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STUDY ON CARBON CONTENT AND ECOLOGICAL MANGROVE INDEX IN MUARAREJA, TEGAL, CENTRAL JAVA

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Abstract. The accumulation of carbon in the atmosphere causing the greenhouse effect as a result of trapping of short-wave sunlight, which increase the temperature of Earth's atmosphere. One of the forest ecosystems that can reduce the effects of greenhouse gases and to mitigate the climate change is a mangrove forest. The role of mangroves related to the Blue Carbon was emphasized as mangrove efforts to utilize CO_2 for photosynthesis and store it in biomass stock and sediment as a climate change mitigation efforts. The purpose of the research are a) to determine the density, dominance and the importance value of mangroves index, b) to know the Diversity Index and Uniformity Index of mangrove that dominates, c) to determine the content of carbon in the mangrove forests, and d) to determine the relationship of the density of mangrove with a carbon content in the mangrove forest area in the village of Muarareja Tegal. Mangrove areas in the Village of Muarareja was dominated by *Rhizophora mucronata* with Relative Density (KR) in ponds: 42.11% - 100%, residential homes: 28.57% - 45.45%, the river: 31.58% - 61.90%, the beach : 59.09% - 73.68%. Relative dominance (DR) of ponds station: 34.71% - 100%, residential home stations: 14.24% - 39.61%, river station: 20.46% - 72.95%, coast stations: 64.08% - 92,25%. Importance Value Index (IVI) in ponds station: 76.82% - 200%, residential home stations: 42.81% - 85.07%, the river station: 52.03% - 134.85%, coast stations: 123.17% - 165.93%. Diversity Index (H) mangrove *Rhizophora mucronata* ranged by 0.000 - 0.692 and Uniformity Index (J) mangrove ranged by 0.000 - 2.107. The largest carbon content (tons / ha) was produced at the coast with the average number of total carbon content of the plot (tons / ha) was 189,942.77 tons / ha, followed by the river with the average number of total carbon content of the plot (tons / ha) was 179,011.49 tons / ha, the average number of total carbon content ot the plot for the ponds (tons / ha) was 176,519.79 tons / ha and with the average number of total carbon content of the plot (tons / ha) for the residential homes was 165,774.82 tons / ha. The density of mangrove has a very close correlation with the total carbon content in liters per hectare of the plot, the total carbon content in plants per hectare of the plot below, the total carbon content in leaves per hectare of the plot, and the total carbon content of soil per hectare of the plot. The total carbon content of the tree biomass per hectare on the plot, the total carbon content of nekromassa per hectare of the plot, and the total carbon content in the roots per hectare of the plots does not have a positive correlation with the density of mangrove.

Keywords: carbon, biomass, density, mangrove

I. INTRODUCTION

1.1 Background

Global warming is the defining issue of climate change impacts that affect life on Earth. Global warming occurs due to increased concentrations of greenhouse gases (GHGs) in the layer of Earth's atmosphere. The atmosphere receives more carbon than emit carbon dioxide, from the combustion of fossil fuels, motor vehicles and industrial machinery, as well as accumulating carbon (Donato et al., 2012.). Tropical deforestation contributed to add carbon to the atmosphere (DeFries et al., 2002), while the volume of CO_2 absorption is reduced as a result of deforestation, land use change and development. The accumulation of carbon in the atmosphere causing the greenhouse effect as a result of trapping of short-wave sunlight, thereby increasing the temperature of the earth's atmosphere. One of forest ecosystems can reduce the effects of greenhouse gases and climate change mitigation are as mangrove forests

(Komiyama et al., 2005). Mangrove is a potential absorber and CO_2 storage that can be used as a parameter for assessment of Blue Carbon Ecosystem. The role of mangroves in conjunction with the Blue Carbon emphasized as mangrove efforts in utilizing CO_2 for photosynthesis and store it in biomass stock and sediment as a climate change mitigation efforts. The existence of mangrove ecosystems provide benefits for coastal water ecosystems, among others as feeding, spawning and nursery grounds. Rapid development has a negative impact on the environment. Anthropogenic activities are known to increase the input of inorganic nutrient and organic carbon in estuarine and coastal waters (Ghufran, 2012).

