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Climate Smart Approaches to Enhance Carbon Sequestration in the Coastal Ecosystems of Bangladesh

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Abstract

A study was conducted in the coastal ecosystems of Bangladesh regarding climate smart approaches to assess soil organic carbon (SOC) stock and their sequestration in the mangrove and salt marsh habitats. Fifty soil samples of 10 soil profiles up to 1 m soil depths were collected. Bulk density and SOC level are the two prerequisites for estimating SOC stock. SOC stock was estimated following standard methodology. In the salt marsh sites, SOC ranged from 13.1 to 45.7 g/kg with a mean value of 27.5 g/kg. In the mangrove sites, SOC varied from 14.1 to 46.3 g/kg with a mean value 26.4 g/kg. The study revealed that both of these ecosystems sequester more carbon than the threshold level (20.0 g/kg). The analytical results also revealed that mangrove and salt marsh ecosystems store and sequester 57.68 kg/m^2 and 83.78 kg/m^2 in the above-ground and 100.56 kg/m^2 and 121.11 kg/m^2, respectively in the below-ground compartments. So, deeper soil horizons sequester more carbon than the subsoil horizons. It is suggested to make a management policy to restore the carbon in the mangrove and salt marsh habitats.

Introduction

The coastal region of Bangladesh covers 710 kilometer coastline covering three distinct geographical parts: western, central and eastern. This lies between 21˚30′ to 22˚30′ north latitudes and 88˚01′ to 92˚00′ east longitudes. It comprises the most active portion of Ganges-Brahmaputra-Meghna River system in Bangladesh. Scientists reported that about 2.4 billion tons/year sediments flows in the Bay of Bengal through the major River channels (Coleman 1969; Anwar 1989). As a result, erosion and accretion games are common phenomenon in the coastal regions and coast line movement towards the Bay of Bengal (Uddin *et al.* 2019). The impact of climate change aggravates the situation of sediment transportation and deposition in a serious turn. To mitigate climate change and enhance blue economy, soil carbon sequestration strategies are getting priority in developing and formulating delta plan 2100. Knowledge of SOC dynamics in deeper soil profiles is essential to understand the SOC sequestration rate (Simo *et al.* 2019). For this reason, a study was initiated to understand how climate smart approaches can enhance carbon sequestration to tackle natural calamities. It is thus important to conserve mangrove forest, sea grass, and the saltmarsh ecosystems etc. to reduce atmospheric CO_2 and mitigate global climate change. It is evident that coastal vegetation sequesters carbon far more effectively and permanently than the terrestrial ecosystem which is often referred to as 'blue carbon' (Howard *et al.* 2014). Authors have noticed the potentials of carbon storage in coastal ecosystems (Hopkinson *et al.* 2012) that covers only 2.5% of total land surface of the world, but their net global carbon storage is estimated to be 25 Pg (Duarte *et al*. 2013). It was estimated that carbon accumulation rate per unit area is 30–50 times higher in coastal wetlands than that of terrestrial forest ecosystems (Ouyang and Lee 2013), highlighting their importance with respect to the global carbon cycle. Chmura *et al.* (2003) reported an annual carbon sequestration rate of ~ 44.6Tg C for soils of mangroves and salt marshes habitats.

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Materials and Methods

Total 50 soil samples from 10 soil profiles at different soil depths up to 100 cm (0-20cm, 20-40cm, 40-60cm, 60-80cm, 80-100cm) were collected covering the mangrove and salt marsh coastal eco-zones of Bangladesh. During soil sampling, soil bulk density for the individual depths were measured which were used in the estimation of SOC dynamics and stocks. The collected soil samples were processed and preserved in plastic bottles for subsequent laboratory analysis.

Soil organic carbon was determined by the wet oxidation method of Walkley and Black (1934) as described by Nelson and Sommers (1982). Bulk density was measured by core method as described by Blake and Hartge (1986). The total soil organic carbon (TSOC) stock or storage was calculated using the equations of Batjes (1996), Chen et al. (2007), Zhang et al. (2013). It may be noted that the bulk density and SOC contens are the two prerequisites for estimating SOC stock or storage. Thus, the soil organic carbon storage was calculated using the following equations:

$$\text{Soil Organic Carbon (TSOC)} = SOC_i \times B_i \times D_i$$

Where, $SOCi$ is the SOC content on the i^{th} layer (g/kg);

B_i is the bulk density of the i^{th} layer (g/cc), and D_i is the depth of the i^{th} layer (cm).

At first, the area of the mangrove and salt marsh eco-zones were visually delineated using the International Union for the Conservation of Nature (IUCN) resources map and the shape files were extracted and digitized in Google Earth Pro. Secondly, the shape files were geo-referenced, projected and subsequently the areas were calculated using the respective polygon attribute tables (PAT) in ARC/GIS 10.3.

