Blue carbon content of mangrove vegetation in Subang district

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Abstract. The purpose of this research was to know the carbon content of mangrove parts such as leaves, stems, and roots and to know its ability to absorb carbon dioxide (CO₂). The research was conducted in 27th April until 16th May 2017 in Blanakan Village, Langensari Village and Jayamukti Village. The samples are dried at Pilotplane Laboratory Faculty of Industrial Engineering Padjadjaran University. The method in this research is explorative survey method. The results showed that there were two dominant mangroves species in the three research stations, they are Avicennia marina and Rhizophora mucronata. Index of Important value of each mangrove type on the three stations in the medium criterion with a range of values is 106,86% - 193,13%. The highest carbon content was found in Rhizophora mucronata at station 1 (93,43%) which was equivalent with 342,87% absorption of CO₂. The lowest carbon content was in Avicennia marina at station 1 (67,49%) which was equivalent with 247,70% absorption of CO₂.

1. Introduction
Global warming is one important phenomenon that has become a problem not only in Indonesia but has also evolved into an issue discussed at the international level. Global warming affects climate change which can cause various disasters such as the rise of sea levels, prolonged drought, flooding during the rainy season, failure of reproduction of various animals living in the wild, declining biodiversity and so on [1].

Global warming followed by climate change is caused by excessive energy use which can increase Green House Gas (GHG) emissions especially CO₂ (carbon dioxide). The increase in population causes the CO₂ concentration in the atmosphere to rise due to the increase of the anthropogenic activity of humans. Undernormal conditions, CO₂ will be utilized by autotrophic organisms located in terrestrial and aquatic ecosystems for photosynthesis which then results in the process of food and oxygen gas (O₂) formation. If there is a decrease in the number of plants acting as CO₂ absorbers, the presence of CO₂ in the atmosphere becomes more abundant and will cause global warming [2].

The high CO₂ gas in the atmosphere is one cause of climate change that can be avoided because the earth can act as a natural carbon storage, among others through terrestrial forests, photosynthesis processes, as well as stored in biomass and sediments known as green carbon. Green carbon is now being applied in the GHG emission reduction mechanism) known as the Reducing Emissions from Deforestation and Degradation Plus by referring to the method developed by the 2006 Intergovernmental Panel Climate Change Guide Line (IPCC GL), however it does not take into account
the existence of coastlines and seas. Seventy percent of the earth's surface are oceans that can absorb, bind and store carbon through photosynthesis mechanisms with a very large carbon pool that is potentially larger than green carbon [2].

Lowland or coastal areas are particularly vulnerable to the effects of climate change, this is because coastal areas are directly affected by rising sea levels caused by rising earth temperatures. These coastal areas include seagrass, mangrove and coral reef ecosystems that are also vulnerable to the impacts of climate change and are feared to disrupt and threaten its sustainability and the living biota inside [1].

Coastal ecosystems can transfer and store carbon in vegetation and sediments with much greater capability and reach thousands of years longer than land forests which can hold hundreds of years. The carbon stored for thousands of years is called blue carbon [3]. Mangrove ecosystems with seagrass beds and coral reefs and brackish swamps are important ecosystems that act as carbon absorbers and binders. The entire ecosystem can bind 235-450 million tons of carbon per year which is equivalent to almost half of carbon emissions through transportation worldwide [4].

Subang Regency is one of the districts in West Java with a considerably large mangrove area of 3033 ha (Forest service of west java 2013). The mangrove areas of Subang Regency are located in four districts namely the Blanakan, Pamanukan, Legonkulon and Pusakanagara Sub-Districts. Subang Regency has a relatively high potential of mangrove resources, however, its carbon stockstoring and its CO$_2$ absorption ability is yet uncertain. Therefore, research is necessary to identify the potential of blue carbon content.

2. Methodology
The research was conducted in Subang Regency with research stations in three villages (Blanakan, Jayamukti and Langensari). The research was conducted between April 27th to May 16th 2017. The analysis of carbon content was carried out at the Pilot plant Laboratory Faculty of Agricultural Industrial Technology, Padjadjaran University.

The methods used in this research were the field survey and explorative methods. An explorative method is a method that examines and reveals something from the field as a finding used to construct models and draw conclusions [5].