1.2 Problems of Study

Muarareja area is one of the villages in which there are quite extensive mangrove areas. Disproportionate utilization may cause the density of mangroves decreased, resulting in decreased absorption and storage of carbon in mangrove. The problems to be solved in this study include:

a. The circumstances of the importance value index of mangrove ecosysrem in Muarareja?

b. How many content of carbon in mangrove vegetation in Muarareja Tegal?

c. How much carbon in mangrove ecosystem in Muarareja?

1.3 Objectives of Study

The purposes of this research are :

1. Knowing density, dominance, uniformity and diversity index, importance value index in the mangrove ecosystem in Muarareja Tegal.
2. Knowing the carbon content in mangrove forest in Muarareja Tegal.
3. Knowing the relationship mangrove density with carbon content in Muarareja mangrove forests.

1.4 Contributions of Study

This study is academically can increase the contribution of science to important information where mangrove towards concentration increased of carbon in the atmosphere, and can provide information for managers to use for the benefit of the protection, utilization of mangrove resources

II. METODE

This research was conducted in October-December 2015 in mangrove forest in Muarareja Tegal. Observations carbon content in mangrove vegetation biomass samples was conducted at the Laboratory of the Agriculture Faculty, University of General Sudirman. The research location wich in the mangrove areas in Muarareja Tegal Village consists of four stations representing vegetation and carbon concentration of mangroves in Muarareja Tegal, namely : 1. mangrove on the pond areas; 2. mangrove in around of human population areas ; 3. mangrove in the river areas; and 4. mangrove in coastal areas.

III. RESULT AND DISCUSSION

3.1 RESULT

3.1.1 Mangrove Vegetation

Mangrove vegetation are calculated in this study consisted of: density (De), dominance (Do), basal area (BA), relative density (RDe), relative dominance (RDo) and importance value index (IVI). Calculation of mangrove vegetation data for each station is presented in Table 1.

Table 1. Data of mangrove vegetation each station

No	Type of mangrove	De	Do (cm)	BA (m^2)	RDe	RDo	IVI
Sta. 1							

a1	*Rhizophora mucronata*	19	532	2.221,74	100,00	100,00	200,00
	Avicenia marina	0	0	0,00	0,00	0,00	0,00
	Total	**19**		**2.221,74**			
a2	*Rhizophora mucronata*	8	175	240,41	42,11	34,71	76,82
	Avicenia marina	11	240	452,16	57,89	65,29	123,18
	Total	**19**		**692,57**			
a3	*Rhizophora mucronata*	19	386	1.169,62	70,37	82,14	152,51
	Avicenia marina	8	180	254,34	29,63	17,86	47,49
	Total	**27**		**1.423,96**			
Sta. 2							
b1	*Rhizophora mucronata*	3	86	58,06	37,50	38,80	76,30
	Avicenia marina	5	108	91,56	62,50	61,20	123,70
	Total	**8**		**149,62**			
b2	*Rhizophora mucronata*	5	98	75,39	45,45	39,61	85,07
	Avicenia marina	6	121	114,93	54,55	60,39	114,93
	Total	**11**		**190,32**			
b3	*Rhizophora mucronata*	2	33	8,55	28,57	14,24	42,81
	Avicenia marina	5	81	51,50	71,43	85,76	157,19
	Total	**7**		**60,05**			
Sta. 3							
c1	*Rhizophora* mucronata	13	335	880,97	61,90	72,95	134,85
	Avicenia marina	8	204	326,69	38,10	27,05	65,15
	Total	**21**		**1.207,65**			
c2	*Rhizophora mucronata*	10	312	764,15	47,62	54,69	102,31
	Avicenia marina	11	284	633,15	52,38	45,31	97,69
	Total	**21**		**1.397,30**			
c3	*Rhizophora mucronata*	6	178,5	250,12	31,58	20,46	52,03
	Avicenia marina	13	352	972,65	68,42	79,54	147,97
	Total	**19**		**1.222,77**			
Sta. 4							
d1	*Rhizophora mucronata*	13	496	1.931,23	65,00	74,79	139,79
	Avicenia marina	7	288	651,11	35,00	25,21	60,21
	Total	**20**		**2.582,34**			
d2	*Rhizophora mucronata*	13	402	1.268,59	59,09	64,08	123,17
	Avicenia marina	9	301	711,22	40,91	35,92	76,83
	Total	**22**		**1.979,81**			
d3	*Rhizophora mucronata*	14	445	1.554,50	73,68	92,25	165,93
	Avicenia marina	5	129	130,63	26,32	7,75	34,07
	Total	**19**		**1685,13**			

