**Soil Carbon Storage in Different Species Dominance of Sarawak Mangrove Forest, Malaysia**

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*Abstract:* Soil carbon contain almost 75% of carbon pool on land which is three times higher than the number of carbon stored in living plants and animal. Carbon storage in forest ecosystems involves inordinate components including plant biomass carbon and soil carbon that can indicate the current status and determined the characteristics of mangrove forest. In the last decade, strong evidence about significant differences among mangrove soils due to the presence of different mangrove species has been arise. Soils of Awat-Awat mangrove forest were collected in 10 different plots with different species dominance using a peat auger at dept of 0-50 cm. The samples were weighted on green weight and after oven drying. The total carbon content of oven-dried soil samples were then analyzed using CHNS analyzer (TruSpec Micro Elemental Analyzer (NCHS), LECO, USA. Soil carbon content of Awat-Awat mangrove forest varied in each plot. The different of species dominance gave different range of results of carbon content. The highest soil carbon content in Awat-Awat mangrove forest was found in soil under dominance of *Rhizophora mucronata* with 6.24% whereas the lowest one was found 1.73% in soil under dominance of *Sonneratia alba*.

*Keywords:* *soil carbon storage, soil carbon, species dominance, mangrove forest.*

**INTRODUCTION**

Carbon is the one of the primary sources of life on earth. It is found in all living organism and available in many forms, majority as tree biomass, soil organic matter and as gasses (CO2) in the atmosphere. Carbon is also the major component of soil organic matter, but its content can vary from 48 to 60% or more of the weight of soil organic matter (Tan, 2005). Carbon storage in forest ecosystems involves inordinate components including biomass carbon and soil carbon (Lal, 2005). Along with soil properties such as soil chemical properties, it can indicate the current status and determined the characteristics of tested mangroves soil. In addition, soil carbon contain approximately 75% of the carbon pool on land and it is three times more than the number of carbon stored in living plants and animal (Lal, 2005).

Sequestration of carbon along with other aggressive conservation efforts helps to mitigate the increasing ne

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gative impact of global warming on the environment and mangroves as the coastal forest. Sequestration of carbon also play an substantial role in global carbon cycling because they store a large stock of carbon as well as potential carbon sinks and sources to the atmosphere (Muukonen and Heiskanen, 2007). Furthermore, in the last decade, strong evidence about significant differences among mangrove soils due to the presence of different mangrove species has been arise. Difference between soil conditions of mangroves can also result from differences in the composition of initial organic inputs from mangrove litter (Lacerda *et al.,* 1994). The main objective of this study was to assess the soil carbon storage in difference species dominanceof Awat-Awat mangrove forest, Sarawak, Malaysia.

**MATERIALS AND METHODS**

![E:\UNIVERSITI PUTRA MALAYSIA\[2013] Philosophy Doctoral\species diversity map.jpg]()

**0 2.5km**

**N**

Figure 1: Location of study of Awat-Awat mangrove forest in Lawas, Sarawak, Malaysia.

This study was located in Awat-Awat mangrove forest, Lawas Sarawak, Malaysia, 4º56’N, 115º14’E (Figure 1). Nine plots were established in each area based on different dominance species. Moreover, *Rhizophora apiculata* Blume is the main species of Awat-Awat mangrove forest, Lawas, Sarawak, Malaysia (Chandra *et, al.,* 2010). Soil sampling was done in November 2012. Soil samples were collected randomly in every plot using a peat auger at a depth of 0 to 50 cm and a total of 32 samples were collected during this study period.

Table 1 Dominant species of each plot in Awat-Awat mangrove forest, Lawas, Sarawak, Malaysia.

|  |  |  |
| --- | --- | --- |
| Plot | Dominant species | Local name |
| 1 | *Rhizophora apiculata* | Bakau minyak |
| 2 | *Lumnitzera racemosa* |  Nggeriting putih |
| 3 | *Nypa fruticans* | Nipah/Apung |
| 4 | *L. littorea* | Nggeriting merah |
| 5 | *Xylocarpus granatum* | Nyireh bunga |
| 6 | *R. mucronata* | Bakau kurap |
| 7 | *Bruguiera parviflora* | Lenggadai |
| 8 | *Sonneratia alba* | Perepat |
| 9 | *S. caseolaris* | Pedada |

To prevent and to minimize sample contamination, soil samples collection were placed into closed labeled plastic bag and put into box case at low temperature during transportation. These samples then were air died at room temperature, grinded and sieved with 0.05 mm for further analysis. Soil pH from each plot was determined use the potentiometric method of Tan (2005). The total C content of soil samples was analyzed using CHNS analyzer (TruSpec Micro Elemental Analyzer (NCHS), LECO, USA). Analysis of variance (ANOVA) test at P≤0.05 was used to check the variance of pH and carbon content among the plots and Duncan’s multiple range test (DMRT) were used to show and specify the difference among them.

**RESULTS AND DISCUSSION**

Soil pH of in every plot of Awat-Awat mangrove forest were acidic with range of 3.93 to 5.41 (Table 2). The most acidic one was found 3.93 in plot 6 soil under *R. mucronata* dominance. Average pH value in Awat-Awat mangrove forest were lower compared to other research areas that were done by other researchers but still in the comparable values (Table 3). Generally, soils of mangrove are neutral to slightly acidic due the sulphur-reducing bacteria and the presence of acidic clays, but in Malaysia there are mangroves with very acidic brackish waters due to the aeration of soil sulphates, forming sulphuric acid (Peter and Sivasothi, 2001).

