a finer texture and have high humidity.

Based on the result of biomass, carbon stock, CO_2absorption and soil organic carbon obtained in the three location, it can be predicted about the area of mangrove vegetation at Ujung Piring Jepara with ton per hectare (ton/ha), presented in Table 11.

Mangrove vegetation in mangrove area of Ujung Piring Jepara has biomass 16,69 ton/ha, carbon stock7,85 ton/ha, CO_2 absorption 28,76 ton/ha and soil organic carbon 656 ton/ha. The results of this study are also lower when compared with research located in Karimun Java, which is 182.62 tons/ha (Cahyaningrum, 2014). Differences that occur are suspected due to differences in the number of trees and the level of density in each location.

Table 7. The Result of Carbon Stock (Cb) Mangrove at Ujung Piring, Jepara.

Location	Species	Cb (kg)
I	*Rhizophora apiculata*	720,86
	Sonneratia caseolaris	344,88
	Sonneratia alba	140,45
	Ceriops tagal	62,60
	Total	**1268,79**
II	*Ceriops tagal*	75,31
	Lumnitzera racemosa	41,30
	Rhizophora apiculata	5,62
	Total	**122,23**
III	*Sonneratia alba*	534,15
	Sonneratia caseolaris	87,99
	Rhizophora mucronata	459,98
	Rhizophora apiculata	7,61
	Total	**1089,73**

Table8. The Result of Carbon Dioxide Absorption (W_{CO_2}) at Mangrove Vegetation of Ujung Piring, Jepara.

Location	Species	W_{CO_2} (Kg)
I	*Rhizophora apiculata*	2643,16
	Sonneratia caseolaris	1264,57
	Sonneratia alba	515,02
	Ceriops tagal	229,52
	Total	**4652,27**
II	*Ceriops tagal*	276,14
	Lumnitzera racemosa	151,43
	Rhizophora apiculata	20,62
	Total	**448,19**
III	*Sonneratia alba*	1958,56
	Sonneratia caseolaris	322,62
	Rhizophora mucronata	1686,59
	Rhizophora apiculata	27,89
	Total	**3995,66**

Table 9. The Result of Soil Organic Matters at Mangrove Vegetation Ujung Piring, Jepara.

Location/ Point		**Soil Organic Matter (BO)**	
		Result (%)	**Category**
I	1	80,22	Very high
	2	80,51	Very high
	3	86,86	Very high
II	1	51,69	Very high
	2	64,16	Very high
	3	60,35	Very high
III	1	87,87	Very high
	2	78,35	Very high

Table 10. The Result of C-organic (C_{org}) and Soil Organic Carbon (Ct) at Mangrove Veggetation Ujung Piring, Jepara

Location / Point		**C_{org} (%)**	**Ct (g/cm^2)**
LI	1	46,53	7,76
	2	46,7	7,79
	3	50,38	8,4
Average		**47,87**	**8,03**
LII	1	29,98	3,12
	2	37,22	4,14
	3	35,01	3,89
Average		**34,07**	**3,71**
LIII	1	50,97	8,4
	2	45,45	7,48
Average		**48,21**	**7,94**

Table 11. The Result of Biomass (B), Carbon Stock (Cn), CO_2 absorption (W_{CO_2}) and Soiil Organic Carbon (C_{soil}) in Ton per Hectare.

Location	**B (ton/ha)**	**Cn (ton/ha)**	**W_{CO_2}(ton/ha)**	**C_{soil}(ton/ha)**
I	30	14,11	51,7	803
II	2,89	1,36	4,98	371
III	17,17	8,07	29,6	794
Average	**16,69**	**7,85**	**28,76**	**656**

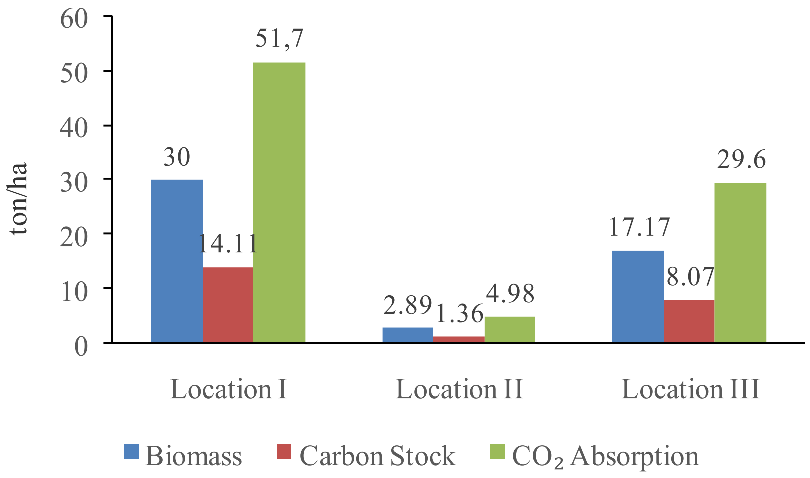

Figure 2. The Result of Biomass (B), Carbon Stock (Cn), CO_2 absorption (W_{CO_2})

CONCLUSION

Based on the results of this study, the conclusions can be drawn: Biomass value of mangrove vegetation in Ujung Piring, Jepara 16.69 tons / ha, carbon savings of 7.85 tons / ha, CO2 uptake of 28.76 tons / ha and Soil organic carbon of 656 ton / ha; The type of mangrove that has the largest carbon stock and CO_2 uptake is Rhizophora apiculata; Comparison of the amount of carbon deposits of mangrove vegetation with soil organic carbon has a linear relationship, the greater the carbon stock of vegetation, the greater the soil organic carbon.

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