Bhitarkanika Mangrove Forest: A Potential Sink of Carbon

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Abstract: *A survey was carried out at Bhitarkanika Wild Life Sanctuary (BWLS) during August 2016 to estimate stored carbon in the stem region of true mangrove floral species. The stored carbon exhibited direct proportionality with stem biomass irrespective of the species documented in the present study area. The total stored carbon in the stems of the selected species is 61.97 t ha^{-1}, which synchronizes well with values (extrapolated through thumb rule) obtained from different mangrove regions of the world. The present study establishes the potential of BWLS mangrove flora in the domain of carbon sequestration, which is a new dimension in the ecosystem services of mangroves thriving in the deltaic complex of Brahmani and Baitarani Rivers.*

Key words: *Bhitarkanika Wild Life Sanctuary (BWLS), Mangroves, Stem biomass, Stem carbon*

1. INTRODUCTION:

In Indian sub-continent mangrove wetlands occupy an area of 4,87,100 ha. The area is more in the east coast of India, which is about 2,75,800 ha and represents 56.63% of the total mangrove area of the country. In the state of Odisha, mangroves occupy an area of 214 sq.km. (FSI, 1999). The Bhitarkanika mangrove forest is the second largest mangrove forest in India. In April, 1975 mangroves of Bramhani and Baitarani delta of Kendrapara district have been declared as the Bhitarkanika Wild Life Sanctuary (BWLS), which covers an area of 145 sq.km. Bhitarkanika is endowed with three major types of ecosystem namely brackish water, marine and terrestrial – intricately mixed with each other. The community structure of mangrove vegetation is greatly influenced by dilution factor, tidal inflow, degree of inundation and salinity gradient. Several works have been carried out on the distribution of mangroves in the Bhitarkanika region (Banerjee and Das, 1972; Misra and Panigrahi, 1987; Patnaik and Choudhury, 1989; Banerjee and Rao, 1990; Dani *et al*., 1999; Mishra *et al*., 2005; Pattnaik *et al*., 2008; Upadhyay *et al*., 2008). These works reveal not only the taxonomic status of mangroves, but also their ecosystem services for which mangroves are well known (Mitra, 2013; Mitra and Zaman, 2014; Mitra and Zaman, 2015; Mitra and Zaman, 2016). However, no baseline data sets are available on the carbon storage potential of mangrove flora in BWLS. The present study undertaken during August, 2016 is an approach to evaluate stored carbon locked in the stem region of true mangrove species thriving in the BWLS.

2. MATERIALS AND METHODS:

2.1 Study area:

BWLS is situated on the east coast of India in the maritime state of Odisha in the district of Kendrapara. The sanctuary lies between 20°4′N to 20°8′N latitude and 86°45′E to 87°50′E longitude covering a geographical area of approximately 672 sq.km., out of which ~150 sq.km. is covered by mangroves (Fig. 1).

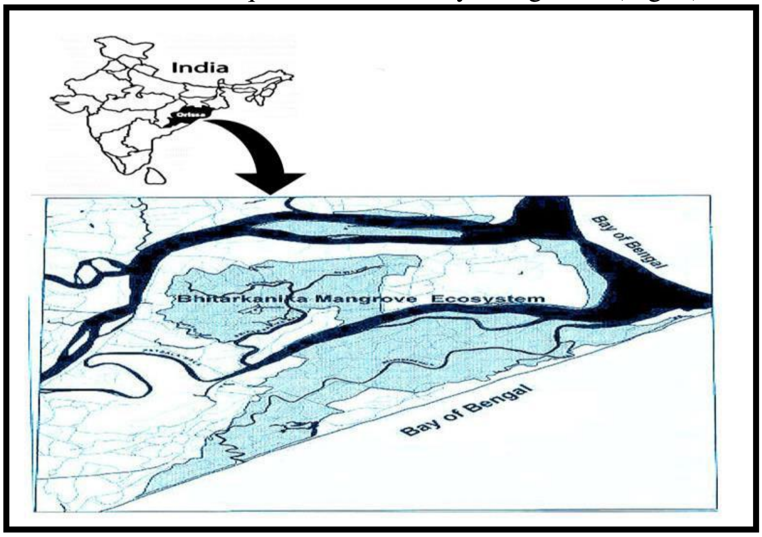

Fig. 1. Map showing the study site at Bhitarkanika Mangrove Ecosystem

The climate of the region is tropical humid with three main seasons namely premonsoon, monsoon and postmonsoon. The average annual rainfall is around 1670 mm of which ~75% occurs during the months of August and September.

