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Role of mangroves in carbon sequestration: A case study from Prentice island of Indian Sundarbans

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ABSTRACT: We conducted a study during August 2012 and 2017 at Prentice island of Indian Sundarbans to estimate the rate of stored carbon (carbon sequestration) in the mangrove vegetation of the island. On the basis of criterion prescribed for carbon sequestration study (DBH ≥ 5 cm), only 23 species were selected for the estimation. We focused on the stem biomass and the carbon locked in this compartment as the other above ground structures (like leaves, twigs and branches) are converted into litter and act as relatively temporary sink of carbon. The total stem biomass of the documented species (except those whose DBH values are less than 5 cm) were 130.21 t ha^{-1} and 201.74 t ha^{-1} during 2012 and 2017 respectively. The respective stored carbon were 58.23 t ha^{-1} and 96.12 t ha^{-1} during 2012 and 2017, which represent a carbon sequestration of 7.58 t $ha^{-1}y^{-1}$ and a CO_2 – equivalent rate of 27.82 t $ha^{-1}y^{-1}$.

KEY WORDS: Carbon sequestration, Indian Sundarbans, Mangroves, Prentice Island.

INTRODUCTION

Every mangrove ecosystem is unique in its dynamic behaviour, which can be expressed in terms of the evolution of the substratum (intertidal mudflats or beach etc.), edaphic factors, tidal behaviour, environmental parameters (preferably salinity in case of true mangroves) etc, although the community structures are mostly generic. The growth and survival of the floral species comprising the mangrove ecosystem is regulated by environmental parameters, which finally form the base of carbon sequestration. The development of mangrove forests occurs where near-horizontal topography coincides with sea level. The response of mangroves to environmental change is, therefore, often indicative of past changes in coastal conditions, especially in context to sea level. Comparing present patterns in forest species with paleo-ecological information provides considerable insight, not only how mangroves responded to past

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sea level changes, but how they may respond to climate change in the future. The present study has been conducted keeping our focus in this direction. Two distinct years (2012 and 2017) have been considered with a gap of five years to evaluate the rate of carbon storage (carbon sequestration) by true mangrove floral species in an island located in the World Heritage site of Indian Sundarbans.

India has a total mangrove cover of 4627.63 sq.km , which is 0.15% of the countries land area, 3% of the global mangrove area and 8% of the Asian mangrove area. Mangroves in India are unique in terms of their extent, variability and biodiversity (Banerjee *et al*., 2016; Mitra and Sundaresan, 2016) [1] [2]. A total of 4011 species, encompassing 920 plants (23%) and 3091 animals (77%) species have been recorded from Indian mangrove ecosystems, which has placed the Indian sub-continent in a prominent position in the world biodiversity panorama (Bhatt and Kathiresan, 2011)[3]. Most of the mangrove forest in India is concentrated in the east coast (~2758 sq.km).

Sundarban Biosphere Reserve in the north east coast of India is the broad domain of the present study, which has been narrowed down to Prentice Island (21° 38′21.20 N latitude 88° 20′29.32 E longitude). The island has a unique diversity of true mangrove vegetation

The present study is an approach to evaluate the carbon sequestration in the stem region of major mangrove floral species present in the island. The approach is undoubtedly an underestimation as carbon is also stored in the branches, twigs and leaves of the trees. However, considering the permanency of the stem region we have focused on this vegetative part as twigs, branches and leaves are transformed into litter and detritus very frequently and subsequently get buried in the underlying soil compartment or conveyed to adjacent water bodies as Particulate Organic Carbon (POC), Dissolved Organic Carbon (DOC) and Dissolved Inorganic Carbon (DIC).

MATERIALS AND METHODS:

SAMPLING

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 period and only the live trees with a diameter at breast height (DBH) ≥ 5 cm were recorded.

ESTIMATION OF STEM BIOMASS

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.

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Trees with multiple stems connected near the ground were counted as single individual and bole circumference was measured separately. Stem height was recorded by using laser based height measuring instrument (model: Bosch GLM 100 C). The methodology 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 Sundaresan, 2016) [2] after considering and measuring parameters like DBH, DBR (Diameter of basal region), height of the stem, density of the stem wood and form factor. The population density of each species was also documented to express the value of stem biomass in t ha^{-1}.

ESTIMATION OF STEM CARBON

Direct estimation of percent carbon in the stem was done by *Vario MACRO elementar* CHN analyzer, after grinding and random mixing the oven dried stems from 15 different sampling plots. The estimation was done separately for each species and mean values were expressed as t ha^{-1}.The stem carbon was converted to CO_2-equivalent by multiplying with a factor 3.67.

