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THE CARBON CONSERVATION OF MANGROVE ECOSYSTEM IN INDONESIA[**]

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Running title: Carbon conservation of mangrove ecosystem

ABSTRACT

The carbon conservation program in mangrove ecosystem shows the carbon sequestration and sinker which gives a positive impact for mangrove sustainability. The carbon conservation of mangrove ecosystem supports the growth of mangrove vegetation based on the carbon percent of mangrove stage consisting of mangrove seedling, sapling and mangrove trees. This paper aimed to analyze carbon percentage of mangrove ecosystem which is SNI 06 – 3730 – 1995 and TAPPI T 211 om 85 methods and to analysis mangrove clustering based on carbon percentage. The results showed that (1) *Avicennia* spp, *Sonneratia* spp, *Bruguiera* spp, *Rhizophora* spp, *Aegiceras* spp, *Lumnitzera* spp, *Ceriop* spp, *Exoecaria agallocha* and *Xylocarpus granatum* had carbon percentage between 45.01% - 55.54%; (2) the carbon percentage of the mangrove growth were seedling (16.3-21.2%), sapling (19.0 – 28.1%), trees with diameter 10 – 20 (38.1 – 46.3%), trees with diameter 20 – 30 cm (40.2 – 51.1 %) and trees with diameter 30 – 40 cm (49,1 – 55,2 %). The carbon conservation has a positive correlation with the ability of carbon sequestration and mangrove growth. We would like to express our sincere gratitude to UNSOED grant that supported this research.

Keywords: carbon sequestration, mangrove ecosystem, carbon conservation, mangrove growth, mangrove clustering

INTRODUCTION

The carbon conservation aims to sequestrate carbon (Dutschke, 2004; Boer, 2004; IPCC, 2005; as well as Jennerjahn and Mitchell, 2013) and reduce atmospheric CO_2 (Silva *et al.,* 2017) which gives positive impact for forest sustainability and social welfare (Murdiyarso, 2003 and Dutschke, 2004). The carbon conservation in mangrove ecosystem followed the concept of carbon conservation program such as LULUCF (*Land Use, Land Use Change and Forestry*) (Boer, 2004) REDD program and Kyoto Protocol (Ajani *et al.,* 2013). The carbon conservation also aims to reduce the negative impact of carbon emission and climate change in some coastal areas (Nanlohy *et al.,* 2015).

The percent of carbon sequestration can be measured by destructive analysis (Hilmi, 2003) or non destructive analysis/remote sensing analysis (Dandois & Ellis, 2013). The carbon sequestration has a positive correlation with carbon absorption (Cathcart, 2000) which can be defined as carbon percentage of carbon sink in forest ecosystem. The carbon percentage is the main variable to support an economic valuation of carbon stock and carbon payment compensation followed by REDD and the Demonstrative Activities Program (Hilmi *et al.*, 2017)

The mangrove ecosystem takes pressures, stresses and shocks from climate change and carbon emission (Mandala *et al.,* 2012; Jennerjahn & Mitchell, 2013). Mangrove as an interface ecosystem between terrestrial and aquatic ecosystem (Hilmi *et al.,* 2014 and Kusmana *et al.,* 2000) has function to preserve coastal stability (Qiu *et al.,* 2014), reduce effect of seawater inundation (Kathiresan & Bingham, 2001 and Parvaresh *et al.,* 2011), give valuable ecosystem services and absorb carbon emission (Brander, 2012). The mangrove ecosystem has productivity 2500 mg C m^{-2} day^{-1} categorized as the high carbon ecosystems producer (Mukherjee & Ray, 2012).

The carbon conservation of mangrove ecosystem shows the ability of mangrove ecosystem to sequestrate carbon emission. The ability of mangrove ecosystem to sequestrate carbon has correlate with mangrove growth. The growth of mangrove following stage of mangrove stage consisting of seedling, sapling and mangrove trees will develop a model of mangrove clustering. The mangrove clustering base on carbon sequestration of mangrove stage give showing the model of carbon conservation of mangrove ecosystem. The mangrove clustering of carbon conservation will shows the carbon of mangrove species and mangrove stage. This paper aimed to analyse the percent of carbon in mangrove eocsystem base on species and growth stage and to analyse mangrove clustering to sequestrate carbon emission.