The measurement of biomass in vegetation can provide information on overall nutrients and carbon stocks. Mangrove biomass is a calculation of production and density based on the diameter, height and weight measurement of the tree species [6]. Biomass or dry weight is calculated using the following formula.

$$\text{Biomass} = \frac{\text{Dry Weight Samples}}{\text{Weight Wet Samples}} \times 100\%$$  \hspace{1cm} (1)

2.1. Carbon Stock
Calculations of Carbon biomass can use [7] and the International Panel on Climate Change (IPCC, 2003).

$$\text{Carbon Stock} = \text{Dry Weight of the plant (Biomass)} \times C\%$$  \hspace{1cm} (2)

Information :
1. Dry weight obtained from biomass sampling
2. C% based on IPCC stipulations in 2006 of 0.5
2.2. Carbondioxide Absorption
Calculation of carbondioxide absorption (CO\textsubscript{2}) is done by using the formula [9]:

$$\text{CO}_2 (\%) = \frac{\text{Mr CO}_2}{\text{Ar C}} \times \text{Carbon content}$$ (3)

Information :
Mr \text{CO}_2 = \text{Relative Molecular Mass Relative Value of Carbon Dioxide} 44
Ar C = \text{Relative Carbon Atomic Value of} 12

3. Result and Discussion
3.1. Biomass and Carbon Content of Mangrove Vegetation
The measurement of biomass and carbon content was done on tree-level mangrove plants with the tree samples of \textit{Avicennia marina} and \textit{Rhizophora mucronata}, which is the dominant type at the Blanakan, Langensari and Jayamukti research stations. The trees were determined based on Diameter at Breast at Highest (DBH) or highest chest diameter in the observation plot. Leaves, stems, roots and sediments were taken from each tree as to determine biomass and carbon content.

An autotrophic organism processes photosynthesis by absorbing CO\textsubscript{2} from the atmosphere and converting it into organic carbon and storing it in its body's biomass such as in leaves, stems, roots, tubers, fruits and other parts. Biomass is a plant dry weight of 50% consisting of carbon content (IPCC 2003).

The carbon content of the \textit{Rhizophora mucronata} mangrove species has a higher value than the \textit{Avicennia marina} type. The total carbon content of \textit{Avicennia marina} was 67.5% while it was 93.42% in \textit{Rhizophora mucronata} (table 1).

| Mangrove Types       | Sample | Gross Weight (g) | Dry Weight (g) | Biomass (%) | Carbon Content (%) |
|----------------------|--------|------------------|----------------|-------------|-------------------|
| \textit{Avicennia marina} | Leaf   | 263              | 71             | 27.00       | 13.50             |
|                      | Stem   | 540              | 284            | 52.59       | 26.30             |
|                      | Root   | 213              | 118            | 55.40       | 27.70             |
|                      | Total  | 530              | 473            | 134.99      | 67.5              |
| \textit{Rhizophora mucronata} | Leaf   | 288              | 100            | 34.72       | 17.36             |
|                      | Stem   | 270              | 191            | 70.74       | 35.37             |
|                      | Root   | 317              | 258            | 81.39       | 40.69             |
| Total                |        | 875              | 549            | 186.85      | 93.42             |

Results from Station 1 showed that the highest carbon content was found in the \textit{Rhizophora mucronata} root at 40.69% which is equal to 129 grams, while the \textit{Avicennia marina} root has a value of 27.70% which equals to 59 grams. The carbon content of the \textit{Rhizophora mucronata} stem was 35.37% which is equal to 95.5 grams, while the value of \textit{Avicennia marina} is 26.30% which equals to 142 grams. The carbon content of \textit{Rhizophora mucronata} leaves was 17.36% (50 grams), while \textit{Avicennia marina} leaves measured 13.5% (35.5 grams).

Comparisons of carbon content at Station 1 based on sample sections of both types indicated that the root has the highest carbon content while the leaves had the lowest. The high carbon content value of the root is caused by environmental conditions which are more extreme at the roots level compared to the carbon content of the above-ground biomass. Additionally, the value of the carbon content of the roots did not vary much with the stem because the characteristics of its constituent substances are almost the same.
The low carbon content of the leaves did not depend on the age of the stand. The differences in leaf biomass in each mangrove species can be due to species characteristics, leaf shape and light availability [10].

The carbon content in *Rhizophora mucronata* compared to *Avicennia marina* was different from Mandari *et al.* [11] in the Bandar Bakau Dumai area, Riau Province. By using allometric method, the measurement of carbon content in the *Rhizophora mucronata* type was 0.34 ton C/ha, while the carbon content of *Avicennia marina* type was 0.93 ton C/ha. This occurs because of the differences in density [11] *Avicennia marina* has a much higher density and has larger average tree diameter of 8.51 cm while the type *Rhizophora mucronata* has an average tree diameter of 6.54 cm.

