Seagrass potency as blue carbon source in Galala and Tanjung Tiram waters, Ambon Island, Indonesia

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Abstract. Seagrass ecosystem is one of the important ecosystems in tropical coastal areas apart from mangrove and coral reefs. Seagrass has been considered recently as one of the potential carbon dioxide (CO_2) absorbent that significantly contribute to reduce CO_2 concentration in atmosphere in attempt to eliminate global climate change. This research is aimed to analyze the organic carbon (C-organic) content in seagrass bed at Galala and Tanjung Tiram waters of Ambon Island, Indonesia. C-organic content was analyzed at leaf, sheath, root and rhizome of each species found. Lost on Ignition (LOI) method was used to analyze organic carbon content. Result shows that seagrass of the species *Enhalus acoroides* found in Galala water has the highest organic carbon at rhizome amounted for 48.3%. Of all 4 species found in Tanjung Tiram,waters almost the highest organic carbon was found at rhizome of that species. Overall, it can be concluded that the highest percentage of organic carbon content in *E. acoroides* found in Galala waters was at below ground and the lowest percentage was at above ground. On the other hand, *E. acoroides* was having higher percentage of organic carbon content at above ground than that of *Halophila ovalis* in Tanjung Tiram waters. While at below ground the highest percentage organic carbon content was found at *Halodule uninervis* and the lowest at *H. ovalis*.
Key Words: blue carbon, C-organic, seagrass, rhizome.

Introduction. Increase in human population all together with their activities especially in coastal area will give an impact on ecosystem performance in this area. According to population number of Ambon City, Indonesia, population growth rate of Ambon city was 3.75 yr^{-1}, which is the highest one compared to other districts of Maluku Province (Centre Bureau of Statistics 2016). The higher the population growth rate will in turn increase ecological pressure on coastal area particularly in small islands like Ambon. Ecological pressure in coastal area contributes to decrease in biodiversity of three important tropical ecosystem *i.e.* seagrass, mangrove and coral. These three ecosystems support many organisms associate with it, some being of economic importance, that contributing to food security of the community. Some studies have shown an increase in human activities in coastal area of Ambon city which has little intention on sustainability theses ecosystems that lead to decrease in seagrass and mangrove ecosystem performance (Tuhumury 2008; Suyadi 2009; Siahainenia et al 2014).

Seagrass ecosystem is one of the important coastal ecosystems found in Maluku Province. Some ecological functions of seagrass ecosystem are nursery ground, feeding ground, and spawning ground of many organisms (Jackson et al 2001; Orth et al 2006; Unsworth et al 2014). Recent studies have shown that seagrass can absorb substantial carbon emission (Duarte et al 2005; Nellemann et al 2009; Kiswara 2010). Many scientists have discussed a way in reducing carbon emission and come up with the concept of blue carbon which stated that three marine ecosystems (mangrove, seagrass and salt marsh) have the ability to maintain absorption balance and decrease of carbon emission (Nellemann et al 2009).

Condition of seagrass bed in Ambon Bay has decreased tremendously which cause the ability of its function in absorbing carbon has also decreased. The only sea grass species found in Galala water nowadays is *Enhalus acoroides* from previously three species recorded in 1990 namely *E. acoroides*, *Thalassia hemprichii* and *Halophila ovalis* (Soselisa et al 2013). Loss of this ecosystem will also reduce the ability of this ecosystem in reducing carbon emission. In order to maintain this ecosystem as a source of carbon sink mechanism in reducing the effect of green house gasses, sustainability of this ecosystem has to be maintained. The objectives of this study are to explore and analyze the potency of C-organic of seagrass at Galala and Tanjung Tiram waters of Ambon Island, Indonesia.

Material and Method. The research was conducted on May 2016 at Galala and Tanjung Tiram waters of Ambon Island (Figure 1). Samples of seagrass leaf were directly collected during low tide. Organic carbon content analysis was performed to all seagrass species found. Two sites for each station were used as a replicate. Samples were than processed at Marine Science Laboratory of the Faculty of Fisheries and Marine Science, Pattimura University with the procedure as follows:

- samples were washed then dried with tissue paper;
- seagrass were than cut into pieces *i.e.* leaf, root, rhizome and sheath according to the study objective;
- each part was than separated, folded with aluminum foil and then oven dried at 100^oC for 16 hours;
- dried samples were then put inside the plastic bag, labeled for further analysis at Chemistry Laboratory of Soil Science Faculty of Bogor Agriculture University.