MATERIALS AND METHODS

Research Site

This research was conducted in Segara Anakan Lagoon (SAL) (Fig. 1) using cluster sampling based on rivers of East Segara Anakan such as Donan River, Kembang Kuning River and Sapuregel river. The number of sampling plots in this research were 10 sampling plots with geographical coordinate were shown on Table 1.

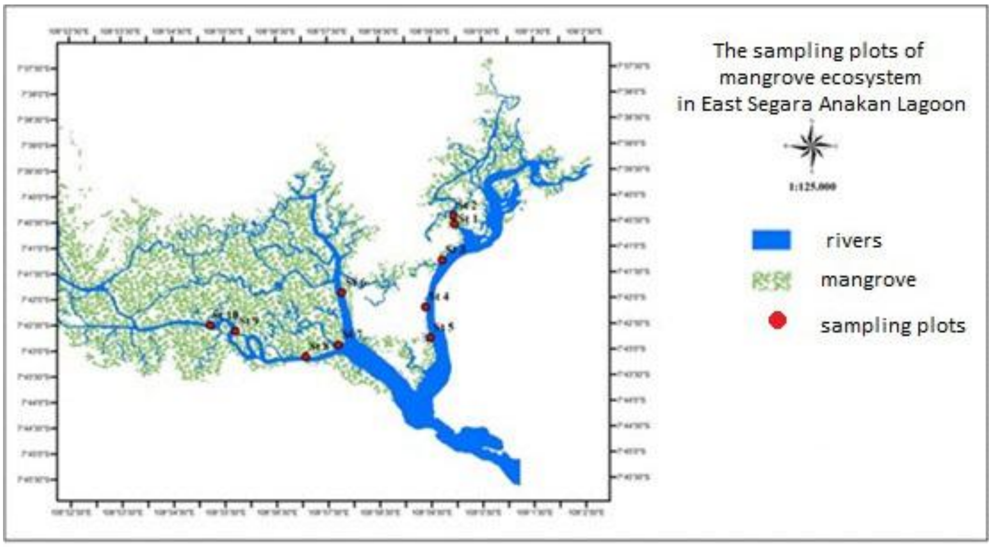

Figure 1 Research site in Segara Anakan Lagoon

Table 1. The geographical coordinate of sampling stations

Stations	Geographical coordinates	
	Latitude (South)	**Longitude (East)**
St. 1	07^0 40’ 33,98”	108^0 59’ 58,10”
St. 2	07^0 40’ 23,79”	108^0 59’ 56,90”
St. 3	07^0 41’ 15,49”	108^0 59’ 43,22”
St. 4	07^0 42’ 10,17”	108^0 59’ 23,75”
St. 5	07^0 42’ 46,06”	108^0 59’ 29,10”
St. 6	07^0 41’ 53,33”	108^0 57’ 46,71”
St. 7	07^0 42’ 54,20”	108^0 57’ 42,07”
St. 8	07^0 43’ 07,52”	108^0 57’ 03,97”
St. 9	07^0 42’ 37,42”	108^0 55’ 42,21”
St. 10	07^0 42’ 30,79”	108^0 55’ 13,23”

Research Procedures

The sampling species

The sampling species of mangrove ecosystem in East Segara Anakan Lagoon to analysis carbon were *Avicennia* spp, *Sonneratia* spp, *Bruguiera* spp, *Rhizophora* spp, *Aegiceras* spp, *Lumnitzera* spp, *Ceriop* spp, *Exoecaria agallocha* and *Xylocarpus* spp.

The growth stage of mangrove sampling

The growth stage of mangrove samplings were divided into 3 stage were seedling, pole and trees (diameter 10 – 20 cm, 20 – 30 cm and 30-40 cm). The number sample/growth stage was five samples to collect carbon content from each species.

The section of mangrove trees sampling

The carbon content analysis of mangrove species used the section of trees such as leaves, branch, twig and stem. The number of sample were five samples/mangrove section.