At Station 2, the value of carbon content of the *Rhizophora mucronata* mangrove is greater than that of *Avicennia marina* which is 87.98 % and 76.68 % respectively (table 2).

| Mangrove Type           | Sample | Gross Weight (g) | Dry Weight (g) | Biomass (%) | Carbon Content (%) |
|-------------------------|--------|------------------|----------------|-------------|--------------------|
| *Avicennia marina*      | Leaf   | 267              | 85             | 31.84       | 15.92              |
|                         | Stem   | 300              | 191            | 63.67       | 31.83              |
|                         | Root   | 242              | 140            | 57.85       | 28.93              |
|                         | Total  | 809              | 416            | 153.36      | 76.68              |
| *Rhizophora mucronata*  | Leaf   | 409              | 131            | 32.03       | 16.01              |
|                         | Stem   | 343              | 250            | 72.89       | 36.44              |
|                         | Root   | 456              | 324            | 71.05       | 35.53              |
|                         | Total  | 1,208            | 705            | 175.97      | 87.98              |

The highest carbon content was found in the stem of *Rhizophora mucronata* at 36.44 % which is equivalent to 125 grams, while the *Avicennia marina* stem has a carbon content value of 31.83% which is equal to 95.5 grams. The value of carbon content at the root of *Avicennia marina* was 28.93% (70 grams), while results of the *Rhizophora mucronata* root measured 35.53 % (162 grams). The lowest carbon content was found in the leaf, with the value of *Avicennia marina* at 15.92 % (42.5 grams) and *Rhizophora mucronata* at 16.01 % (65.5 grams). Comparisons of carbon content at Station 3 obtained from sample sections of both types indicated that the rod had the highest carbon content while the leaf portion had the lowest.

Results from Stations 1 and 2 showed that *Rhizophora mucronata* leaves were measured to have higher a carbon content than *Avicennia marina* leaves. This is due to the characteristics of *Rhizophora mucronata* leaves that are wider and larger than *Avicennia marina* leaves. Higher levels of carbon content were also present in the stem of *Rhizophora mucronata* at the two research stations. The method used in the research was a drying method, hence the carbon content of the stem was not affected by the diameter of the tree. This allows the carbon content value of the *Rhizophora mucronata* rod to measure higher although the the *Avicennia marina* has a greater tree diameter. The value of carbon content of the *Rhizophora mucronata* root was greater than that of *Avicennia marina* at Stations 1 and 2, this may be due to the root characteristic of *Avicennia marina* which has a pencil-like vertical root, while the *Rhizophora mucronata* has above ground root that has a larger structure and is harder than the *Avicennia marina* root.

The *Rhizophora mucronata* at Stations 1 and 2 had a higher carbon content value compared to the *Avicennia marina*. The result was in accordance with the research conducted by Rahmawati *et al.* [13] in the coastal area of Muara Gembong of Bekasi Regency, which used the method of allometric equation and measured the carbon content value of *Rhizophora mucronata* mangrove at 17.60 ton C/ha while it is 5.27 ton C/ha for the *Avicennia marina* type.
3.2. Carbondioxide Absorption

The amount of carbon content in a plant can illustrate how much the plant can absorb carbon dioxide (CO₂). The greater the carbon content in the plant, the greater the ability to absorb carbon dioxide (CO₂).

Table 3. Carbondioxide absorption.

| Types of Mangrove      | Station 1 Carbon Content | Station 2 Carbon Content |
|------------------------|--------------------------|--------------------------|
| Avicennia marina       | 67.49%                   | 247.70%                  |
| Rhizophora mucronata   | 93.43%                   | 342.87%                  |

The highest amount of CO₂ absorption measured was at 342.87 % in Rhizophora mucronata (Station 1), while the lowest was in Avicennia marina at Station 1 at 247.70 %. The ability of mangroves to absorb CO₂ depends on the carbon content in the trees.

The ability of Rhizophora mucronata to absorb CO₂ is higher than that of Avicennia marina. This was caused by the average value of the carbon content of the Rhizophora mucronata which is also higher. Density values and biomass content also influenced the mangrove's ability to absorb CO₂. This is in accordance with research by Heriyanto et. al. [9] which states that the Rhizophora mucronata can absorb carbon dioxide at 398.60 tons CO₂/ha in Alas Purwo National Park. Rhizophora sp. has a very important and potential role in carbon sequestration when compared to other types.

The content of the carbon store in vegetation depends on the amount of biomass contained in the tree. Plants absorb carbon from the air and converts it through photosynthetic processes where there are used for vertical and horizontal growth [12].

4. Conclusions

The highest carbon content was found in Rhizophora mucronata in Station 1 with the amount of 93.43% which is equivalent to 342.87 % CO₂ absorption. Meanwhile, the lowest carbon content was measured in Avicennia marina at Station 1 with the amount of 67.49 %, equivalent to 247.70 % absorption of CO₂. At Station 2 the carbon content of Rhizophora mucronata was found to be at 87.98 % and equivalent to 322.90 % absorption of CO₂ and also in Aveccinia arina at 76.86 % which is equivalent to 281.4 % absorption of CO₂.

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