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Research Article

Estimation of Soil Carbon Stocks in Mangrove Forest of Chaung Tha Coastal Area, Myanmar

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Abstract
This study aims to assess the soil organic carbon stock and physiochemical properties in the mangrove forests of the Chaung Tha coastal area, Ayeyarwady Region in Myanmar. A total of 3 species of mangroves: *Rhizophora apiculata*, *Bruguiera gymnorhiza*, and *Ceriops tagal* were commonly found distributed in the study area and *Rhizophora apiculata* was the dominant species. The average dry bulk density (DBD) of U-to and Kanyinkwin was 0.7 g/cm^3 and 0.8 kg/m^3 in Kanyinkwin. Dry bulk density was negatively correlated with soil organic matter (%C). Soil organic carbon content was 65.6 kg/m^3 in U-to, 57.9 kg/m^3 in Kanyinkwin and 67.8 kg/m^3 in Kan Gyi. The soil texture of the mangrove forest in U-to, Kanyinkwin, and Kan Gyi were silt and silt loam. These research findings reinforce the importance of mangrove forests as useful carbon sinks and climate change mitigation.

Keywords
Dry bulk density, mangrove, soil organic carbon stock

1. Introduction

Mangrove ecosystems are unique habitats formed by plants and organisms that must survive changing salinities, extreme tides, and muddy soils. Mangrove areas of Myanmar rank about 8th in the world and 3rd in Southeast Asian regions. Of these mangroves, 46% are included in Ayeyarwady, 37% in Tanintharyi, and 17% in Rakhine (Spalding et al., 2010).

Another function of mangroves is their role in carbon (C) sequestration and storage. Carbon storage is one of the most important environmental services provided by mangrove forests. Indeed, the carbon sequestration in mangrove forests is strong and sustainable in above-ground and below-ground carbon sinks. It is reported that annual carbon sequestration in coastal mangrove forests is much higher than in tropical forests (Nguyen et al., 2021).

Donato et al. (2011) reported mangrove forests are three to five times more effective in storing carbon compared to other types of forest, and almost 70% to 90% of it was stored in the soil. Mangroves annually sequester two to four times more carbon compared to mature tropical forests and store three to four times more carbon per equivalent area than tropic forests (Giri, 2016).

The coastal vegetation and soil are recognized as one of the largest terrestrial pools of sequestrated carbon (C) per unit area, popularly known as the “blue carbon”. Variation of organic carbon in the sediment results from changes in deposition from multiple sources and the decomposition of organic matter by microbes (Kusumaningtyasa et al., 2019). An admixture of allochthonous sediment input by the river might cause lower concentrations at the surface. Mangroves have the greatest carbon stock among the blue carbon ecosystems (Cleyndert et al., 2020).

This research is intended: 1) to estimate the carbon stock stored in the mangrove forests, 2) to quantify the organic carbon content of soil samples, 3) to determine the distribution and community structure of the mangrove ecosystem, 4) to know the type of mangrove soil in the study areas, and 5) to provide policy maker with carbon stock information for climate change mitigation and adaptation activities.

2. Materials and Methods

2.1. Study Area

This research was conducted in the mangrove forests of U-to, Kanyinkwin, and Kan Gyi in the Chaung Tha coastal area, starting from November 2022 to September 2023. There are 15 plots in U-to, 12 plots in Kanyinkwin, and 13 plots in Kan Gyi (Fig. 1).

2.2. Sampling Design

Soil samples were carried out randomly from 3 stations (U-to, Kanyinkwin, Kan Gyi) in the mangrove forest along the tidal creeks at the neap tide period. Soil samples were collected from the surface layer to 1 m depth with the soil core sampler under the three dominant species of mangroves, *Rhizophora sp*, *Bruguier sp,* and *Ceriops sp*. The mouth of the diameter of the soil core sampler is 4.5 cm. The core was immediately sectioned into three pieces, each 1 ft (33.33 cm) long. The cutting soil samples were put into the container, stored in a cool place, and transported to the laboratory of the Marine Science Department of Pathein University.