The carbon content analysis

The carbon content was showed by percent of carbon was measured by destructive analysis. Hilmi et al., (2017) wrote the destructive analysis to calculate the percent carbon with (1) the Wood dust procedure used SNI 06 – 3730 – 1995 and TAPPI T 211 om 85 in the wood properties Laboratory, Forest Faculty IPB and Forestry Departement;(2) The Analysis of carbon percentage used SNI 06 – 3730 – 1995 (volatile analysis) and TAPPI T 211 om 85 (dust analysis). The formulation to analyse percent of carbon was analyzed by dust approach TAPPI T 211 om 85 (gravimetric method) that was (Hilmi et al., 2017)

$$\text{Percent of Carbon } (\%) = \left(\frac{\text{C - D}}{\text{C - A}}\right) : \left(1.724 \text{ x } 100\ \%\right)$$

Note.

A: empty cup

C : cup and sample after heated with temperature raise up to 105^{o}C for 24 hours.

D : cup and sample after heated in the tenure with temperature 700 ^{c}o. for 2 hours.

Data Analysis

The descriptive analysis (data tabulation, graph and figure) was used to analyse carbon percent of mangrove species (leaves, twig, branch and stem) and carbon percent base on mangrove growth stage. While, the mangrove clustering based on carbon content was used to draw distribution of carbon content in mangrove ecosystem followed the growth stage and species distribution.

RESULT AND DISCUSSION

The Carbon Distribution of Mangrove Species

The carbon distribution of mangrove species were shown on Table 2. The carbon distributions show the carbon content and carbon sinker from each species which is stored in stem, branch, leaves, twig, root and flower. The percent of carbon has positive correlation with ability of carbon sequestration (Charoenjit *et al.,* 2013, Prasad *et al.,* 2013).

Table 2. The percent of carbon from mangrove species

The mangrove species	The percent of carbon		
	distribution interval	Average	STDV
Aegiceras spp	49.40 - 51.14	50.27	1.23
Avicennia spp	45.01 - 49.73	47.37	3.34
Bruguiera spp	50.89 - 55.54	53.22	3.29
Ceriops spp	47.02 - 49.84	48.43	1.99

Excoecaria aggallocha	48.61 - 49.56	49.09	0.67
Heritiera sp.	47.01 - 49.95	48.48	2.08
Lumnitzera spp	46.02 - 51.03	48.53	3.54
Rhizophora spp	50.25 - 55.38	52.82	3.63
Sonneratia spp	49.00 - 50.56	49.78	1.10
Terminalia sp.	46.57 - 49.95	48.26	2.39
Xylocarpus spp	46.50 - 49.77	48.14	2.31

Tabel 2 showed that the carbon percent of *Bruguiera* spp and *Rhizophora* spp > *Aegiceras* spp., *Ceriops* spp and *Lumnitzera* spp > *Avicnnia* spp*., Sonneratia* spp*., Terminalia sp, Heritiera sp., Excoecaria aggallocha,* and *xylocarpus* spp. Based on Table 2 can be classified that *Bruguiera* spp and *Rhizophora* spp (class 1) *Aegiceras* spp., *Ceriops* spp and *Lumnitzera* spp (class 2) *Avicnnia* spp*., Sonneratia* spp*., Terminalia sp, Heritiera sp., Excoecaria aggallocha,* and *xylocarpus* spp (class 3). The carbon percent in mangrove trees (Table 1) had range between 46.02 – 55.54 % which was bigger than other ecosystem (Casasola *et al.,* 2017 and Brown, 1997). IPCC (1996) noted that the carbon percentage of other forests are between 41 – 54 %. The Table 2 showed that carbon percentage of mangrove ecosystem has score bigger than other ecosystem. The percent of carbon in mangrove ecosystem refflect the mangrove sinker which has correlation with carbon sequestration (Hilmi et al., 2017; Dutschke, 2004; Boer, 2004; IPCC, 2005; Jennerjahn and Mitchell, 2013). The carbon sequestration of mangrove expressed the ability to sequestrate carbon from air, soil and water (Prasad *et al.,* 2013; Mukherjee & Ray, 2012; Charoenjit *et al.,* 2013;Ajani *et al.,* 2013; Harmon, 2001). The carbon percentage also shows the ability to absorb atmospheric carbon dioxide and is stored in stem, leaves, branch and other segment of tress (Jennerjahn & Mitchell, 2013; Mukherjee & Ray, 2012).