Source: Research (2015)

Type of mangrove vegetation in Muarareja Tegal is dominated by *Rhizophora mucronata* with Relative Density (RDe) at Station 1 (pond) of : 42.11 to 100%, Station 2 (residential) of: 28, 57 to 45.45%, station 3 (rivers) of: 31.58 to 61.90%, station 4 (beach) of: 59.09 to 73.68%. Relative dominance (RDo) at Station 1 (pond) of : 34.71 to 100%, Station 2 (residential) of : 14.24 to 39.61%, Station 3 (rivers) of : 20.46 to 72, 95%, station 4 (beach) of : 64.08 to 92.25%. Importance Value Index (IVI) at Station 1 (pond) of : 76.82 to 200%, Station 2 (residential) of : 42.81 to 85.07%,

Station 3 (rivers) of : 52.03 to 134 , 85%, station 4 (beach) amounted to: 123.17 to 165.93%.
Type *Avicenia marina* with Relative Density (RDe) at Station 1 (pond) of : 0.00 to 57.89%, Station 2 (residential) of : 54.55 to 71.43%, Station 3 (rivers) of : 38.10 to 68.42%, station 4 (beach) of : 26.32 to 40.91%. Relative dominance (RDo) at Station 1 (pond) of : 0.00 to 65.29%, Station 2 (residential) of : 60.39 to 85.76%, Station 3 (rivers) of : 27.05 - 79.54%, station 4 (beach) of : 7.75 to 35.92%. Importance Value Index (IVI) at Station 1 (pond) of : 0.00 to 123.18%, Station 2 (residential) amounted to : 114.93 to 157.19%, Station 3 (river) at : 65.15 - 147.97%, station 4 (beach) of : 34.07 to 76.83%. The density of mangroves in coastal areas (Station 4) has a density of mangrove higher than at the other stations.

The high density of mangroves in the coastal areas related mangrove rehabilitation program in Tegal conducted in 2010 - 2012.
The Diversity Index (H) and Uniformity Index (J) of Mangrove in Muarareja Tegal presented in Table 2.

Table 2. Diversity Index (H) and Uniformity Index (J) of Mangrove in Sub Muarareja

No	Type of mangrove	Pi	Pi Ln Pi	H'	J'
Station 1					
a1	*Rhizophora* mucronata	1,000	0,000	0,000	0,000
	Avicenia marina	0,000	0,000		
a2	*Rhizophora* mucronata	0,421	0,364	0,681	2,004
	Avicenia marina	0,579	0,316		
a3	*Rhizophora* mucronata	0,704	0,247	0,608	2,003
	Avicenia marina	0,296	0,360		
Station 2					
b1	*Rhizophora* mucronata	0,375	0,368	0,662	1,376
	Avicenia marina	0,625	0,294		
b2	*Rhizophora* mucronata	0,455	0,358	0,689	1,652
	Avicenia marina	0,545	0,331		
b3	*Rhizophora* mucronata	0,286	0,358	0,598	1,164
	Avicenia marina	0,714	0,240		
Station 3					
c1	*Rhizophora* mucronata	0,619	0,297	0,665	2,023
	Avicenia marina	0,381	0,368		
c2	*Rhizophora* mucronata	0,476	0,353	0,692	2,107
	Avicenia marina	0,524	0,339		
c3	*Rhizophora* mucronata	0,316	0,364	0,624	1,836
	Avicenia marina	0,684	0,260		
Station 4					
d1	*Rhizophora* mucronata	0,650	0,280	0,647	1,940
	Avicenia marina	0,350	0,367		
d2	*Rhizophora* mucronata	0,591	0,311	0,677	2,091
	Avicenia marina	0,409	0,366		
d3	*Rhizophora* mucronata	0,737	0,225	0,576	1,697
	Avicenia marina	0,263	0,351		

Source: Research (2015)

The mangrove species uniformity in Muarareja Tegal is dominated by *Rhizophora mucronata*. Diversity Index (H) of mangrove is ranged from .000 to .692 and Uniformity Index (J) of mangrove is ranged from 0.000 to 2.107.

