A COMPARATIVE STUDY OF REDUCING CARBON FOOTPRINT BY URBAN AND COASTAL VEGETATION

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Abstract: We undertook an emission reduction study during January, 2018 through documentation of carbon sequestration potential of endemic dominant floral species (tree variety) in two major sites of West Bengal. The two sites where Barasat within the city of Kolkata and Jharkhali in central Indian Sundarbans. We observed greater biomass and carbon sequestration in the trees of Barasat region urban area compared those in the mangroves of Jharkhali (deltaic complex region). The study reveals that carbon sequestration is regulated by biomass and edaphic factors. Region-specific plantation with higher biomass and specific gravity are suggested as the end conclusion of the work.

***Keywords* - Carbon sequestration, urban trees, urban design, urban landscape, urban sustainability, mangrove trees.**

I. INTRODUCTION

Natural resources of the planet Earth are under extreme pressures due to rapid industrialization and urbanization across the world and even in the coastal regions [1-4]. The carbon dioxide level is gradually increasing throughout the globe and a critical analysis on the trend of carbon dioxide rise shows that the level of carbon dioxide in the atmosphere has increased greatly in recent times [5]. This has resulted in the rise of atmospheric temperature in the maritime state of West Bengal [6]. The present paper attempts to understand the impact of urbanization on carbon sequestration potential of vegetation based on the study of two sites. Among these two sites, we have selected the Jharkhali region of Indian Sundarbans as the control site as there is minimum human interference and girdled with mangrove vegetations [7]. The other site was selected in the Barasat region of North 24 Parganas where the mushrooming of housing complex, shopping malls etc has been initiated since the last decade.

II. EXPERIMENTAL DESIGN

The present study adopted a series of methodologies, which include literature review, secondary data collection, field surveys and discussion with local people on urban development issues and vegetation landscaping.

Based on the synthesis of these steps, series of field works and samplings were conducted twice (during 2012 and 2017) to evaluate carbon sequestration by Above Ground Stem Biomass (AGSB) of dominant trees in these two areas as per the method outlined by Agarwal *et al.* [8].

Sampling

Simple random sampling method was used to collect the samples. Sample plots were laid along line transects based on tidal variation in the mangrove dominated Jharkahli 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.

In the Barasat region, sampling plots of same dimension (stated earlier) were considered for biomass estimation.

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.

Trees with multiple stems connected near the ground were counted as single individuals and bole circumference was measured separately. Stem height was recorded by using laser based height measuring instrument (BOSCH DLE 70 Professional model). 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[5] 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 for each regions (Barasat in the city of Kolkata and Jharkhali in central Indian Sundarbans) and mean values were expressed as t ha^{-1}.

In the combustion process (furnace at ~ 1000ºC), carbon is converted to carbon dioxide; hydrogen to water; nitrogen to nitrogen gas/ oxides of nitrogen and sulphur to sulphur dioxide. If other elements such as chlorine are present, they will also be converted to combustion products, such as hydrogen chloride. A variety of absorbents are used to remove these additional combustion products as well as some of the principal elements, sulphur for example, if no determination of these additional elements is required.

The combustion products are swept out of the combustion chamber by inert carrier gas such as helium and passed over heated (about 600º C) high purity copper. The function of this copper is to remove any oxygen not consumed in the initial combustion and to convert any oxides of nitrogen to nitrogen gas. The gases are then passed through the absorbent traps in order to leave only carbon dioxide, water, nitrogen and sulphur dioxide.

Detection of the gases can be carried out in a variety of ways including (i) a GC separation followed by quantification using thermal conductivity detection (ii) a partial separation by GC ('frontal chromatography') followed by thermal conductivity detection (CHN but not S) (iii) a series of separate infra-red and thermal conductivity cells for detection of individual compounds. Quantification of the elements requires calibration for each element by using high purity 'micro-analytical standard' compounds such as acetanilide and benzoic acid.

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 July 2012 and July 2017 in the same locations. 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 (5 years in this case).

III. RESULT

Table 1 reflects the Above Ground Carbon (t ha^{-1}) sequestration pattern for 5 years (2012-2017) for mangrove dominated area of Indian Sundarbans.