The data on Table 2 also showed that the mangrove ecosystem can be categorized as the best carbon pool, because the mangrove species have effective activities of CO_2 flux balancing between photosynthetic uptake, respiratory releasing (Mukherjee & Ray, 2012) and carbon reducing (Avelar *et al.,* 2017). Bassicaly, the carbon percentage shows the ability to sequestrate carbon is the essential ecological function (Anneboina & Kumar 2017) to reduce carbon emission and climate impact mitigation (Duncan *et al.,* 2016)

The Table 2 also showed that *Bruguiera* spp., and *Rhizophora* spp., had best carbon percentage in mangrove ecosystem expressed the effectiveness of carbon sequestration and absorbtion. The best carbon percentage of mangrove species have correlation with the potential of cellulose, hemicellulose, lignin and extractive as the wood matter of the trees. The potency of cellulose, hemicellulose and extractive compound had positive correlation with wood density (Hilmi, *et al.,* 2017; Tsoumis, 1991). Hilmi *et al.,* (2017) wrote that the wood density from

Bruguiera gymnorrhiza was 0.94 (0.82–1.03), *Rhizophora apiculata* was 1.05 (0.95–1.12), and *Rhizophora mucronata* was 0.94 (Martawijaya et al., 1989).

The carbon percentage of mangrove species is a part of the major process of transporting carbon in carbon cycle process (Prasad *et al.,* 2013). This carbon cycle in this ecosystem is influenced by the soil-water interaction (Charoenjit *et al.,* 2013), carbon sources, sinks and reservoirs (Ajani *et al.,* 2013), decomposition and subsequent remineralization (Roya *et al.,* 2012), species abundance (Zanden *et al.,* 2017), the biomass (Duncanson *et al.,* 2017) litter biomass, dissolved oxygen, primary productivity, community respiration, temperature, pH and air-water exchange of carbon dioxide (Mukherjee *&* Ray, 2012). The carbon percentage also has positive correlation with ecosystem productivity. Mukherjee *&* Ray (2012) note that mangrove is highly productive ecosystems with productivity carbon 2500 mg C m^{-2} day^{-1}. Cohen *et al.* (2013) also write that forest carbon stocks from Rhizophora forest is 134.5 Mg ha^{-1}. Charoenjit *et al.* (2013) describe that the rate of carbon sequestration of mangrove vegetation is 0.04 tons C $km^{-2}year^{-1}$.

The carbon percantage of mangrove species gives positive impact for the carbon ecosystem. Hilmi *et al.* (2017) and Porte *et al.* (2002) wrote the percent of carbon ecosystem from *Rhizophora apiculata* as major species will give carbon ecosystem between 45.88 – 244.99 tons C ha^{-1} higher than *Aegiceras floridum* (16,16 tonC ha^{-1}) and *Bruguiera gymnorrhiza* (34.71 tons C ha^{-1}), and *Xylocarpus granatum* (37,69 tons C ha^{-1}). Hartoko *et al.* (2015) also note that total mangrove carbon between 182.4 tons ha^{-1} which is not different from forest plantation with carbon ecosystem 192.80 Mg ha^{-1} (Charoenjit *et al*., 2013; Chheng *et al.,* 2016; Rahman *et al.*, 2015) and in natural forest was 23.5 Mg C ha^{-1} (Thapa *et al*., 2015).

Carbon Distribution of Mangrove Ecosystem

The carbon distribution of mangrove ecosystem (vertical distribution and horizontal distribution) can be viewed by the stage of mangrove growth like as seedling, sapling and mangrove trees (Table 3).