3. SAMPLING METHOD:

Simple random sampling method was used to collect the samples. Sample plots were laid along line transects based on tidal variation in the study area. 15 random sampling plots of 10 m × 10 m were selected on the intertidal mudflats. To evaluate the stored carbon in the stem biomass, the taxonomic diversity, population density and stem biomass of all the true mangrove floral species were recorded. The sampling was carried out during low tide and only the live trees with a diameter at breast height (DBH) ≥ 5 cm were recorded. The DBH was measured at breast height, which is 1.3 m from the ground level. It was measured by using tree calliper and measuring tape (Fig. 2).

Fig. 2. Measuring the DBH with a measuring tape

Trees with multiple stems connected near the ground were counted as single individuals and bole circumference was measured separately. Tree height was recorded by using laser based BOSCH height measuring instrument. The methodology and procedures to estimate the stem biomass of the selected true mangrove tree species were carried out step by step as per the VACCIN project manual of CSIR (Mitra and Sunderasan, 2016).

3.1 Carbon estimation:

Direct estimation of percent carbon in the stem biomass was done by *Vario MACRO elementar* CHN analyzer, after grinding and random mixing the oven dried stems from 15 different sampling plots (Fig. 3). The estimation was done separately for each species and mean values were expressed as t h^{-1}.

Fig. 3. ***Vario MACRO elementar*** **CHN analyzer for estimating % carbon in the mangrove stem**

4. RESULTS:

4.1 Taxonomic diversity:

A total of 29 true mangrove floral species were documented from the study area and the population density (in No./100m^2) followed the order *Heritiera fomes* (28.85) > *Excoecaria agallocha* (19.21) > *Cynometra ramiflora* (8.13) > *Aegiceras corniculatum* (4.06) > *Sonneratia apetala* (3.95) > *Heritiera littoralis* (2.88) > *Avicennia officinalis* (2.09) > *Ceriops decandra* (1.91) > *Amoora cucullata* and *Aegialitis rotundifolia* (1.09 for each) > *Avicennia marina* (1.02) > *Cerebra manghas* (0.97) > *Xylocarpus granatum* (0.89) > *Sonneratia caeseolaris* (0.88) > *Hibiscus tiliaceous* (0.79) *Rhizophora mucronata* (0.75) > *Bruguiera gymnorrhiza* (0.71) > *Kandelia candel* (0.61) > *Pongamia pinnata* (0.59) > *Xylocarpus mekongensis* (0.51) > *Xylocarpus molluccensis* (0.45) > *Rhizophora apiculata* (0.36) > *Intsia bijuga* (0.31) > *Phoenix paludosa* (0.25) > *Avicennia alba* (0.15) > *Tamarix troupii* (0.12) > *Thespesia populnea* and *Brownlowia tersa* (0.09 for each) > *Lumnitzera racemosa* (0.08).

4.2 Stem biomass:

The stem biomass values computed for all the 29 species ranged from 0.7 t ha^{-1} (in case of *Thespesia populnea*) to 25.16 t ha^{-1} (in case of *Avicennia officinalis*). The order is represented in Fig 4.

