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Suaeda Maritima: A Potential Carbon Reservoir of Coastal Zone

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Abstract: Currently there has been an increasing focus on coastal floral community because of their carbon storing capacity. Although, the true mangrove species have been widely covered worldwide to highlight their stored and sequestered carbon in this natural carbon reservoir, very little species-wise data is available on carbon stored in tidal marsh vegetation which constitutes the mangrove associate floral community and is also an important component of blue carbon reservoir. Stored carbon in the Above Ground Biomass (AGB) and Below Ground Biomass (BGB) of *Suaeda maritima* (a mangrove associate species) was estimated during April, 2015 at Frazergaunge and Bali island of Indian Sundarbans. Soil Organic Carbon (SOC) was also monitored simultaneously to evaluate the amount of carbon stored in the vegetation along with the associated soil. The Above Ground Carbon (AGC) and Below Ground Carbon (BGC) were relatively higher in Frazergaunge compared to Bali island, which may be attributed to relatively higher anthropogenic pressure in the former region.

Key words: Carbon content, mangrove associate, Suaeda maritima, Indian Sundarbans.

INTRODUCTION

Mangrove forests are the most recognizable intertidal colonizer in the tropics: this habitat type is dominated by 73 species of trees and shrubs, including some ferns and at least one type of palm, that have evolved to thrive in anaerobic soils with varying levels of salinity (Spalding *et al*., 2010). Saltmarshes are the other *vital* intertidal habitat included in mangrove ecosystems and constitute the mangrove – associate floral community. They are often found in similar environments as mangroves, including estuaries, deltas, and low-lying coasts that experience low wave energy (Adam, 2002).

The mangrove associate floral community does not possess the typical features of true mangrove species, but they play a crucial role in shaping the entire mangrove ecosystem as a blue carbon sink. In India, the mangrove ecosystems have 809 species of associate flora (Kathiresan and Qasim, 2005) that includes 12 species of saltmarsh vegetation, 11 species of seagrasses, 559 species of algae, 69 species of bacteria, 103 species of fungi, 23 species of actinomycetes and 32 species of lichens (Kathiresan and Rajendran, 2005).

Saltmarsh plants adapt to survival under submerged conditions. The diversity of plant communities is modest - about ten to twenty species in saltmarshes. They must cope with the stress of flooding and salinity (Keddy, 2000). Saltmarshes exhibit unique plant zonation based on hydrology and salinity levels. High marshes include *Spartina patens* (salt meadow cordgrass), *Distichlis spicata* (spikegrass), *Iva frutescens* (marsh elder), *Juncus gerardi* (blackgrass), *J. roemerianus* (black rush), *Limonium carolinianum* (sea lavender) and other genera such as *Arthrocnemum, Artriplex, and Suaeda* (seablite). The short form of *Spartina alterniflora*, *Salicornia* spp. and *Distichlis* spp. are in the middle marshes. The tall form of *Spartina alterniflora* Loisel (smooth cordgrass) dominates low marshes (Mitsch and Gosselink, 2000).*Suaeda* species are halophytes, one of the most common plants in saline and alkaline soils (Shao and Li, 1998). More than 100 annual or perennial species belonging to the genera *Suaeda* occur along sea coasts and in other saline habitats throughout the world (Powell, 1998). *S. maritima* (L.) Dumort is a saltmarsh mangrove associate herbaceous shrub which normally grows in the intertidal mudflat where the soil is regularly exposed to changing environmental variables because of high and low tides. Locally known as *Giria shak* or *Gire shak* in Indian Sundarbans, the plant is also called as seablite which belongs to the Chenopodiaceae family and are normally 30 to 37 cm in height. The stem develops many lateral branches and the leaves are fleshy, green – red in colour. *S. maritima* is a hairless annual, prostrate to erect, and its height ranges from 10 to greater than 30 centimetres (Clapham *et al*., 1959). *S. maritima* normally grows on mid-and-outer estuaries, on the muds and river flats. The species grows gregariously and covers large scale in the frequently inundated river flat lands. It is distributed throughout the coastal areas and in the saltmarshes in India and South East Asian coasts (Naskar and Mandal, 1999). An observation of saltmarshes of Sussex, Southern England revealed that *S. maritima* thrives at the extreme high tide mark, where they grew on sheltered banks without other species, were greater than 30 cm in height with many lateral branches (Wetson *et al.*, 2012).