ESTIMATION OF CARBON SEQUESTRATION

Carbon sequestration is defined as the rate of change of stored carbon with time. In the present study, estimation of stored carbon in the stem of the selected mangrove trees was done during August 2012 and August 2017 in the same sampling plots. Hence, the rate of change of stored carbon in the stem biomass of the selected species (carbon sequestration) was calculated by dividing the difference in stored carbon between years with the time factor/span (5 years in this case).

RESULTS

POPULATION DENSITY

A total of 23 true mangrove floral species were documented from the study area and the population density of all these species (in No. m^{-2}) was 69.01 during 2012. After a span of 5 years the value decreased to 68.75 in 2017 (Fig 1).

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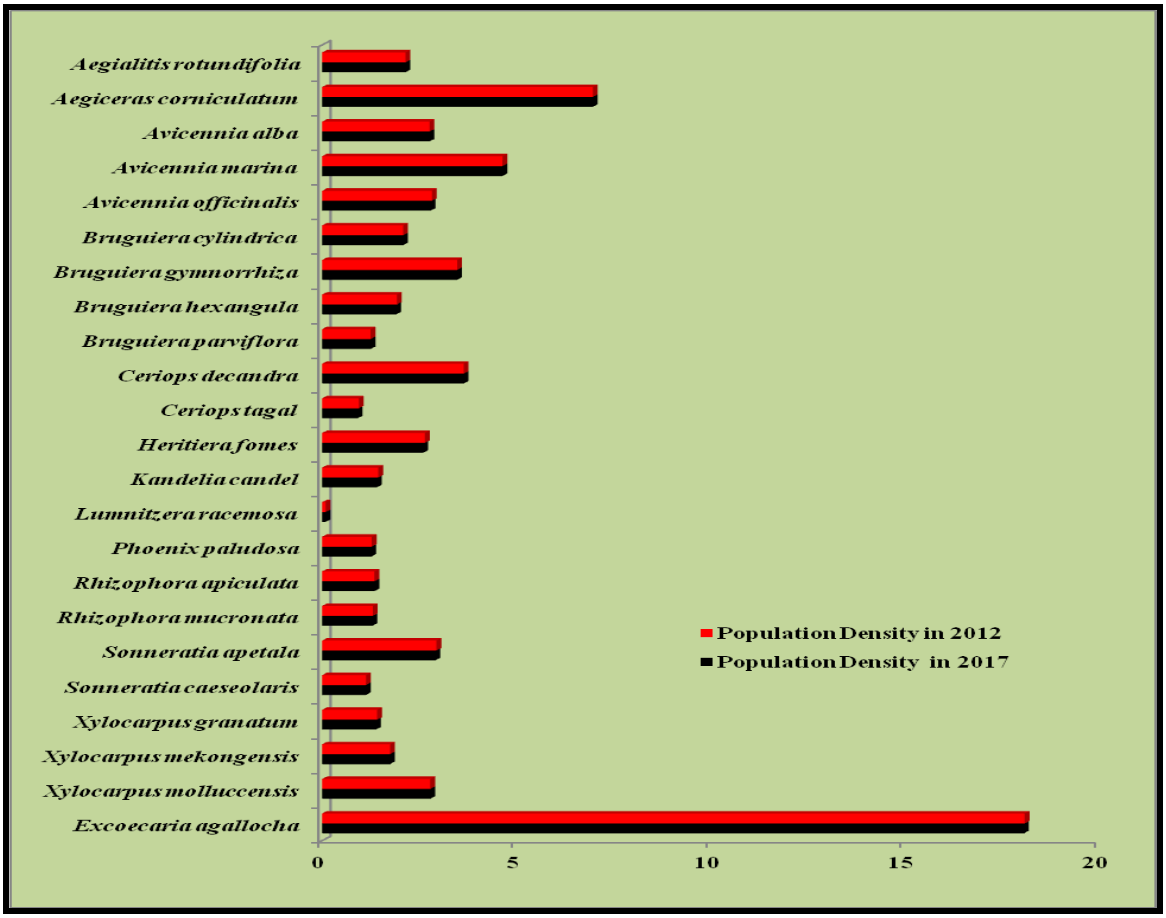

Fig 1: Population density of true mangrove floral species (No.m^{-2}) during 2012 and 2017

STEM BIOMASS

The total stem biomass was 130.21 t ha^{-1} during 2012 considering all the 23 selected true mangrove floral species. The value increased to 201.74 tha^{-1} during 2017, which is hike of 54.93 % (Fig 2).