3.1.2 Content of Carbon

The carbon content is measured in this study consisted of : total carbon content of tree biomass, litter, undergrowth, necromassa, leaves, roots and soils per hectare on a plot. The content of carbon during the study presented in Table 3.

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Table 3. Content of Carbon

Location	Total of carbon (ton/ha.)						
	$C_{biomassa}$	C_{litter}	$C_{undergrowth}$	$C_{necromassa}$	C_{leaves}	C_{roots}	C_{soils}
Stationn 1							
a1	7.993,21	4.750,13	222,47	1,15	5.922,00	5.113,60	156.275,00
a2	2.607,10	4.649,87	219,33	1,15	5.796,67	5.138,67	155.100,00
a3	3.616,28	4.659,27	219,33	1,15	5.890,67	5.107,33	156.275,00
Average	4.738,86	4.686,42	220,38	1,15	5.869,78	5.119,87	155.883,33
Station 2							
b1	1.077,62	4.173,60	162,93	2,19	4.991,40	5.057,20	151.222,50
b2	1.271,27	3.822,67	156,67	2,19	4.856,67	5.013,33	150.635,00
b3	499,24	3.825,80	156,67	2,19	4.888,00	5.107,33	150.400,00
Average	949,38	3.940,69	158,76	2,19	4.912,02	5.059,29	150.752,50
Station 3							
c1	4.738,50	4.894,27	263,20	2,31	5.865,60	5.148,07	159.565,00
c2	5.690,58	4.862,93	253,80	2,31	5.796,67	5.013,33	159.800,00
c2	499,24	4.888,00	250,67	2,31	5.765,33	5.107,33	158.625,00
Average	3.642,77	4.881,73	255,89	2,31	5.809,20	5.089,58	159.330,00
Station 4							
d1	17.638,48	4.869,20	288,27	2,34	5.943,93	5.144,93	161.445,00
d2	11.531,73	4.888,00	288,27	2,34	5.890,67	5.107,33	159.800,00
d3	10.234,13	4.897,40	294,53	2,34	5.903,20	5.151,20	160.505,00
Average	13.134,78	4.884,87	290,36	2,34	5.912,60	5.134,49	160.583,33

Carbon content at Station 4 (mangrove in coastal area) obtained a higher than the other stations. This is related to the density of mangroves in Station 4.

Total carbon stock in stratum contained in Muararejа mangrove areas presented in Table 4.

Table 4. Total Carbon Stock in Stratum

Location	C_{plot} (ton/ha)	$C_{stratum}$ (ton)
Station 1		
a1	180.277,56	12.018.504,20
a2	173.512,78	
a3	175.769,03	
Average	1765.19,79	
Station 2		
b1	166.687,44	
b2	165.757,79	11.112.496,20
b3	164.879,22	
Average	165.774,82	
Station 3		
c1	180.476,95	
c2	181.419,62	12.031.796,75
c2	175.137,88	
Average	179.011,49	
Station 4		
d1	195.332,16	
d2	187.508,34	13.022.143,71
d3	186.987,81	
Average	189.942,77	

Source: Primary Data, 2015

The total carbon content in the plot generated at Station 4 with the average amount of 189,942.77 tons / ha followed by stations 3 of 179,011.49 tons / ha, Station 1 amounted to 176,519.79 tons / ha and station 2 of 165,774.82 tons / ha. The carbon stocks in mangrove forest stratum ($C_{stratum}$) is the highest obtained at Station 4 of 13,022,143.71 tons / ha.