A series of studies have been carried out worldwide on tidal marshes to pinpoint their carbon storage capacity. Compared to true mangrove floral species, marsh vegetation has slightly less carbon per hectare (about 393t C ha^{-1}) and significantly smaller global coverage (Siikamäki *et al*., 2012). Saltmarshes are considered to be an important component of the global carbon cycle (Choi and Wang, 2004). Although, the lower carbon level in tidal marshes is attributed to the herbaceous nature of plants that do not accumulate carbon in wood as in the case of mangrove tress (Bridgham *et al*., 2006), the tidal marsh covers 22×10^3 km^2 area globally (Chmura *et al*., 2003). The carbon pool in tidal marsh plant biomass has been estimated at 7×10^{12}g C (Bridgham *et al*., 2006). Another global picture suggests that the total carbon pool in tidal marshes ranges from 437×10^{12} g C (Bridgham *et al*., 2006) to 2010×10^{12} g C (Siikamäki *et al*., 2012). Considering the distribution of tidal marsh vegetation and their capacity to function as a natural carbon pool, it is therefore highly important to assess the saltmarsh plant community in an elaborate manner. In the present study, an approach has been made to estimate the carbon content of *S. maritima* which is a predominant mangrove associate species found in Indian Sundarbans.

MATERIALS AND METHODS

Sampling for biomass estimation of *S. maritima*

Tidal marsh beds of Frazergaunge and Bali island, belonging to the Indian side of Sundarban mangrove wetland, were selected for this study. The field work was undertaken during ebb tide in April, 2015. The survey month belongs to the pre-monsoon period of the study area. The marsh bed is inundated by high tide water twice a day as the area experiences semidiurnal nature of tide.

A perpendicular belt (~50 m width) transect to the shore was laid on the *S. maritima* beds in the selected stations. The length of transect varied from 20 to 250 m depending upon the horizontal extent of beds to the shore. The population density of *S. maritima* was estimated through quadrate (1 m × 1 m in size) method in both the sampling sites. The quadrates were selected at random along the belt transect.

The biomass was estimated by removing the entire plants along with roots and shoots from five quadrates. Plant material was thoroughly washed in the ambient water immediately after collections, as well as with tap water, to remove adhering debris and sediments. The root, stem and leaves were separated and sun dried and weighed and the results were expressed as gm m^{-2} on an average basis.

Surface soil sample was collected from the muddy substratum and then sun dried. All non-soil objects were removed as accurately as possible and the soil was finally oven dried for estimation of organic carbon.

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Carbon estimation

Direct estimation of percent carbon in the leaf, stem and root was done by Vario MACRO elementar CHN analyzer, after grinding of the oven-dried above ground and below ground plant structures separately. Organic carbon of soil was determined following the modified version of Walkley and Black method (1934).

RESULT

The growing interest on global warming has led the researchers worldwide to study the carbon-storing ability of coastal vegetation. The carbon-storing capacity of this unique producer community is a function of biomass production capacity, which in turn depends upon interaction between edaphic, climate, and topographic factors of an area. Hence, results obtained at one place may not be applicable to another. Therefore region based potential of storing and sequestering carbon by coastal vegetation on different land types or substratum characteristics needs to be worked out. In the present study stored carbon has been worked out separately for AGB and BGB of *S. maritima* from two sampling stations, significantly different from each other in terms of anthropogenic activities.