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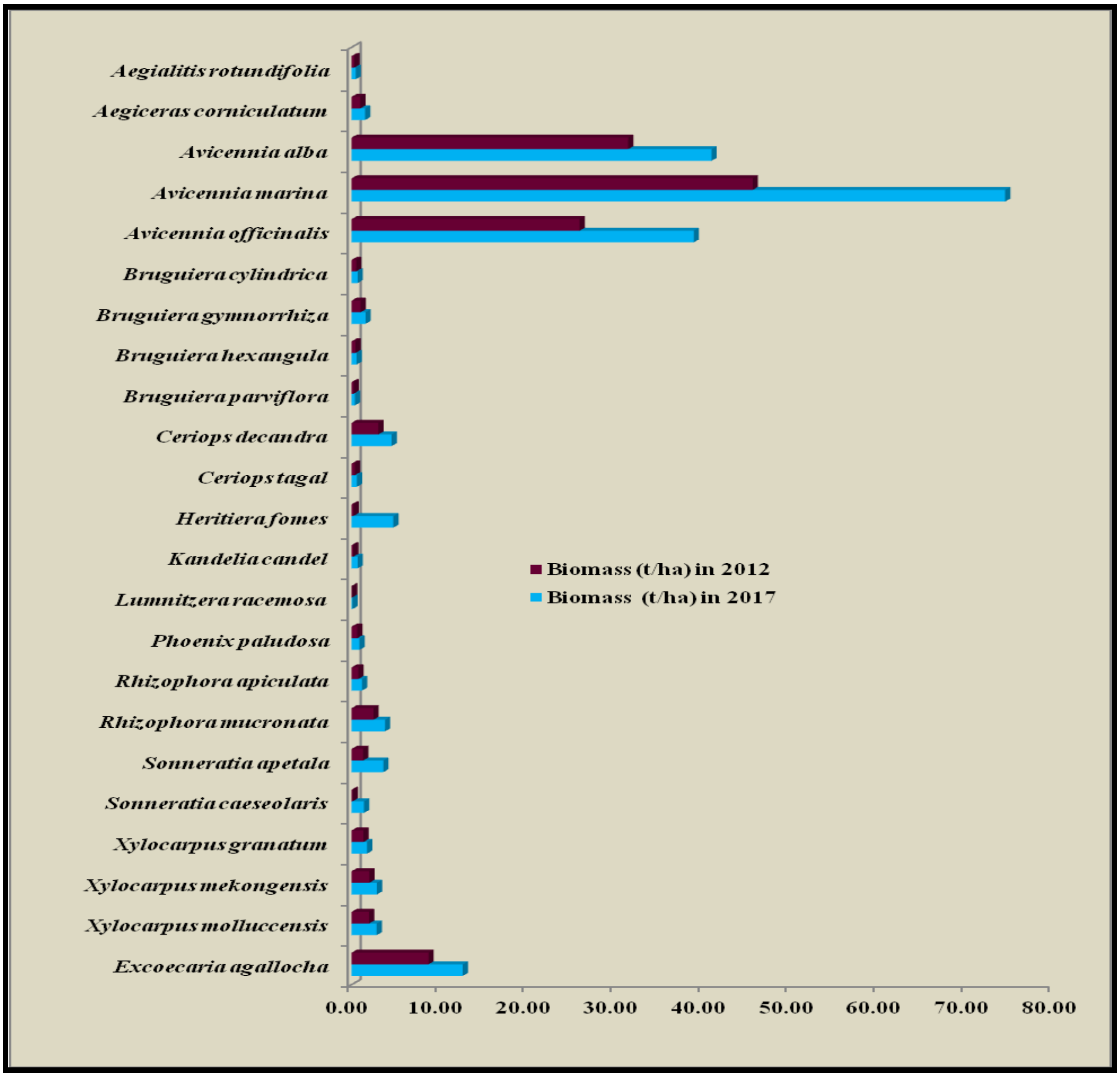

Fig 2: Stem biomass (in t ha^{-1}) of selected mangrove trees in Prentice island

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STEM CARBON

The stored carbon in the stems of the selected species was 58.23 t ha^{-1} during 2012, which increased to 96.12 t ha^{-1} during 2017, an enhancement of 65.07% (Fig 3).