The horizontal distribution is a carbon distribution base on diameter classes. The horizontal distribution of carbon percentage had positive correlation with diameter of mangrove vegetation (Porte *et al.,* 2002; Rindyastuti and Sancayaningsh, 2018; Haripriya 2002; Bismark *et al.,* 2008; Johnson *et al.,* 2001). The carbon percent of seedling < sapling < mangrove trees 10 – 20 cm < mangrove trees 20 – 30 cm < mangrove trees 30 – 40 cm. Table 2 showed that the increasing of mangrove diameter from *Rhizophora* spp*, Bruguiera* spp.*, Sonneratia* spp.*, Avicennia* spp.*, Aegiceras* spp.*, Ceriops* spp.*, Lumnitzera* spp.*, Heritiera* sp., *Terminalia cattapa*, and *Excoecaria aggallocha* would give the increasing of carbon percent. The growth of mangrove diameter give positive effect for the ability to sequestrate and accumulate carbon. The increasing of sequestration and accumulation carbon will increase carbon percentage (Ong, 1993 and Sato *et al.,* 2002). The horizontal distribution of carbon percent of mangrove species were influenced by the potential of specific gravity, wood chemical compound (hemicellulose, cellulose, extractive matter), dust degree and volatile degree as the main variables to analyze carbon percentage (Ahmadi, 1990; Haygreen & Bowyer, 1993; Hilmi *et al.,* 2017; and Hilmi *et al.,* 2015). Generaly, volatile degree showed volatile matter which is arranged by aliphatic, terpena and phenolic compound (Pettersen, 1984). While, dust degree showing metal oxide substances which is arranged by calcium, potassium and magnesium. The increasing of diameter will effect to increase the wood chemical compound and specific gravity and decreasing of volatile and dust degree.

Based on the vertical distribution also showed that the mangrove percentage of stem > branch > twig and root > leaves. The fruit and leaves had bigger potential of volatile and dust than stem, branch and twig (Hilmi *et al.,* 2015). And the stem had the bigest carbon because the mangrove stem had the bigest potential of cellulose, hemicellulose, and lignin (Hilmi, 2003; Hilmi *et al.,* 2015; and Tsoumis, 1991).

The carbon percentage was also influenced by the potential of heart wood and juvenile wood which was represented by specific gravity (Hilmi, *et al.,* 2015 and Hilmi, 2003). Twig and branch had heart wood and juvenile wood bigger than mangrove stem. The other factor was water content. Leaf and fruit of mangrove vegetation had the highest water content and the lowest cellulose, hemicellulose, and lignin.

Whereas, the mangrove root also showed the low of carbon percentage because the mangrove roots was dominated by cork cell, penuematophora, low of cellulosa, hemicellulose and lignin (Haygreen & Bowyer, 1993; Ahmadi, 1990; and Tsoumis, 1991). This condition had correlation with pneumatophore pattern to absorb nutrient, water and air in photosynthesis and respiration system.

The mangrove leaves had low of carbon percentage because they had correlation with photosynthesis process. The photosynthesis develops organic matter which is constructed by nutrient supply like as water, mineral and nutrient compound. Whereas the fruit of mangrove had the lowest carbon because the highest potential of water degree, mineral, organic and an organic matters to supply food for cotyledon (Hilmi, 2003; Hilmi *et al.,* 2015; and Hilmi *et al.,* 2017)

Table 3. The Carbon Distribution of Mangrove ecosystem (Vertical and Horizontal Distribution)