3.1.3 The Relationship between Mangrove Density with Carbon Content

Relationship between mangrove density (x) with carbon content (y) can be seen from the relationship linear regression as follows:

1. Total carbon content of trunks biomass ($C_{biomassa}$)
   Regression analysis between mangrove density (x) to the total carbon content of tree biomass (trunks) per hectare on a plot (y), resulting in the regression line equation y = -1,544.820 + 403.452 x with correlation coefficients (r) = 0.452 and determinants (D) = 0.205. Test F produces F count = 2,571 <F table (1; 10) = 4.96 with probability sig / 0.140 greater significance (> 0.05), so the regression equation can not predict the total value of the carbon content of tree biomass based on the values of mangrove density.
2. The total carbon content in litter (C_{litter})
   Regression analysis between mangrove density (x) to the total carbon content in litter per hectare on a plot (y), resulting in the regression line equation y = 3562.271 + 58.375 x with

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correlation coefficients (r) = 0.840 and determinants (D) = 0.705. Test F produces F count = 23.876> F table (1; 10) = 4.96 with probability sig / significance 0.001 smaller (<0.05). The regression equation can predict the total value of the carbon content in litter based on the values of mangrove density. T test to determine the significance of the constants and the dependent variable (total carbon content in litter per hectare on the plot) obtained 4.886 t count > t table 0,025 (11) = 2.201 with probability sig / significance 0.001 smaller (<0.05). It was decided there is a positive correlation (real) between mangrove density to total carbon content in litter. This means that the density of mangrove and total carbon content in litter per hectare has a relationship of mutual influence on each other. Each additional mangrove density strongly influence the addition of total carbon content in litter.

3. The total carbon content in undergrowth ($C_{undergrowth}$)
Regression analysis between mangrove density (x) to the total carbon content in undergrowth per hectare on the plot (y), obtained regression line y = 118.837 + 6.338 x with correlation coefficients (r) = 0.743 and determinants (D) = 0.552. F test obtained F count = 12.305> F table (1; 10) = 4.96 with probability sig / significance 0.006 smaller (<0.05). The regression equation can predict total value of the carbon content in undergrowth based on values of mangrove density. T test to determine the significance of constants and dependent variable (total carbon content in undergrowth per hectare on the plot) obtained 3.508 t count> t table 0,025 (11) = 2.201 with probability sig / significance 0.006 smaller (<0.05). There is a positive correlation (real) between mangrove density to total carbon content in undergrowth. This means that density of mangrove and total carbon content in undergrowth per hectare on a plot (y) has a relationship of mutual influence on each other. Each additional mangrove density strongly influence the addition of total carbon content in undergrowth.

4. Total carbon content in necromass ($C_{necromassa}$)
Regression analysis between mangrove density (x) to total carbon content necromass per hectare on the plot (y), resulting in regression line equation y = 2.456 + 0.026 x with correlation coefficients (r) = 0.300 and determinants (D) = 0.090. Test F produces F count = 0.987 < F table (1; 10) = 4.96 with probability sig / 0.344 greater significance (> 0.05). The regression equation can not predict total value of carbon content on necromass based on values of mangrove density. This is due dead mangrove necromass have little nutritional value and can not grow well, due to weathering and flooding are common.

5. Total carbon content in leaves (C_{leaves})
Regression analysis between mangrove density (x) to total carbon content in leaves per hectare on a plot (y), resulting in regression line equation y = 4447.564 + 66.385 x with correlation coefficients (r) = 0.912 and determinants (D) = 0.831. Test F produces F count = 49.207 > F table (1; 10) = 4.96 with probability sig / significance 0.000 (<0.05). The regression equation can predict the total value of the carbon content in leaves based on values of mangrove density. T test to determine the significance of the constants and the dependent variable (total carbon content in leaves) yielded 7.015 t count > t table 0,025 (11) = 2.201 with probability sig / significance 0.000 (<0.05). It was decided there is a positive correlation (real) between mangrove density to total carbon content in leaves. This means that density of mangrove and total carbon content in leaves have a relationship of mutual influence one another. Mangrove density is high, biomass of trees are large and the leaves are dense so that the power uptake and storage carbon was higher. Each additional mangrove density strongly influence the addition of total carbon content in leaves.