Results

In the salt marsh sites, SOC ranged from 13.1 to 45.7 g/kg with a mean value of 27.5 g/kg (Table 1). On the other hand, SOC storage in the salt marsh sites ranged from 19.01 to 61.53 kg/m^2 with a mean value of 41.53 kg/ m^2.

Table 1: Soil Organic Carbon (SOC) Storage (kg/m^2) in the Salt Marsh Sites at 100 cm Depths in the Coastal Areas of Bangladesh

Salt Marsh Sites	Geo-Coordinates & Elevation (m)	SOC (g/kg)	Areas (ha)	SOC storage (kg/ m^2)
Char Kukri Mukri, Bhola	21˚ 55′ 51.5″ N; 90˚ 40′ 062″ E E= -1m	19.8	272	30.77
Reju Khal, Cox's Bazar	21˚ 17′ 52.2″ N; 92˚ 03′ 16.1″ E E= -2m	13.1	239`	19.01
Bakkhali Estuary -1	21˚ 28′ 16.68″ N; 91˚ 58′ 21 88″E E= 2 m	27.2	106	42.92
Bakkhali Estuary -2	21˚ 28′ 54.01″ N; 91˚ 58′ 44.59″ E E= 5 m	31.9	108	50.70
Rangi Khali Khal, Teknaf, Cox's Bazar	21˚ 00′ 11.6″ N; 92˚ 15′ 48.6″ E E= 8 m	45.7	281	61.53
Mean SOC	-	27.5 g/kg	1006	41.53

In the mangrove sites, soil organic carbon (SOC) varied from 14.1 to 46.3 g/kg with a mean value 26.4 percent (Table 2). On the other hand, SOC storage varied from 18.85 to 46.76 Kg/m^2 with a mean value of 31.64 kg/ m^2.

Table 2: Soil Organic Carbon (SOC) Storage (kg/m^2) in the Mangrove Sites at 100 cm Depths in Coastal Areas of Bangladesh

Mangrove Sites	Geo-Coordinates & Elevation (m)	SOC (g/kg)	Areas (ha)	SOC storage (kg/m^2)
Munshiganj, Shyamnagar, Satkhira	22˚ 15′ 85.8″ N; 89˚ 11′ 69.4″ E E= 7 m	18.4	8,000	24.46
Magurkhali, Dumuria, Satkhira	22˚ 41′ 69.8″ N; 89˚ 21′ 59.4″ E E= 5 m	46.3	19	38.76
Char Kukri Mukri, Bhola	21˚ 55′ 67.6″ N; 90˚ 39′ 54.3″ E E= 8m	14.1	2763	18.85
Reju Khal, Cox's Bazar	21˚ 17′ 62.4″ N; 92˚ 03′ 17.2″ E E= -2m	20.0	376	29.41
Boroitoli, Teknaf, Cox's Bazar	20˚ 53′ 29.3″ N; 92˚ 17′ 44.7″ E E= 9m	33.6	535	46.76
Mean SOC	-	26.4 g/kg	11,693	31.64

From the above datasets, it was found that salt marsh sites sequester more SOC than the mangrove sites.

Discussion

The above study revealed that the spatial variability of soil organic carbon (SOC) differs depending on the local hydro morphological conditions where salt marsh habitat carries diverse vegetation with higher level of SOC stock. Benner *et al.* (1991) reported that salt marsh soils are rich in organic carbon derived from dead plant material, and thus contain more carbon than tidal flat soils and getting accumulated in the deeper soil horizons. Byun *et al.* (2019) noted that the mean carbon storage per unit area of coastal wetlands sinks four times higher than terrestrial ecosystems in South Korea. Soil carbon storage in South Korea in the pristine mud flat was also higher than that of other ecosystems (Byun et al., 2019). The analytical results revealed that mangrove and salt marsh ecosystems store and sequester 57.68 kg/m^2 and 83.78 kg/m^2 in the above-ground and 100.56 kg/m^2 and 121.11 kg/m^2, respectively in the below-ground compartments. So, deeper soil horizons sequester more carbon than the subsoil horizons. It was also reported that mangrove ecosystems store and sequester significant quantities of carbon (Kauffman *et al.* 2014).The global mean SOC concentration of mangroves is 22 g C kg^{-1} (Kristensen *et al.* 2008) where it is higher value of C (26.4 to 27.5 g/kg) in the study sites than the stated value. Weiss *et al.* (2016) reported that SOC stocks in mangrove ecosystem vary from 27.1 to 57.2 Kg C m^2 which is consistent with the present study. It is evident that SOC threshold for sustaining soil quality is widely suggested to be about 20 g/kg (Patrick *et al.* 2013), below which deterioration in soil quality occurs. It is found that both mangrove and salt marsh habitats sequester more carbon beyond the threshold level. There is no alternative to protect and regenerate mangrove and salt marsh habitat in the coastal ecosystem to tackle climate change and other often disasters. It is the high time to formulate a management policy of zoning mangrove and salt marsh ecosystem and to conserve wetland bio-resources and their carbon storage.