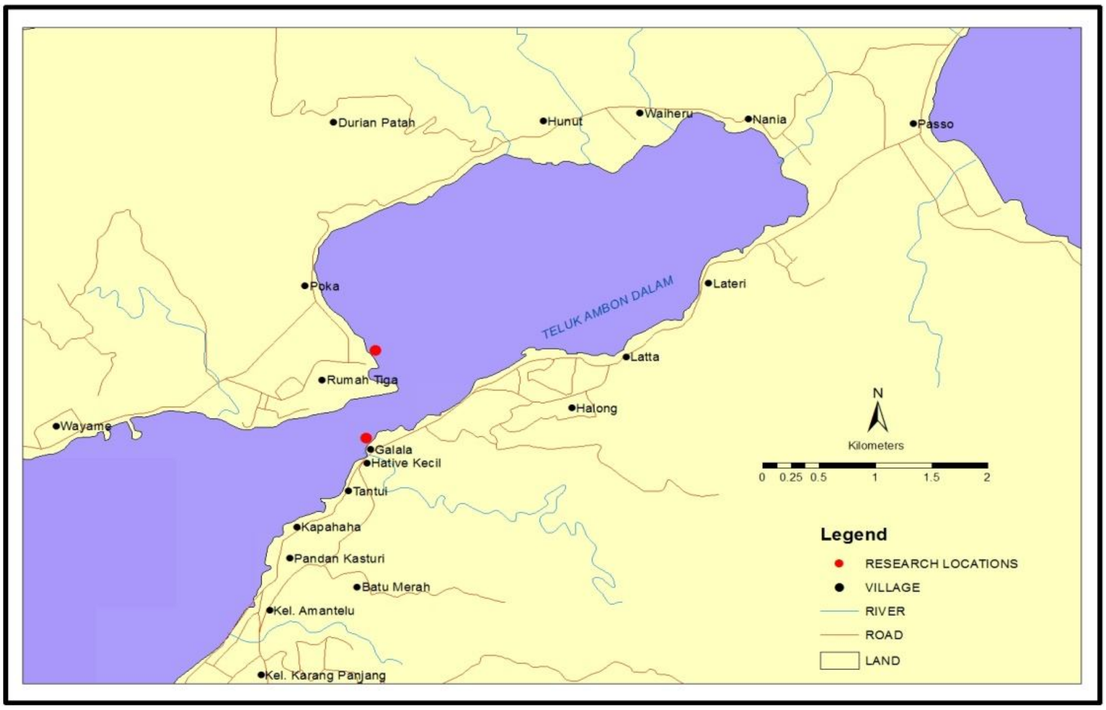

Figure 1. Map showing research location.

***Sample analysis**.* On arrival at Chemistry Laboratory in Bogor, samples were oven dried again for 24 hours using NAPCO Oven at 100^0C because of humidity during transportation. After oven dried, samples were then analyzed for carbon content at each part of the leaves using Lost on Ignition (LOI) method following the procedures below:

- weight the empty dish (g);
- put the sample into weighted dish then weight it again;
- samples were then oven dried at 105^oC for 24 hours;
- dried samples were then cooled down at desiccator then weighted again;
- samples were then transferred into furnish oven at 700^oC for 2 hours;
- after 2 hours, samples were then cooled down at desiccator then weighted again.

C-organic was analyzed following LOI method (Soil Research Center 2005) using the following formula:

$$\text{C-organic} = ((C-D/C)-A)/1.724) \times 100$$

where: A = weight of empty dish;
C = weight of dish after oven dried for 105^{o}C;
D = weight of dish after dried at 700^{o}C.

Results and Discussion

Organic carbon content in seagrass found at Galala waters. There was only one seagrass species, *E. acoroides,* found in Galala waters from previously three species in 1990. The organic carbon content found in this species was 48.3% at rhizome part and the lowest was found at sheath with the value of 35.1% (Figure 2). In total, carbon absorption was higher (89.1%) at lower part (root and rhizome) compared to upper part (leaf and sheath) with the value of 74.7%.