The Mangrove Species	The Percent of Carbon (%)																
	Seedling	Sapling	The diameter of mangrove trees														
			10-20 cm					20 – 30 cm					30 – 40 cm				
			Leaves	Twig	Branch	Stem	Root	Leaves	Twig	Branch	Stem	Root	leaves	Twig	Branch	Stem	Root
Aegiceras spp	15.1-19.0	19.1-21.0	19.6-22.1	20.2-23.2	24.2-28.8	40.4-43.1	21.2-25.1	19.7-22.3	20.4-23.2	24.4-28.9	45.4-48.1	22.2-25.3					
Avicennia spp	15.3-19.2	19.0-20.3	19.8-22.0	20.1-23.4	24.1-28.5	40.0-43.7	16.1-18.0	19.9-22.2	20.3-23.4	24.2-28.6	43.0-47.7	16.3-18.2					
Bruguiera spp	16.2-20.2	20.1-22.2	20.2-23.5	20.2-25.3	25.1-30.2	40.1-45.1	21.2-25.2	20.3-23.8	20.3-35.4	25.1-30.3	48.2-51.1	22.2-28.3	20.2-23.6	20.2-34.6	25.2-30.4	49.2-55.6	22.1-28.2
Ceriops spp	14.2-19.2	19.3-20.5	20.2-23.0	21.0-24.3	24.6-29.1	40.0-43.8	20.0-24.1	20.3-23.4	21.2-24.4	24.8-29.3	43.0-48.2	20.4-23.4					
Excoecaria aggallocha	15.6-19.2	18.9-20.3	20.2-23.0	21.3-24.2	24.6-28.8	40.6-43.6	20.2-23.0	20.2-23.0	21.4-24.3	24.8-28.9	43.0-47.6	20.3-23.2					
Heritiera sp.	16.0-19.0	18.8-19.8	19.8-22.0	20.2-23.4	24.1-27.6	40.0-43.9	20.1-23.1	19.9-22.1	20.4-23.6	24.3-27.8	42.0-46.9	19.9-22.3					
Lumnitzera spp	15.6-19.0	18.8-20.5	20.0-22.8	21.4-24.0	24.2-27.9	40.0-43.0	20.2-23.3	20.3-22.9	21.6-24.1	24.4-28.1	43.0-48.0	20.2-22.9					
Rhizophora spp	16.7-21.1	19.2-23.1	23.7-25.7	21.0-24.5	29.1-31.4	40.1-46.3	20.3-25.1	23.7-25.5	21.9-26.7	25.9-30.5	46.1-50.2	20.8-25.1	20.4-25.1	23.1-26.2	28.1-31.3	49.1-55.2	21.6-25.0
Sonneratia spp	16.5-19.4	18.8-20.4	22.9-24.0	20.5-23.0	24.2-28.1	39.0-43.6	16.1-18.2	22,8-24.1	20.6-23.1	24.3-28.3	43.0-48.6	16.3-18.3					
Terminalia sp.	16.1-19.0	19.0-20.4	22.0-24.0	20.0-23.2	23.8-28.9	39.6-43.9	20.0-22.0	22.3-24.0	20.1-23.3	23.8-28.9	43.6-47.9	20.2-22.3					
Xylocarpus spp	15.9-19.2	19.5-20.7	21.4-23.0	20.4-23.4	23.6-29.0	39.5-43.8	20.2-22.0	21.5-23.1	20.1-23.4	23.7-29.1	44.5-47.8	20.2-22.1					

This research showed that (1) specific gravity of stem > branch > twig > leaf and fruit > root; (2) dust degree of leaf > fruit > branch, twig, root > stem; and (3) volatile degree of root > leaf and fruit > branch and twig > stem. The dust degree, volatile degree and specific gravity will influence potential carbon of mangrove. Carbon percentage showed that carbon percentage of stem > branch > twig > leaf and fruit > root.

Clustering of Mangrove Ecosystem based on Carbon Percentage

The clustering of mangrove ecosystem can be developed by the carbon zoning of mangrove ecosystem. The clustering of mangrove ecosystem based on carbon percentage drew the potential of carbon based on growth stage of mangrove vegetation (Seedling, sapling, and trees) as in **Figure 2**. The clustering of mangrove ecosystem viewed the zonning model of mangrove ecosystem to support carbon conservation program.

The clustering of mangrove ecosystem had correlation with the dynamic system in mangrove ecosystem (mangrove climax). The mangrove dynamic is an adaptive complex system (Karl & Church, 2017) which uses invention of growth stage as the first stage of ecological dynamic (Hagstrom & Levin, 2017). The growth stage and dynamic process of carbon for mangrove landscaping showed that the zoning of the mangrove ecosystem at zone 1 was dominated by *Avicennia* spp having carbon 15.3 - 19.2 % (seedling), 19.0 – 20.3% (sapling), 40.0 – 43.7 % (mangrove trees with diameter 10 – 20 cm), 43.0 – 47.7% (mangrove trees with diameter 20-30 cm). Then, *Sonneratia* spp had carbon 16.5-19.4 % (seedling), 18.8-20.4% (sapling), 39.0-43.9 % (mangrove trees with diameter 10 – 20 cm), 43.0-48.6% (mangrove trees with diameter 20-30 cm). Next, *Ceriop* spp had carbon 14.2-19.2 % (seedling), 19.3–20.5% (sapling), 40.0–43.8% (mangrove trees with diameter 10 – 20 cm), 43.0–48.2% (mangrove trees with diameter 20-30 cm). *Aegiceras* spp had carbon 15.1-19.0% (seedling), 19.1-21.0% (sapling), 40.0-43.1% (mangrove trees with diameter 10 – 20 cm), 45.4 - 48.1% (mangrove trees with diameter 20-30 cm).