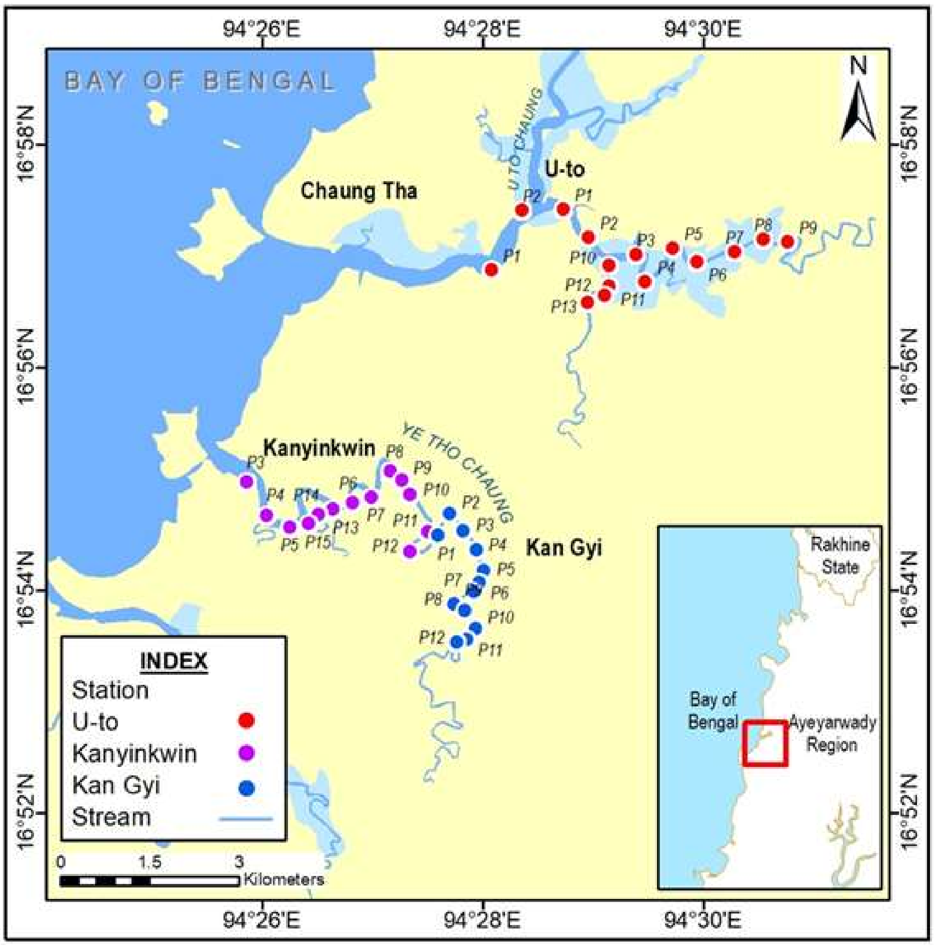

Fig. 1. Geographical coordinates of the random sampling plots in U-to, Kanyinkwin, and Kan Gyi

2.3. Assessment of Soil Organic Carbon Content

To determine the organic carbon content, soil samples were extracted from the surface layer of the soil to a depth of 90 cm by using the core sampler from each selected plot and then analyzed indirectly by the method of loss on ignition (LOI), also called the furnace method (Bojko and Kabala, 2014).

*Organic Matter Content (%LOI) = [(DW1-DW2)/DW1] *100* (Howard et al., 2014) (1)

where; DW1 = dry mass before combustion (g) and DW2 = dry mass after combustion (g).

The relationship between %LOI and $\%C_{org}$ for mangroves is

$\%C_{org} = 0.415 * \%LOI + 2.89$ (Kauffman et al., 2011) (2)

Dry bulk density is determined by using the following equation:

$$\text{Dry bulk density } (gcm^{-3}) = \frac{\text{Mass of dry soil } (80°C)}{\text{Original volume sampled } (cm3)} \quad (3)$$

3. Results

3.1. Assessment of Soil Organic Carbon Content

The dry bulk density resulted in U-to range from 0.46 g/cm^3 (plot 14) to 0.89 g/cm^3 (plot 4). In Kanyinkwin, the highest value of DBD varied from 0.57 g/cm^3 (plot 3) to 1.00 g/cm^3 (plot 12). The highest value of DBD was 0.8 g/cm^3 (plot 9) and the lowest value was 0.57 g/cm^3 (plot 1) in Kan Gyi. The total average DBD in plots was 0.7 ± 0.1 g/cm^3 in U-to, 0.8 ± 0.14 g/cm^3 in Kanyinkwin and 0.7 ± 0.06 g/cm^3 in Kan Gyi (Fig. 2).