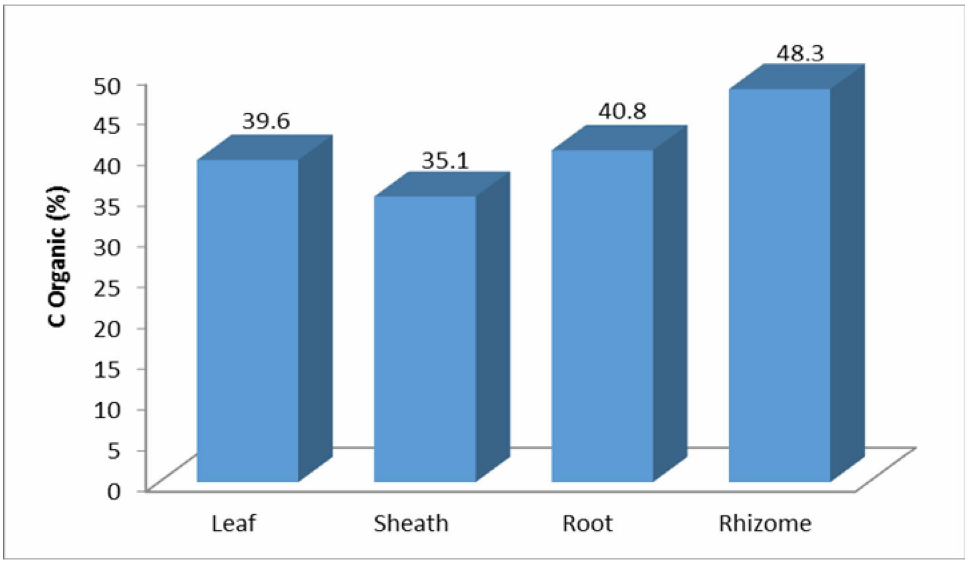

Figure 2. Percentage of organic carbon of *E. acoroides* found in Galala waters.

Theoretically, seagrass with high density will have higher organic carbon content and visa versa. Tuahatu et al (2015) found that *E. acoroides* density at Galala Waters with a value of 12.3 shoot m^{-2}. It is lower than the same species found at Waai and Lateri Waters with value of 27.9 shoot m^{-2} (Tuahatu et al 2016a). According to Decree Minister of Environmental number 200 (2004), percentage coverage of seagrass at Galala Waters is 11.25% and can be classified in the lack of abundance category (Table 1).

Table 1

Criteria for the seagrass coverage status

Condition	*Coverage*	
Abundant	High abudance / healthy	≥ 60%
Average dense	Average abundance / less healthy	30-59.9%
Damaged	Lack of abundance	≤ 29.9%

Source: Ministerial Decree of State Minister for The Environment No. 200, Year 2004

Low density and percent coverage found in Galala waters could be due to high human activities in this area which produce garbage, oil pollution from near harbor, ship yard, electrical power generator, high sedimentation from run off and bridge construction at that location. All these factors in turn cause degradation on seagrass bed nearby. Seagrass growth is highly influenced by condition of substrate where they live. High sedimentation increases water turbidity and lower light penetration which is essentially important for seagrass photosynthesis (Dahuri et al 2001). Physical structure of the bridge nearby will also create changes in sea water circulation and current pattern which will also have an effect on sea grass condition.

Carbon reserve stored in seagrass depends on organic carbon content and seagrass biomass. Seagrass biomass at Galala waters is the lowest one with a value of 324.16 gbk m^{-2} compared to some other parts Ambon Island (Waai, Tanjung Tiram an Lateri) which have 908.12 gbk m^{-2}, 731.26 gbk m^{-2} and 479.85 gbk m^{-2} respectively (Tuahatu et al 2015). Some studies have shown that carbon content of lower parts (rhizome and root) is higher than upper parts (leaf and sheath) (Rahmawati & Kiswara 2012; Duarte & Chiscano 1999). Decomposition process is faster at leaf and sheath part compared to rhizome and roots. Apart from that, upper part of seagrass is also consumed by some organisms in water, and this explains why the lower part has higher carbon content.