Zone 2 was developed by *Rhizophora* spp had carbon 16.7 - 21.1% (seedling), 19.2 - 23.2% (sapling), 40.1 - 46.3% (mangrove trees with diameter 10 – 20 cm), 46.1 - 50.2% (mangrove trees with diameter 20 - 30 cm), 49.1 - 55.2% (mangrove trees with diameter 30 - 40 cm). *Bruguiera* spp had carbon 16.2 - 20.2% (seedling), 20.1 - 22.2% (sapling), 40.1 - 45.1% (mangrove trees with diameter 10 – 20 cm), 48.2 - 51.1% (mangrove trees with diameter 20 - 30 cm), 49.2 - 55.6% (mangrove trees with diameter 30 - 40 cm). *Lumnitzera* spp had carbon 15.6 - 19.0% (seedling), 18.8 - 20.5% (sapling), 40.0 - 43.0% (mangrove trees with diameter 10 – 20 cm), 46.1 - 50.2% (mangrove trees with diameter 20 - 30 cm), 43.0 - 48.9% (mangrove trees with diameter 30 - 40 cm).

The last zone was *Excoecaria agallocha* having carbon 15.6 - 19.2% (seedling), 18.9 - 20.2% (sapling), 40.6 - 43.6% (mangrove trees with diameter 10 – 20 cm), 43.0 - 47.6% (mangrove trees with diameter 20 - 30 cm). *Xylocarpus* spp had carbon 15.9 - 19.2% (seedling), 19.8-20.7% (sapling), 39.5-43.8% (mangrove trees with diameter 10 – 20 cm), 44.5 - 47.8% (mangrove trees with diameter 20 - 30 cm). Then, *Heritiera sp* had carbon 16.0 - 19.0% (seedling), 18.8 - 19.8% (sapling), 40.0 - 43.9% (mangrove trees with diameter 10 – 20 cm), 42.0 - 45% (mangrove trees with diameter 20 - 30 cm). *Terminalia cattapa* had carbon 16.1 - 19.0% (seedling), 19.0 - 20.4% (sapling), 39.6 - 43.9% (mangrove trees with diameter 10 – 20 cm), 43.6 - 47.9% (mangrove trees with diameter 20 - 30 cm. Based on data, it showed that seedling and sapling had the carbon percentage less than mangrove trees. And, mangrove with big diameter had the potential carbon bigger than small diameter. The potential of carbon had positive correlation with linier model carbon accretion rates of ecosystem (D'Amore *et al.,* 2015)

The potential carbon also had positive correlation with the potential of cellulose, hemicellulose, lignin and extractive substances, water degree, volatile degree, dust degree and specific gravity. The data also expressed the vertical distribution of carbon percentage had positive correlation with growth stage and diameter stratification of mangrove vegetation. The growth stage and diameter stratification in mangrove ecosystem based on carbon percentage viewed the dynamic growth of mangrove ecosystem to sequestrate carbon. The carbon seqestration of mangrove growth stage will show the ability of mangrove species to manage the environment factors to support mangrove life (Hagstrom & Levin, 2017). The carbon factor is a essential factor to support life of mangrove species. The dynamic process of carbon had relation with ability to sequester carbon to construct potential of the net ecosystem carbon balance (NECB) from seedling, sapling and trees (White & Plaskett, 1981)