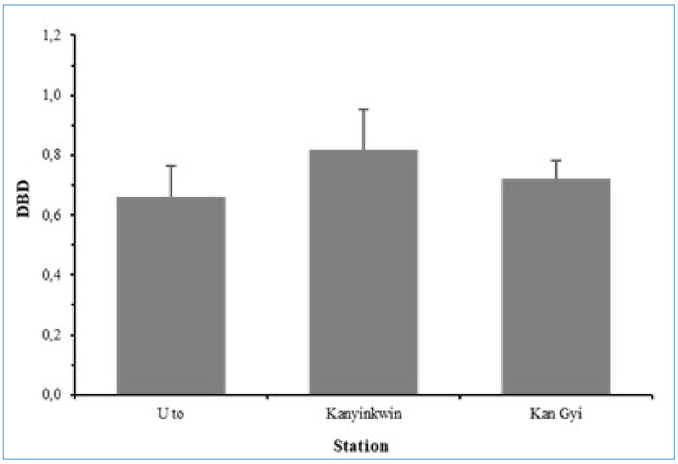

Fig. 2. Mean dry bulk density of U-to, Kanyinkwin, and Kan Gyi in plots

The resulting value of soil organic matter (%C) in U-to ranges from 7.35 %C (plot 4) to 16.85 %C (plot 1). The value of soil organic matter (%C) calculated from 10.05 %C in (plot 2) was the highest and 5.68 %C (plot 8) was the lowest of Kanyinkwin. The value of soil organic matter (%C) of Kan Gyi varied from 7.57 %C (plot 11) to 11.03 %C (plot 5). The total average soil organic matter was 1037 ± 3.01 %C in U-to, 7.3 ± 1.54 %C in Kanyinkwin, and 9.4 ± 1.24 %C in Kan Gyi (Fig. 3).

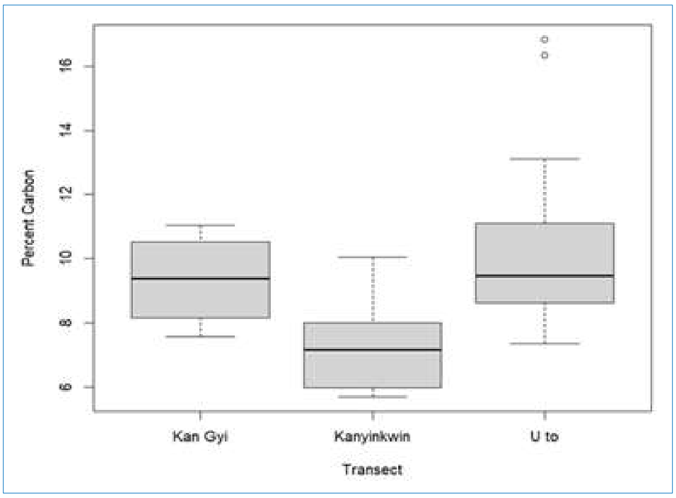

Fig. 3. Soil organic matter (%C) of U-to, Kanyinkwin, and Kan Gyi in plots

The soil organic matter (%C) of U-to, Kanyinkwin, and Kan Gyi were negatively correlated with dry bulk density with an 'r' value of -0.65. The higher %C in the soil resulted in the lower dry bulk density (Fig. 4).

The soil organic carbon varied from 42.66 kg/m^3 in plot 6 to 104.79 kg/m^3 in plot 2 along the 15 plots in U-to. The soil organic carbon along the 12 plots in Kanyinkwin fluctuated from 47.5 kg/m^3 in plot 3 to 69.91 kg/m^3 in plot 1. The soil organic carbon along the plots (13 plots) in Kan Gyi ranged between 51.56 kg/m^3 in plot 11 and 88.05 kg/m^3 in plot 5. The total soil organic carbon of the three stations in plots was 65.6 ± 15.5 kg/m^3 in U-to, 57.9 ± 5.98 kg/m^3 in Kanyinkwin, and 67.8 ± 11.5 kg/m^3 (Fig. 5).

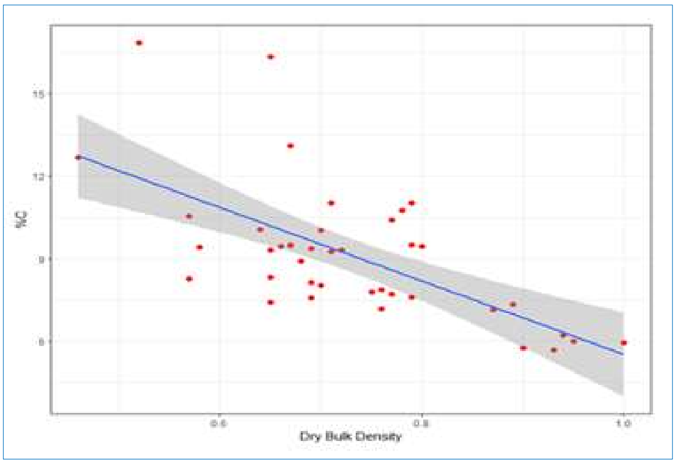

Fig. 4. Relationship between dry bulk density and soil organic matter (%C) of U-to (U) and Kanyinkwin (KK)