Biomass of *S. maritima*

Located in the western sector of Indian Sundarbans, Frazergaunge (Station I) exhibited an AGB of 93.69 gm m^{-2} to 331 gm m^{-2} and BGB of 4.96 gm m^{-2} to 8.31 gm m^{-2}. The mean AGB and BGB were 153.36 gm m^{-2} and 7.89 gm m^{-2} respectively. In the vicinity of Bidya riverine system, at Bali island (Station II), the (AGB) and (BGB) values of *S. maritima* ranged from 74.35 gm m^{-2} to 236.06 gm m^{-2} and 3.98 gm m^{-2} to 7.64 gm m^{-2} respectively. The mean values of AGB and BGB were 137.284 gm m^{-2} and 5.974 gm m^{-2} respectively which were relatively lower compared to Station I.

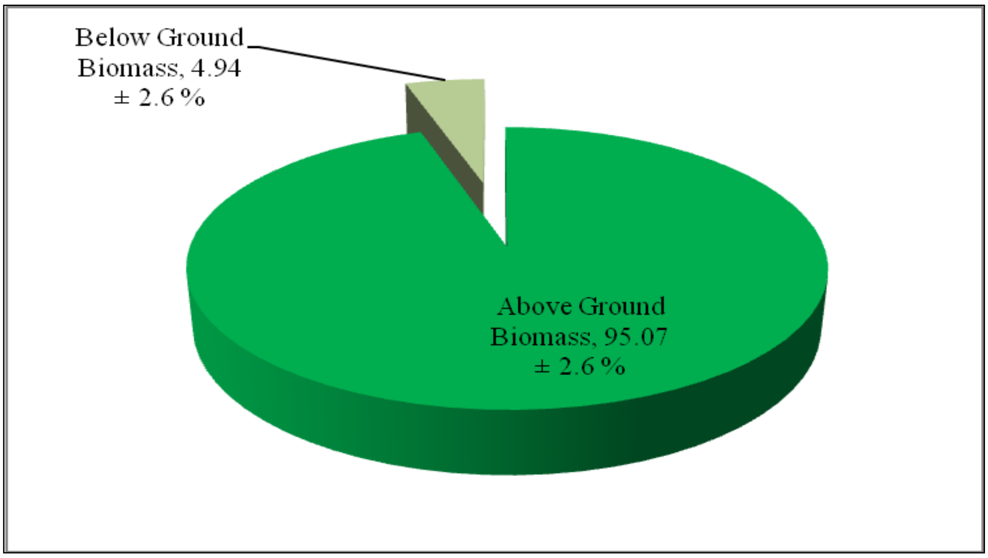

Figure 1: A comparative view of Above Ground Biomass and Below Ground Biomass (AGB & BGB in % ± S.D.) of *Suaeda maritima*

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Above Ground Carbon (AGC)

In the AGB of the species collected from Frazergaunge, the values of stored carbon ranged from 59.64 to 198.82 gm C m^{-2}. The average carbon stored in the AGB was estimated at 71.01 gm C m^{-2}. In case of Bali island, values of stored carbon ranged from the mean 34.9 to 110.83 gm C m^{-2} and the mean value was 64.45 gm C m^{-2}.

Below Ground Carbon (BGC)

At Frazergaunge, the carbon content in BGB of *S. maritima* ranged from 1.93 to 4.12 gm C m^{-2} and the mean value was 3.02 gm C m^{-2}. In case of Bali island, the BGC ranged from 1.64 to 3.15 gm C m^{-2} and the mean carbon stored in the BGB was 2.46 gm C m^{-2}.