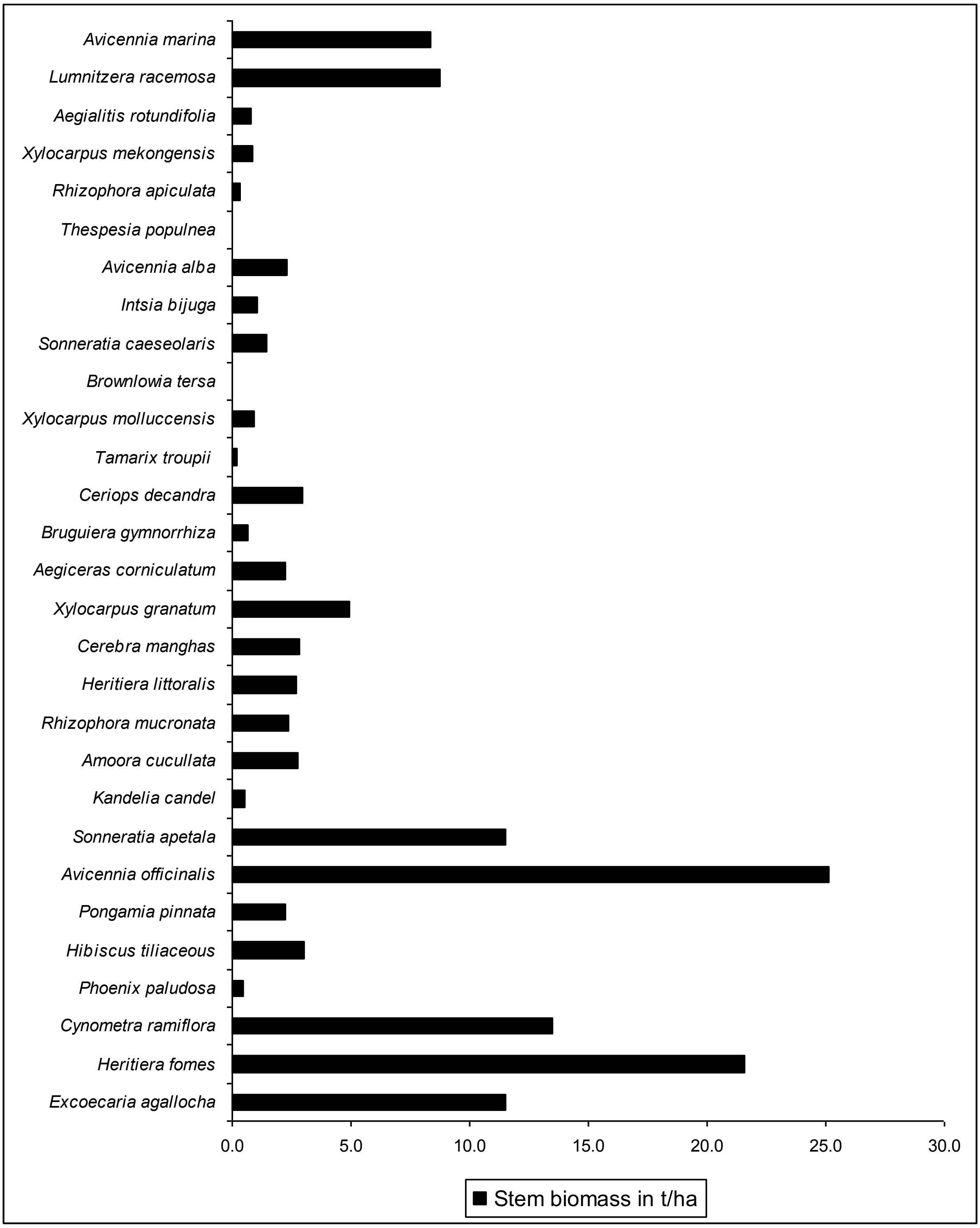

Fig.4. Stem biomass of mangrove trees in Bhitarkanika

4.3 Stem carbon:

The stored carbon in the stem of the selected species varied from 0.03 t ha^{-1} in *Thespesia populnea* to 11.32 t ha^{-1} in *Avicennia officinalis* as shown in Fig. 5.