References

Anwar J (1988): Geology of coastal area of Bangladesh and recommendation for resource development and management. In: National workshop on coastal area resource development and management, part II. Organized by CARDMA, Dhaka, Bangladesh, pp. 36–56.

Batjes NH (1996): Total carbon and nitrogen in the soils of the world. European Journal of Soil Science 65, 10–21.

Benner R, Fogel ML & Sprague EK (1991): Diagenesis of belowground biomass of *Spartina alterniflora* in salt-marsh sediments. Limnology and Oceanography 36(7), 1358–74.

Blake GH & Hartge KH (1986): Bulk density. In: Klute A (Ed.), Methods of Soil Analysis. Part 2. Second Edition, American Society of Agronomy, Soil Science Society of America, Madison, USA, pp. 363-375.

Byun C, Shi-Hoon L & Hojeong K (2019): Estimation of carbon storage in coastal wetlands and comparison of different management schemes in South Korea. Journal of Ecology and Environment 43, 8.

Chen LD, Gong J, Fu BJ, Huang ZL, Huang YL & Gui LD (2007): Effect of land use conversion on soil organic carbon sequestration in the Loess hilly area, loess plateau of China. Ecological Research 22, 641-648.

Chmura GL, Anisfeld SC, Cahoon DR & Lynch JC (2003): Global carbon sequestration in tidal, saline wetland soils. Global Biogeochemical Cycles 17(4), 1–12.

Coleman JM (1969): Brahmaputra River: Channel Processes and Sedimentation. Sedimentary Geology 3, 129-238.

Duarte CM, Losada IJ, Hendriks IE, Mazarrasa I & Marba N (2013): The role of coastal plant communities for climate change mitigation and adaptation. Nature Climate Change 3(11), 961–8.

Hopkinson CS, Cai WJ & Hu X (2012): Carbon sequestration in wetland dominated coastal systems—a global sinks of rapidly diminishing magnitude. Current Opinion in Environmental Sustainability 4(2),186–94.

Howard J, Hoyt S, Isensee K, Pidgeon E & Telszewski M (2014): Coastal Blue Carbon: Methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and sea grass meadows. Conservation International, Intergovernmental Oceanographic Commission of UNESCO, International Union for Conservation of Nature. Arlington, Virginia, USA.

Kauffman JB, Heider C, Norfolk J & Payton F (2014): Carbon stocks of intact mangroves and carbon emissions arising from their conversion in the Dominican Republic. Ecological Applications 24(3), 518–527.

Kristensen E, Bouillon S, Dittmar T & Marchand C (2008): Organic carbon dynamics in mangrove ecosystems: a review. Aquatic Botany 89(2), 201–219.

Nelson DW and Sommers LW (1982): Total carbon, organic carbon and organic matter. In: Page AL, Miller RH, Keeney DR (Eds.), Methods of Soil Analysis. Part 2. Second Edition, American Society of Agronomy, Soil Science Society of America, Madison, USA, pp. 539-577.

Ouyang X & Lee S (2013): Carbon accumulation rates in salt marsh sediments suggest high carbon storage capacity. Biogeosciences Discussions 10, 19155–88.

Patrick M, Tenywa JS, Ebanyat P, Tenywa MM, Mubiru DN, Basamba TA & Leip A (2013):Soil carbon thresholds and nitrogen management in tropical agro-ecosystems: concepts and Prospects. Journal of Sustainable Development **6**(12), 32–43.

Simo I, Schulte R, O'Sullivan L & Creamer R (2019): Digging deeper: Understanding the contribution of subsoil carbon for climate mitigation, a case study of Ireland. Environmental Science and Policy 98, 61–69.

Uddin MJ, Iquebal T, Mohiuddin ASM & Sarker MH (2019): Shoreline change detection and their morphological analysis of the coastal regions of Bangladesh using remote sensing techniques. Journal of Earth Sciences and Climate Change 10, 15-24.

Walkley A and Black IA (1934): An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science 37, 29-38.

Weiss C, Weiss J, Boy J, Iskandar I, Mikutta R & Guggenberger G (2016): Soil organic carbon stocks in estuarine and marine mangrove ecosystems are driven by nutrient co-limitation of P and N. Ecological Evolution 6, 5043–5056.

Zhang C, Liu G, Xue S & Sun C (2013): Soil organic carbon and total nitrogen storage as affected by land use in a small watershed of the loess plateau, China. European Journal of Soil Biology 54, 16-24.

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