According to Duncan’s multiple range test (DMRT), there were 4 grouping of soil pH among 9 plots that were significantly different among each other. It were plot 8 and 9; plot 7 and 9; plot 1,2,3,4,5 and 7; plot 1, 5 and 6. Soil pH in the plot with same group was not significantly different among each other (Table 2).

Soil carbon content of Awat-Awat mangrove forest was vary, ranged from 1.73% to 6.24% with average mean was 3.29%. The highest soil carbon content in Awat-Awat mangrove forest was found 6.24% in soil under dominance of *R. mucronata* (plot 6) whereas the lowest soil carbon content was found 1.73% in soil under dominance of *S. alba*. According to DMRT test, there were 5 grouping of soil carbon content which were significantly different among each other whereas soil carbon content with same group was not significantly different (Table 2).

Table 2. Mean of pH and soil carbon content of Awat-Awat mangrove forest at Lawas, Sarawak, Malaysia.

|  |  |  |  |
| --- | --- | --- | --- |
| Plot | Species dominance | pH | C Content (%) |
| 1 | *Rhizophora apiculata* | 4.20 cd | 2.72 cde |
| 2 | *Lumnitzera racemosa* | 4.65 c | 3.62 bcd |
| 3 | *Nypa fruticans* | 4.61 c | 4.08 bc |
| 4 | *L. littorea* | 4.68 c | 2.22 de |
| 5 | *Xylocarpus granatum* | 4.19 cd | 2.30 de |
| 6 | *R. mucronata* | 3.93 d | 6.24 a |
| 7 | *Bruguiera parviflora* | 4.76 bc | 4.60 b |
| 8 | *Sonneratia alba* | 5.41 a | 1.73 e |
| 9 | *S. caseolaris* | 5.24 ab | 2.08 de |

\*Mean with same letter for each variable are not significantly different at P≤0.05 using ANOVA, Duncan’s multiple range test was used to check the differences among the station.

Soil carbon studies of mangrove have been done in many place of the world with many different site characteristics. In present study, carbon content of soil under dominance of *R. apiculata* in Awat-Awat mangrove forest was comparatively same with carbon content in soil under *R. mangle* in Sepetiba Bay, Brazil (Lacerda *et. al.,* 1995). Furthermore, the soil carbon content of Awat-Awat mangrove forest was comparable with the values recorded in elsewhere (Table 3).

Studies revealed that the soil carbon content is different and varies from one place to another. Different species dominance gave different result of soil carbon content. Moreover, Lacerda *et al.* (1995) were also noted for an accumulation of strong evidence for significant differences among mangrove soils due to the presence of different mangrove species in the last decade.

Table 3 Comparison of the found results for C content and pH values of mangroves with other studies

|  |  |  |  |
| --- | --- | --- | --- |
| Author | Site Characteristics | C Content (%) | Average pH  |
| Sukardjo (1994) | Mangrove forest of the Apar Nature Reserve, East Kalimantan, Indonesia. With species of *Avicennia* and *Ceriops*. | 3.96% (*Avicennia* forest)11.40% (*Ceriops* forest) | 4.35 to 5.29 (Avicennia),3.70 to 4.20(Ceriops) |
| Lacerda *et. al.* (1995) | Itacuruca Experimental Forest, Sepetiba Bay, Brazil | 2.70% - 2.80% (under *Rhizophora mangle)* and 3.80% - 6.10% (under *Avicennia schaueriana)* | - |
| Shazra *et. al.* (2008) | Mangrove forest of HA. Baarah, Maldives. With species *R. mucronata* and *Hibiscus tiliacius* | 0.196% and 0.017% | 6.0 (*R. mucronata*),6.5 (*H. tiliacius)* |
| Wakushima *et al.* (1994)a | Mangrove forest of Amphur Laemngop, Thailand. With species of *R. apiculata R. mucronata. C. tagal, Excoecaria agallocha,* and *Lumnitzera racemosa*. | - | 4.27±0.05 to 7.32±0.09 |
| Wakushima *et al.* (1994)b | Mangrove forest of southern Japan. With species of *R. stylosa.* | - | 3.31 to 8.16 |
| Ukpong (1995) | Mangrove swamp of southeastern Nigeria. With species of *Rhizhophora spp* and *Nypa fruticans.* | - | 2.9 to 3.8 |
| Mahmood H. (2005) | Mangrove forest of Kuala Selangor, Malaysia. With species of *Bruguiera parviflora* | - | 6.77±0.05 to 7.07±0.04 |
| Muhibbullah *et al.,* (2005) | Sundarband mangrove forest, Bangladesh. With various species. | - | 6.3 to 7.13 |
| Rambok *et al.* (2010) | Wildlife sanctuary mangrove forest, Sibuti, Malaysia. With species of *R. apiculata*. | 12.18% | 3.34 |
| Present study | Awat-Awat mangrove forest, Malaysia. With species of *R. apiculata* | 1.73% – 6.24% | 3.93 to 5.41 |

**CONCLUSION**

Soil acidity of Awat-Awat mangrove forest was acidic and varies in each species dominance. The most acidic pH in Awat-Awat mangrove forest was found 3.93 in soil under dominance of *R. mucronata*. According to ANOVA test at P≤0.05, pH in different species dominance of Awat-Awat mangrove forest were significantly different.

Soil carbon content of Awat-Awat mangrove forest was varies in each species dominance. The highest soil carbon content was found 6.24% in soil under dominance of *R. mucronata* whereas the lowest soil carbon content was found 1.73% in soil under dominance of *S. alba*. The difference of species dominance in Awat-Awat mangrove forest gave the different result of pH and soil carbon content.

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