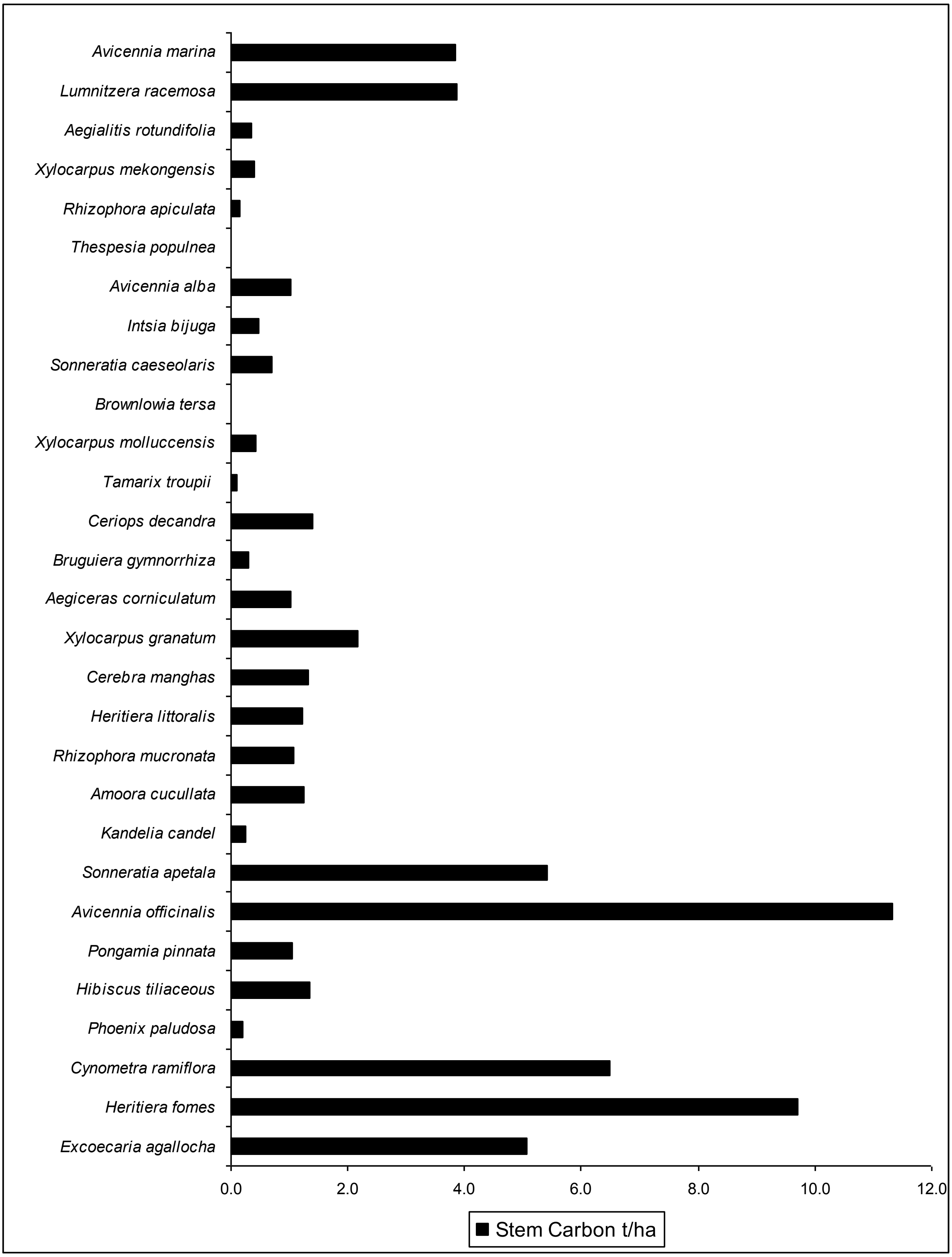

Fig. 5. Stem carbon of mangrove trees in Bhitarkanika

4. DISCUSSION:

Mangroves are unique and highly dynamic ecosystem of the tropics that occupy a large fraction of the coastline, dominating the intertidal zone of diverse environmental settings. India has 5% of the world's mangrove vegetation which are mainly concentrated in the east coast of the country (preferably in the maritime states of West Bengal and Odisha).

The present paper is a first order analysis on the BWLS mangroves situated in the state of Odisha. This ecosystem is known for its rich faunal and floral diversity and has come up luxuriantly in the deltaic complex formed by the rich alluvial deposits of Brahmani and Baitarani Rivers. The growth and survival of mangroves in this deltaic complex is regulated by the river discharges from Brahmani and Baitarani. Considerable dilution factor of the aquatic system of BWLS has direct linkage with the flourishing of *Heritiera* spp. in this deltaic complex, unlike Indian Sundarbans in the adjoining state of West Bengal where the genus *Heritiera* is gradually getting extinct owing to increase of salinity due to Bidyadhari siltation (Mitra, 2013).