Organic carbon content in seagrass found at Tanjung Tiram waters. There are four species of seagrass found in Tanjung Tiram, namely *Enhalus acoroides*, *Halophila ovalis*, *Halodule uninervis* and *Thalassia hemprichii*. Organic carbon content found at *H. ovalis, H. uninervis* and *T. hemprichii* was higher at rhizome part compared with other parts whilst at *E. acoroides,* organic carbon content was higher at leaf part, even the difference is not significant enough compared to rhizome part.

Based on Tuahatu et al research (2015) at Tanjung Tiram waters, the higest biomass content for that four species are found at below ground. This can be seen from total biomass value from all four species with upper sediment total biomass amounted for 261.49 g m^{-2} (*H. uninervis* = 30.92 g m^{-2}; *T. hemprichii* = 62.30 g m^{-2}; *E. acoroides* = 154.71 g m^{-2} and *H. ovalis* = 13.56 g m^{-2}). Whereas below sediment total biomass is 469.77 gr m^{-2} (*H. uninervis* = 46.68 g m^{-2}; *T. hemprichii* = 101.44 g m^{-2}; *E. acoroides* = 311.42 g m^{-2}; and *H. ovalis* = 10.23 g m^{-2}). In comparison, above ground total biomass from Galala waters with only one species, *E. acoroides*, amounted for 130.45 g m^{-2} comes from leaf biomass (91.78 g m^{-2}) and sheath biomass (38.67 g m^{-2}), whilst total biomass of below ground amounted for 193.71 g m^{-2} (root biomass = 53.40 g m^{-2} and rhizome biomass = 140.31 g m^{-2}) (Figure 3).

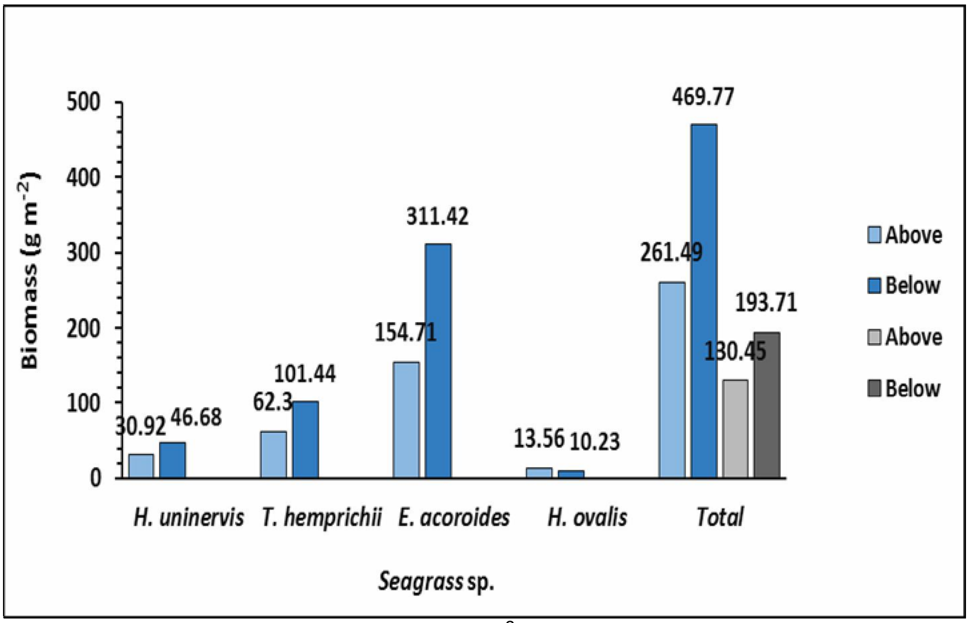

Figure 3. Percentage biomass content (g m^{-2}) found at seagrass from Tanjung Tiram waters (light and dark blue) and from Galala waters (light and dark grey).

Based on this study, the highest percentage of carbon content was found at rhizome of *H. uninervis* with the value of 50.5% and the lowest percentage at root on the species

H.ovalis with value of 11% (Figure 4). *H. uninervis* at Tanjung Tiram was found at highest density which is supported by good habitat substrate composed of sandy mud, fine sand, sandy mix with pebble, and broken coral (Tuahatu et al 2015). *H. universis* was small in its morphological structure compare to *E. acoroides,* but high in organic carbon content. This was also evident by organic carbon content of the same species found at Waai waters which has 50.7% organic carbon content (Tuahatu et al 2016b). This shows that *H. universis* has a potency as blue carbon source which can absorb and keep carbon particularly at below ground.