Table 1: A brief summary of our findings on *S. maritima* collected from Indian Sundarbans

Station	Geographic Location	Mean AGB (gm m^{-2})	Mean BGB (gm m^{-2})	Mean AGC (gm C m^{-2})	Mean BGC (gm C m^{-2})	Soil organic carbon (%)
I. Frazergaunge	21º 33′ 47.76" N 88º 15′ 33.98" E	153.36 (93.69 – 331)	7.89 (4.96 – 8.31)	71.01 (59.64 - 198.82)	3.02 (1.93 – 4.12)	1.49
II. Bali island	22º 04′ 35.17" N 88º 44′ 55.70" E	137.28 (74.35 – 236.06)	5.97 (3.98 – 7.64)	64.45 (34.9 – 110.83)	2.46 (1.64 – 3.15)	1.04

DISCUSSION

In the context of global warming and climate change, one important criteria of coastal vegetation is their potential to function as a 'blue carbon' sink. Although vegetated habitats are acknowledged to be of major importance to sustain marine biodiversity (Duarte, 2001; Alongi, 2002), they are neglected from present accounts of the global ocean carbon cycle. The neglect of marine vegetation is possibly a consequence of the limited extent of marine vegetation, which cover only < 2% of the ocean surface (Duarte and Cebri´an, 1996). The marsh vegetation of the Sundarbans comprises of creepers like *Suaeda maritima* and *S. nudiflora* in low-lying areas of upper intertidal flats. *S. maritima* forms stable matting even on the desiccated ground (Das, 2015). The species can survive with salt concentration equal to or greater than 2%, i.e., 20 psu (Shao and Li, 1998). These halophytes can grow in soils with high salinity and high concentration of iron where non-halophytes are unable to thrive (Sun et al., 2011). The selected stations in the present study are located in two entirely different sectors within the mangrove forest belt of Indian Sundarbans. Therefore statistically pronounced variation was observed in the total plant biomass (AGB and BGB) and carbon content (AGC and BGC) of our targeted species (*S. maritima*) between the two stations. The AGB (leaves and stem) constitutes more than 90% of the total plant biomass (Figure 1). The carbon content in *S. maritima* is accounted primarily by AGB as mean AGB in both the stations, in our study, is around 20 times more than the mean BGB (Table 1). The same has been reflected in carbon content too (Table 1). The carbon sequestration in the AGB of this mangrove associate species, thus, is a function of biomass production capacity that depends on the interaction between edaphic, climate and topographic factors. Hence, results obtained at one location may not be generalized through out the entire coastal region.

Soil organic carbon (SOC) also plays a critical role that makes *S. maritima* habitat an ideal inventory of atmospheric CO_2. The SOC value of *S. maritima* soil collected from Station I was estimated at 1.49 % which was 0.45 % higher compared to the SOC value of 1.04 % recorded at Station II (Table 1). This difference may be attributed to some prominent anthropogenic factors to

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which Station I is exposed to, but are to some extent absent in Station II, as it falls under the central sector of Indian Sundarbans and close to the pristine Reserve Forest of Indian Sundarbans.

Globally, the carbon content of true mangrove species has been well documented. But our finding backs the concept that a significant amount of atmospheric carbon is also stored annually by the coastal marsh vegetation. The present assessment generates few core findings as listed here.

1. In *S. maritima*, the AGB is around 90% of the total plant biomass, which reflects more storage of carbon in AGB compared to the BGB.
2. Pronounced spatial variation in AGB and AGC in the present study reflects the type and magnitude of anthropogenic activities existing in and around study area.
3. Relatively higher AGB and AGC in the species collected from Frazergaunge (Station I) may be linked with the anthropogenic activities like fish landing (in the Frazergaunge harbour), intense tourism, large number of shrimp farms (that generate organic waste without treatment) and industrial discharge. The sewage released from these units not only fertilize the soil with macro- and micro-nutrients (as evidenced through relatively higher biomass of the species), but also increases the organic matter in surface soil (higher SOC value compared to Bali island).
4. The considerable carbon pool in *S. maritima* along with the soil strongly advocates the need of marsh vegetation (apart from true mangrove species) to be included as one of the vital components in the vertical of blue carbon.

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