Table1: Carbon sequestration of true mangrove flora at Jharkhali

Sl. No.	Species	ΔAGB/Δt (t ha^{-1})	ΔAGC/Δt (t ha^{-1})
1.	 *Aegialitis rotundifolia*	0.15	0.06
2.	 *Aegiceras corniculatum*	0.35	0.16

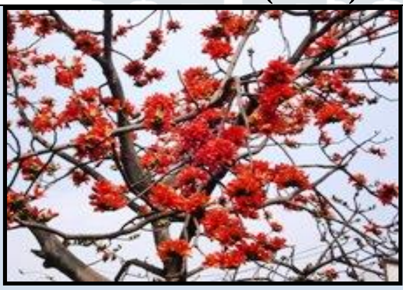
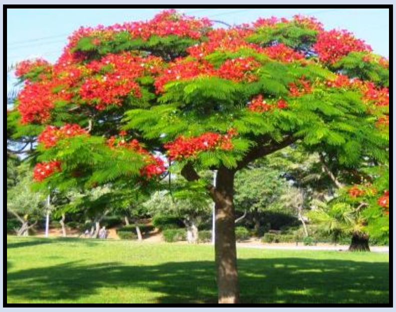
3.	 *Avicennia alba*	0.23	0.10
4.	 *Avicennia marina*	0.99	0.46
5.	 *Avicennia officinalis*	3.85	1.73
6.	 *Bruguiera cylindrica*	0.07	0.03
7.	 *Bruguiera gymnorrhiza*	0.09	0.04
8.	 *Excoecaria agallocha*	1.48	0.65

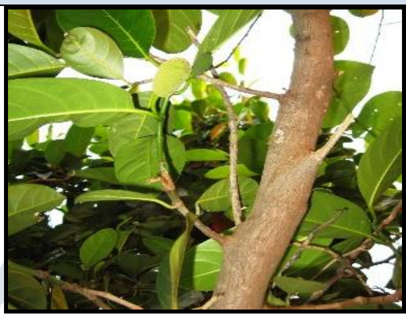
9.	 *Lumnitzera racemosa*	0.03	0.01
10.	 *Phoenix paludosa*	0.05	0.02
11.	 *Xylocarpus molluccensis*	0.15	0.07

The result of a similar study carried out in the Barasat area of Kolkata is exhibited as Table 2.

Table 2: List of dominant tree species in the selected stations with their respective AGB and AGC

Sl. No.	Species	ΔAGB/Δt (t ha^{-1})	ΔAGC/Δt (t ha^{-1})
1.	 ***Cocos nucifera* (Coconut)**	**199.756**	**95.084**
2.	 ***Azadirachta indica* (Neem)**	**97.824**	**46.076**

3.	 ***Mangifera indica* (Mango)**	**157.846**	**75.924**
4.	 ***Tamarindus indica* (Tentul)**	**101.866**	**47.674**
5.	 ***Bombax ceiba* (Shimul)**	**157.38**	**75.858**
6.	 ***Aegle marmelos* (Bel)**	**46.978**	**22.55**
7.	 ***Terminalia arjuna* (Arjun)**	**49.178**	**22.622**
8.		**249.956**	**114.73**

	***Delonix regia* (Krishnachura)**		
9.	 ***Artocarpus heterophyllus* (Jackfruit)**	**130.84**	**63.196**

IV. DISCUSSION

Trees in urban and rural areas including coastal regions are important natural and cultural resources which provide several ecosystem services. Trees are form of community green infrastructure and provide important services such as storm water management, erosion control and energy conservation. The tree canopy of its recovery potential effects particularly in reduction of carbon emissions released from thermal power plants [9]. Also in coastal regions the carbon dioxide emitted from fishing vessels and trawlers and coastal industries are also sequestered by trees (known as producers in the Ecological Science). Enhancing urban, rural and coastal forest sequestration offers immediate environmental and consumer benefits. The present paper aims to study the carbon sequestration potential of urban (Barasat) and a rural coastal region (Jharkhali), which is a comparative study in nature. The amount of carbon stored in a tree depends upon its biomass and growth pattern. It is found that fast growing trees seize more carbon than slow growing trees [10,11]. In the long term the amount of carbon accumulated by slow growing species is larger than by fast growing species. This indicates faster growing trees may accumulate larger amount of carbon in early stage of their life. We also observed in this study that mangroves have very low biomass compared to urban trees like ficus, peepal, neem, gulmohor etc. Because of this fact the carbon sequestration potential of the trees is more in Barasat compared to Jharkhali. However, considering the saline belt and other edaphic factors into account mangroves are more suited in coastal zone. Hence region specific plantation is needed to reduce carbon footprint and lower the temperature at local scale.

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