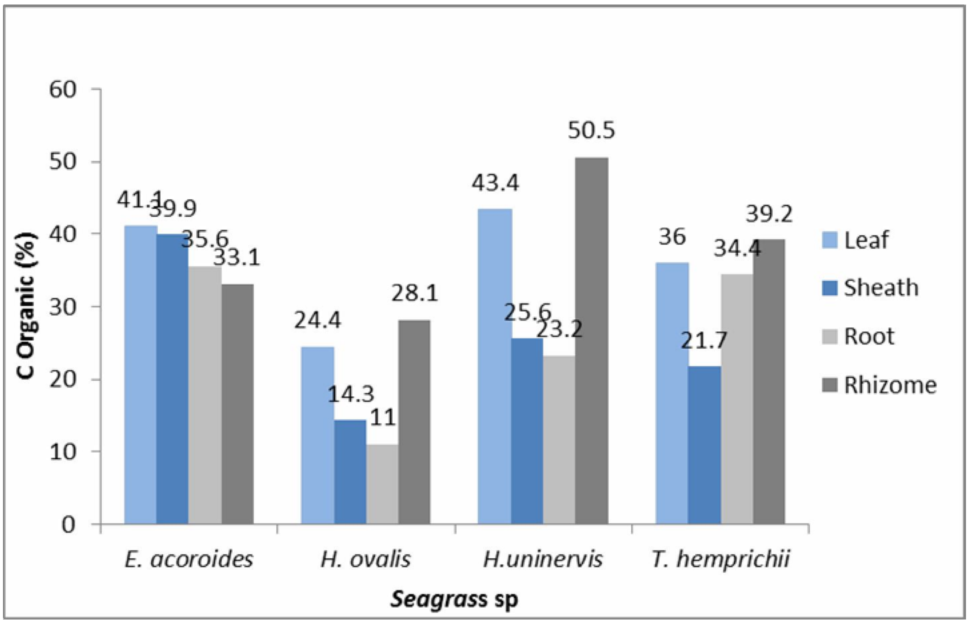

Figure 4. Percentage of organic carbon content found at seagrass of Tanjung Tiram waters.

The higest organic carbon content of *E. acoroides* was found at above ground (81%) and the lowest at below ground (68.7%). Compared to all different species, amount of organic content as a whole at all parts of *E. acoroides* has the highest value. This explains that this species has the potency to absorb and store carbon since this species is morphologically larger than other species and has high biomass as well, therefore this species can be a blue carbon source (Graha et al 2016). It can be described that there are several factors that make *E. acoroides* having a significant role as a blue carbon source *i.e.* firstly, this species is morphologically larger compared to other species hence it can accumulated more carbon in its tissues; secondly, the biomass is higher than other species. Biomass per transect of *E. acoroides* ranged from 93-235 gC m^{-2} whilst for other species the value ranged between 26-153 gC m^{-2}; thirdly, this species is widely distributed with percent of occurrence of 46%. Based on above mentioned study, as well as this current study, it can be concluded that *E. acoroides* has a potency to become a blue carbon source. Seagrass bed at Tanjung Tiram waters can be classified to abundant condition, because several species are found in this area with percent coverage is 64.99% (Tuahatu et al 2015). According to Decree Minister of Environmental number 200 (2004), this percentage coverage of seagrass at Tanjung Tiram waters belongs to healthy status.

Considering the importance of seagrass as climate change mitigation program through its mechanism in absorbing CO_2 for photosynthesis, the existence of seagrass in Maluku therefore should be kept in sustainable condition. In that case seagrass bed condition should be restored and make protection zone in Ambon Bay in order to protect seagrass ecosystem.

Conclusions. Organic carbon content at Galala waters was found in *E. acoroides* with highest percentage at below ground and the lowest at above ground. Tanjung Tiram waters has different condition of organic carbon content compared to Galala waters.

Above ground at *E. acoroides* has the highest percentage of organic carbon content and the lowest at *H. ovalis*, while at below ground the highest percentage of organic carbon content was found at *H. uninervis* and the lowest at *H.ovalis.*

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