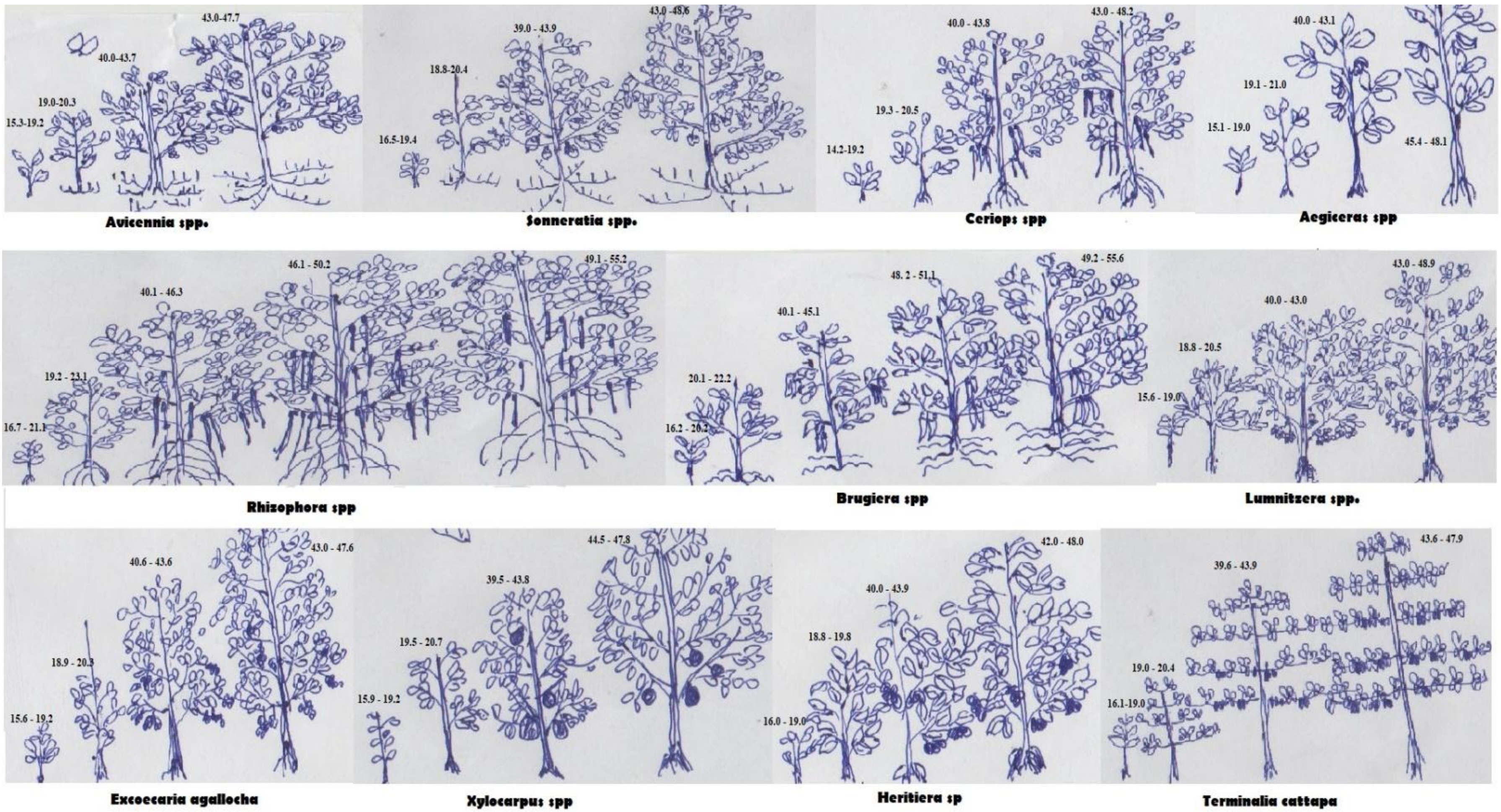

Figure 2 Mangrove Clustering based Carbon Percentage

CONCLUSION

The mangrove clustering can be developed by the zone of carbon in mangrove ecosystem. Based on carbon data, it showed that the class 1 was dominated by *Bruguiera* spp and *Rhizophora* spp. The class 2 was dominated by *Aegiceras* spp., *Ceriops* spp and *lumnitzera* spp. And the class 3 was dominated by *Avicennia* spp*., Sonneratia* spp*., Terminalia sp, Heritiera sp., Excoecaria aggallocha,* and *xylocarpus*spp. The potential of carbon in mangrove trees had range between 46.02 – 55.54 %.

The dynamic of carbon in mangrove ecosystem showed that the growth stage and diameter had positive correlation with the carbon percent. The carbon percent of seedling < sapling < mangrove trees with diameter 10 – 20 cm < mangrove trees with diameter 20 – 30 cm < mangrove trees with diameter 30 – 40 cm.

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