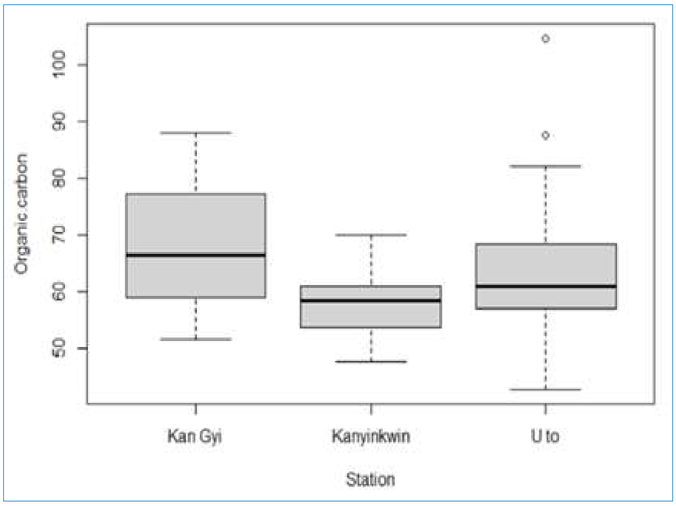

Fig. 5. Soil organic carbon of U-to, Kanyinkwin and Kan Gyi in plots

4. Discussion

The estimation and calculation of DBD and soil organic carbon content were carried out in the mangrove forests of U-to, Kanyinkwin, and Kan Gyi, Chaung Tha Coastal Area. The average value of DBD was 0.7 g/cm^3 (U-to, Kan Gyi) and 0.8 g/cm^3 (Kanyinkwin). The mean soil DBD observed from the present study area was lower than that of the value of mangrove soil DBD in the Sepala mangrove forest, Bilu Island, Mon coastal area (Lin, 2022). Gnanamoorthy et al. (2019) stated that bulk density is an indicator of soil compaction. The higher bulk density can indicate low soil porosity and soil compaction.

The resulting value of average soil organic matter (9.04%) along the plots of the Chaung Tha coastal area was much higher than that reported by Haymarn (2020) in Shwe Thaung Yan Coastal Area, Myanmar. The distribution and dynamic of the soil organic carbon content may differ due to the influence of tide, vegetation biomass, productivity, species composition, and sedimentation (Sherman et al., 2003).

Soil bulk density could affect soil structure and carbon accumulation. The relationship between soil organic matter and bulk density can be used to estimate the soil carbon pool. In the present study, a negative correlation was found between bulk density and soil organic matter in U-to, Kan Gyi, and Kanyinkwin. A similar result was reported by Aung et al. (2023) from Shwe Thaung Yan Coastal Region.

The main source of soil organic carbon (SOC) for soil is litter production and dead wood debris from the plant. The decomposition and decaying of the organic material by the bacteria would increase the accumulation of organic matter in the soil sediment (Forrester et al., 2013). Soil organic carbon in mangrove soil varies greatly because of the influence of tidal gradient, forest age, biomass productivity, species composition, sedimentation of suspended matter, rapid water circulation, and decomposition of organic matter by microbes (Kusumaningtyasa et al., 2019).

Mangroves with high biomass will produce a high number of litters so that a higher amount of carbon will be stored in the sediment. The increase of carbon soil with depth indicates the predominance of autochthonous mangrove organic matter in the sediments. Low carbon soil value occurred in areas frequently flushed by tides and are exposed to frequent changes in hydrology, and sedimentology, and were directly struck by tropical storms, which inhibited the accumulation of organic matter (Adame et al., 2015).

5. Conclusion

Concerning the estimation of soil organic carbon stocks in the mangrove forests of the Chaung Tha coastal area. It would be suggested that the mangrove forest of the present study areas is currently in healthy condition of storing vast amounts of atmospheric carbon. Based on the calculated values of soil organic carbon content, the mangrove forest of the Chaung Tha coastal area showed a high potential for carbon sequestration in soil. Thus, the protection from deforestation, conservation, and sustainable management activities for mangroves are the most effective ways to mitigate and prevent the negative impact of climate change. The present study will serve as baseline information for further research as well as the basis for proposing the application of carbon credits.

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