6. Total carbon content in the roots (C_{roots})
Regression analysis between mangrove density (x) to total carbon content in roots per hectare on a plot (y), resulting in the regression line equation y = 5049.370 + 2.898 x with

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correlation coefficients (r) = 0.358 and determinants (D) = 0.128. Test F produces F count = 1,470 < F table (1; 10) = 4.96 with probability sig / 0,253 greater significance (> 0.05). The regression equation can not predict the value of the total carbon content in the roots based on the values of the density of mangrove, shown by a carbon content in total at the root. Station 4 has the highest value and the lowest at station 2 which in this region often happens post, so the tree often undergo a process of adaptation to a place to grow and have a weak rooting system.

7. The total carbon content of soil (C_{soil})

   Regression analysis between mangrove density (x) to the total carbon content of soil per hectare on a plot (y), resulting in the regression line equation y = 147,315.120 + 525.193 x with correlation coefficients (r) = 0.781 and determinants (D) = 0.610. Test F produces F count = 15.616> F table (1; 10) = 4.96 with probability sig / significance 0.003 smaller (<0.05). The regression equation can predict total value of the carbon content of soil based on the value of mangrove density. T test to determine the significance of the constants and the dependent variable (total carbon content of soil per hectare on the plots) yielded 3.952 t count > t table 0,025 (11) = 2.201 with probability sig / significance 0.003 smaller (<0.05). It was decided there a positive correlation (real) between mangrove density to total carbon content of soil. This means that the density of mangrove and the total carbon content of soil have a relationship of mutual influence on each other. Each additional mangrove density strongly influence addition of total carbon content of soil. The land is a source of organic nutrients derived from biogenic materials wich degraded by bymicrobe / microorganism (decomposition).

8. Total carbon content in the plot (C_{total})

   Regression analysis between mangrove density (x) of the total Carbon content (y), resulting in the regression line equation y = 158,950.787 1062.616 + x with a correlation coefficient (r) = 0.673 and determinants (D) = 0.453. Test F produces F count = 8.285 > table F (1, 10) = 4.96 with probability sig / significance of 0.016 smaller (<0.05). The regression equation can predict total value of carbon content of soil based on values of mangrove density. T test to determine the significance of constants and dependent variable (total carbon content of soil), yieldied 2.878 t count > t table 0,025 (11) = 2.201 with probability sig / significance of 0.016 smaller (<0.05). It was decided there is a positive correlation (real) between mangrove density to total carbon content of soil. This means that density of mangrove and total carbon content of soil have a relationship of mutual influence on each other. Each additional mangrove density strongly influence addition of total carbon content of soil.

IV. Conclusion

Based on the results of the study can be summarized as follows:

1. Mangrove area in Muarareja Tegal dominated by *Rhizophora mucronata* with Relative Density (DeR) at Station 1 (pond) of: 42.11 to 100%, Station 2 (residential) of: 28.57 to 45.45%, station 3 (rivers) of: 31.58 to 61.90%, station 4 (beach) of: 59.09 to 73.68%. Relative dominance (DoR) at Station 1 (pond) of: 34.71 to 100%, Station 2 (residential house) of: 14.24 to 39.61%, Station 3 (rivers) of: 20.46 to 72, 95%, station 4 (beach) of: 64.08 to 92.25%. Importance Value Index (IVI) at Station 1 (pond) of: 76.82 to 200%, Station 2 (residential house) of: 42.81 to 85.07%, Station 3 (rivers) of: 52.03 to 134 , 85%, station 4 (beach) amounted to: 123.17 to 165.93%.
2. Diversity Index (H) of *Rhizophora mucronata* ranged from .000 to .692 and Uniformity Index (J) ranged from 0.000 to 2.107.
3. The largest carbon content generated at Station 4 with average number of total carbon content amounting to 189,942.77 tons / ha., followed at Station 3 amounting to 179,011.49 tons / ha, Station 1 amounting to 176,519.79 tonnes / ha and at station 2 amounting to 165,774.82 tons / ha.

4. Mangrove density has a very close relationship with total carbon content in litter, undergrowth, leaves, and soil. Mangrove density does not have a positive correlation with total carbon content in stem of tree biomass, necromass, and roots.

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