Our team members documented a total of 29 true mangrove floral species, which play a crucial role in carbon storage. Mangroves are today viewed as carbon-rich ecosystems that warrant their preservation and restoration (Van Lavieren *et al*., 2012).

A comparative account of carbon sequestration by mangroves with other coastal ecosystems exhibit that salt marshes have relatively high sequestration rate of approximately 218 $gCm^{-2}y^{-1}$, but sea grasses, estuaries and continental shelves have lower rates (Table 1).

Table 1. Contributions of Mangroves and other coastal habitats to carbon sequestration in the global coastal ocean

Ecosystem	Area (10^{12} m^2)	Sequestration Rate (g C m^{-2} y^{-1})	Global Sequestration (Tg C y^{-1})	Potential Global Loss (Tg C y^{-1})
Mangrove	0.14	174 ± 23	24	90 - 970
Salt marsh	0.20 - 0.40	218 ± 24	5 - 87	20 - 240
Seagrass	0.17 - 0.60	138 ± 38	48 -112	50 - 330
Estuary	1.1	45	50	-
Shelf	26	17	44	-

Source : Alongi (2014)

The present study although is a baseline configuration of carbon storage potential of mangroves of BWLS of Odisha, but many of the carbon lockers like branches and leaves of the floral species have not been considered. It is observed from the present study that the total carbon stored in the stems of the selected mangrove species is 61.97 t ha^{-1}, which is comparable to other data sets collected from different mangrove regions of the world (Table 2).

Table 2. Global data of AGB and AGC of different mangrove species

Region	Location	Condition or age	Species	AGB (tha^{-1})	Reference	AGC* (tha^{-1})
Australia	27 ° 24'S, 153 ° 8'E,	Secondary Forest	*A. marina* forest	341.0	Mackay (1993)	170.50
Thailland (Ranong Southern)	9 ° N, 98'E,	Primary Forest	*Sonneratia* forest	281.2	Komiyama *et.al* (1987)	140.60
Sri Lanka	8 ° 15' N, 79 ° 50'E	Fringe	*Avicennia* spp.	193.0	Amarasinghe and Balaubramaniam (1992)	96.50
Indonesia (Halmahera)	1 ° 10 'N, 127 ° 57'E	Primary Forest	*Sonneratia* forest	169.1	Komiyama *et.al* (1987)	84.55
Australia	33 ° 50' S, 151 ° 9'E	Primary Forest	*A. marina* forest	144.5	Briggs (1977)	72.25
French Guiana	4 ° 52' N, 52 ° 19'E	Matured Coastal	*Lagucularia, Avicennia, Rhizophora,*	315.0	Fromard *et.al* (1998)	157.50
South Africa	29 ° 48' S, 31 ° 03'E	-	*B. gymnorrhiza, A. marina*	94.5	Steinke *et.al* (1995)	47.25
French Guiana	5 ° 23' N, 52 ° 50'E	Pioneer stage 1 year	*Avicennia* spp.	35.1	Fromard *et.al* (1998)	17.55
Western Indian Sundarbans	88 ° 10'E 21° 43'N	Natural Forest	*Sonneratia apetala, Avicennia alba, Excoecaria agallocha*	113.67	Banerjee *et.al* (2013)	56.84
Central Indian	88 ° 48' E 22° 16'N	Natural Forest	*Sonneratia apetala,*	97.35	Banerjee *et.al* (2013)	48.68

Sundarbans			*Avicennia alba, Excoecaria agallocha*			
BWLS	20°4′N to 20°8′N and 86°45′E to 87°50′E	Natural forest	Mixed vegetation	136.03	This study	61.97

AGB= above ground biomass, AGC = above ground carbon; * Computed by the present authors as per the thumb rule AGC= 0.5 AGB*

The available data is a snap shot of the stored carbon in the stems of major mangrove floral species of BWLS of Odisha, but the value is comparable to stored carbon in the AGB of mangroves in the other parts of the world considering 50% of the AGB is stored as carbon (as per the thumb rule). It is also clear from the present study that differences in carbon storage potential between species is largely due to variation in biomass and population density, which leaves a space to conclude that enhancement of carbon storage can be done through proper soil and water management and safe guarding the environment from anthropogenic disturbances.

5. ACKNOWLEDGEMENT:

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