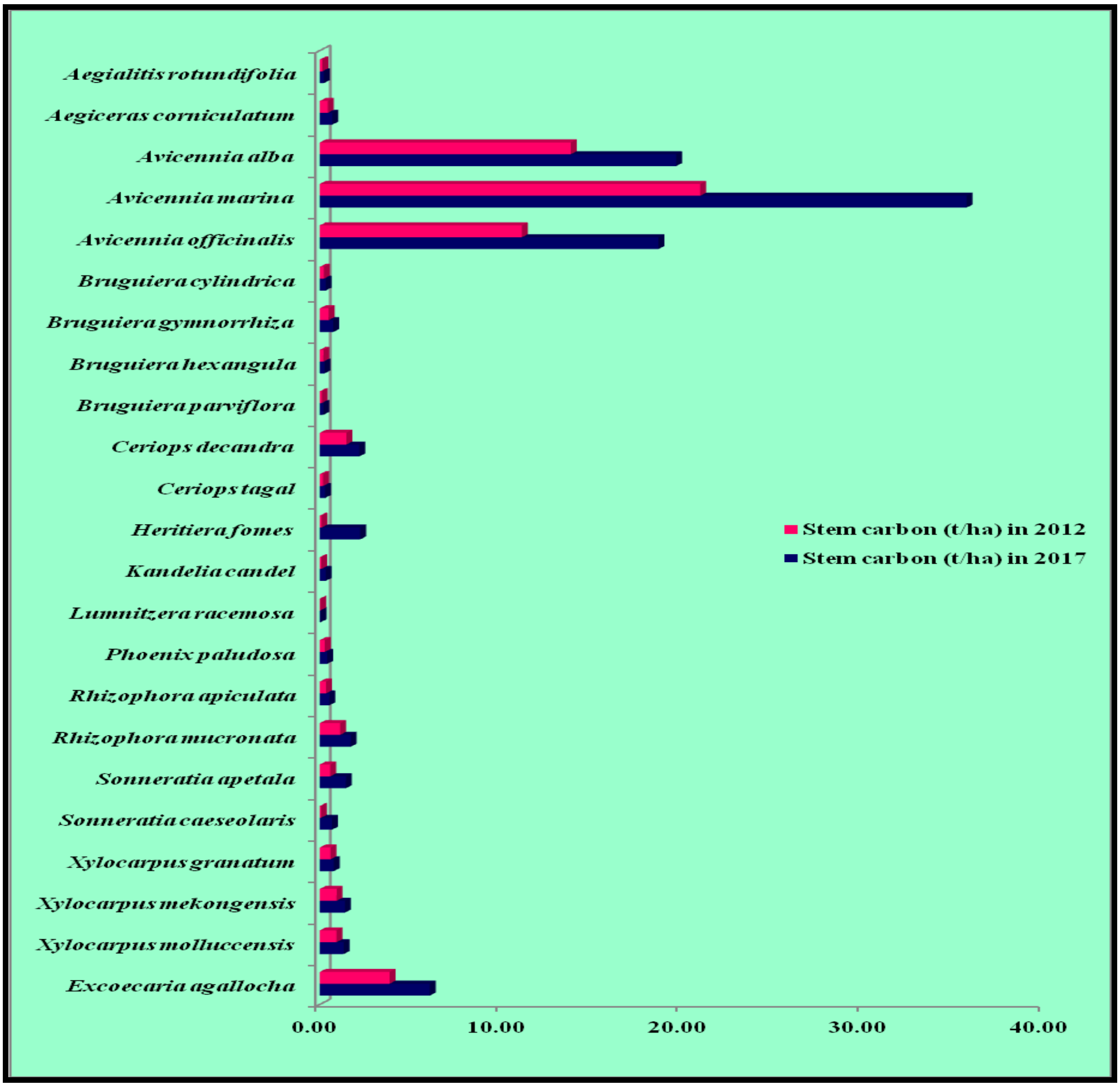

Fig 3: Stem carbon (in t ha-1) of selected mangrove trees in Prentice island

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CARBON SEQUESTRATION AND CARBON-DIOXIDE EQUIVALENT

The stored carbon were 58.23 t ha^{-1} and 96.12 t ha^{-1} during 2012 and 2017 respectively, which represent a carbon sequestration of 7.58 t $ha^{-1}y^{-1}$ and a CO_2 – equivalent rate of 27.82 t $ha^{-1}y^{-1}$.

DISCUSSION

The Indian Sundarban mangroves sustain mixed mangrove vegetation with a total of 69 floral species (included within 29 families and 50 genera), out of which 34 species are true mangrove type (Mitra, 2000) [4]. Because ground based data and allometric equations are needed to develop carbon estimates and there are not many empirical studies about mangroves in Indian Sundarbans except a few (Banerjee *et al*., 2013; Mitra and Zaman, 2015; Mitra and Zaman, 2016)[5][6][7], we firstly calculated a conversion percentage between alive stem biomass and stored carbon in 5 years (2012 and 2017) in order to provide a base over to which the present assessment is built up. The stored carbon were 58.23 t ha^{-1} and 96.12 t ha^{-1} during 2012 and 2017 respectively, which represent a carbon sequestration of 7.58 t $ha^{-1}y^{-1}$ and a CO_2 – equivalent rate of 27.82 t $ha^{-1}y^{-1}$. The present data is, however, an underestimation in terms of stored carbon in the above ground structures and carbon sequestration as we have omitted the vegetative parts like the branches, twigs and leaves. Finally, we suggest that the conservation of mangroves in any region is not only worthy in terms of biological diversity but also in context to retardation of the present state of CO_2 rise in the atmosphere.

FINANCIAL AND COMPETING INTEREST DISCLOSURE

The authors have no financial involvement with any organization or entity with a financial conflict with subject matter or materials discussed in the manuscript. No writing assistance was utilized in the production of this manuscript.

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