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Significance of forests tree species in litter biomass and carbon storage of Bangladesh

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Abstract
Litter is the most crucial component in forest ecosystems and plays a vital role to carbon sequestration. The present study was conducted on litter in the Kaptai national park under Rangamati Hill Tracts district at South Forest Division of Bangladesh. The main objectives of the study were to estimate biomass and carbon of litter in six forest areas of the Kaptai national park. The total number of plots was three hundred eight, where 100 m was apart from each other and each plot size was 1 m radius. Plots were selected using global positioning systems. A systematic sampling and destructive method were used for the estimation of litter carbon. Total litter samples were collected from each plot and carbon stock was converted per hectare. The maximum biomass was 1.5 t ha^{-1} in Gmelina arborea and the minimum biomass was 0.69 t ha^{-1} in Lagerstroemia speciosa and with an average biomass was 1.21 t ha^{-1}.The study revealed that the highest carbon stock was 0.31 t ha^{-1} in Gmelina arborea and the lowest carbon stock was 0.13 t ha^{-1} in Lagerstroemia speciosa and with an average 0.22 t ha^{-1} in the whole study area. The total amount of litter carbon was varied from species to species and was also affected by biotic and abiotic factors. High litter producer forest tree species should be selected in the implementation of plantation programs. The findings of the study will be indicated the role of forest tree species in the litter storage of tropical forests.

***Keywords**: Tropical forest, GPS, destructive method, litter, biomass, carbon stock*

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I. Introduction

Litter is the most important dead organic substance in the forests of the world and it is derived from trees, herbs and shrubs. Litter plays a vital role to continue the sustainable development of forests and contains organic carbon. Intergovernmental Panel on Climate Change recognized litter carbon as one of five carbon pools (IPCC 2006). Litter is deposited on the forest floor which is originated directly from the living plants (leaves, twigs, branches and barks etc.). Different parts of plants are converted into litter and decomposed through different microorganisms.Decomposing forest litter is one of the main sources of soil nutrients and impacts on plant growth. The physical and chemical properties of soil are also influenced by litter. Litter contains organic matter which helps to reduce bulk density, and increases water-holding capacity and cation exchange capacity. Litter provides soil organic matter in many tropical and sub-tropical soils where organic matter concentrations are insufficient (Hoyle, 1973). The depositing litter in the forest floor controls weeds, protects soil erosion and reduces surface water run -off and provides essential elements for the growth of plants. (Singh et al., 1984). Maximum organic carbon enters the soil in the form of dead plant matter that is broken by microorganisms during decay.

Maximum organic carbon enters the soil in the form of dead plant matter that is broken by microorganisms during decay. In the decay process, some organic carbon emits into the atmosphere due to the metabolism of these microorganisms. Finally, emitting carbon is mixed with oxygen in the air and converted into CO2 and which creates the problems of global warming (IPCC, 1998). Many scientists suggested that the litter contained about 5% of organic carbon in globally of all ecosystems (Pan et al., 2011). So litter has essential in the storage of organic carbon in forest areas. A few studies on litter biomass and carbon storage of forests have been carried out worldwide and still maximum forests remain unexplored due to lack of sufficient information. Scientific research is required on litter biomass and carbon storage for the sustainable development of forests of Bangladesh. In this case, protected forests can be selected where the mixed plantation is available. Considering this fact, the study was undertaken to estimate biomass and carbon storage of litter in the tropical forest of Kaptai National Park in Bangladesh.

II. Materials and Methods

The study area was located in the Kaptai National Park under Kaptai Forest Range and Rangamati Hill Tracks South Forest Division of Bangladesh (Figure 1). It lies between 220 27ˈto 220 32ˈ N latitudes and 920 30ˈ to 92016ˈ E longitudes. The total area of the park was 5464 hectares. The minimum and maximum elevations were 5 meters and 95-meter above the mean sea level (MSL).

The mean annual temperature, rainfall and humidity were 20.500C, 2513 mm and 80% respectively. About 90% of rainfall occurs from June to August (source: Kaptai hydroelectricity project). The Sitapahar Reserved Forest was converted into the Kaptai national park in 1999 (Feeroz et al., 2011). Teak (*Tectona grandis*) was introduced from Myanmar in 1871 and a massive plantation was started in the Kaptai region with teak (*Tectona grandis*) in 1873 under the management of the forest department which was the first artificial plantation in the Indian sub-continent (Uddin et al., 1998). About 90% of the area's land is hilly, 4% is covered with settlement and 6% is arable (Uddin et al., 1998).

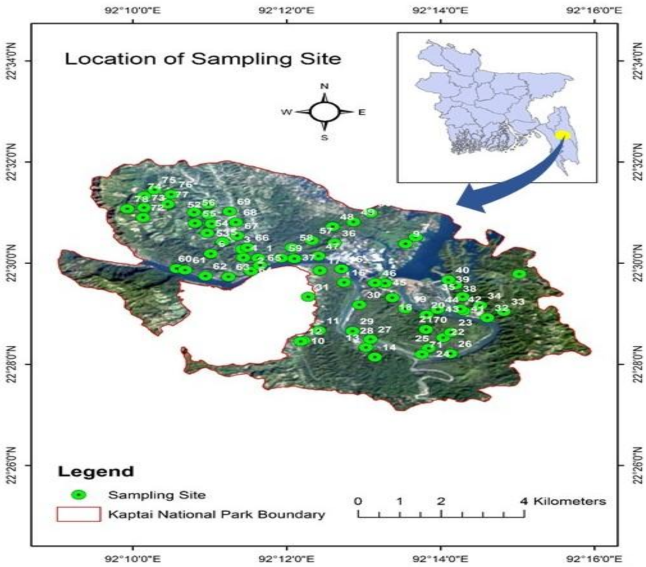

Figure 1: Map showing the location of the study area in Kaptai National Park, Bangladesh.

A systematic sampling method was used for collection of litter samples. For the convenience of the study, Kaptai National Park was divided into three hundred eight plots which were 100 m apart from each other and each plot was identified by using GPS in the field. Each plot was circular size in 1 meter radius. (Figure 2). Litter samples were collected from each sampling plot. Samples were collected from the study area in the period of January 2014 to December 2016. The samples were cut into small pieces and mixed uniformly with its components and then measured green weight (in kg) by field balance. From the green sample of each track, a sample of 1 gm was collected for laboratory analysis. The Loss of Ignition method was followed to estimate biomass carbon stock in the study area.

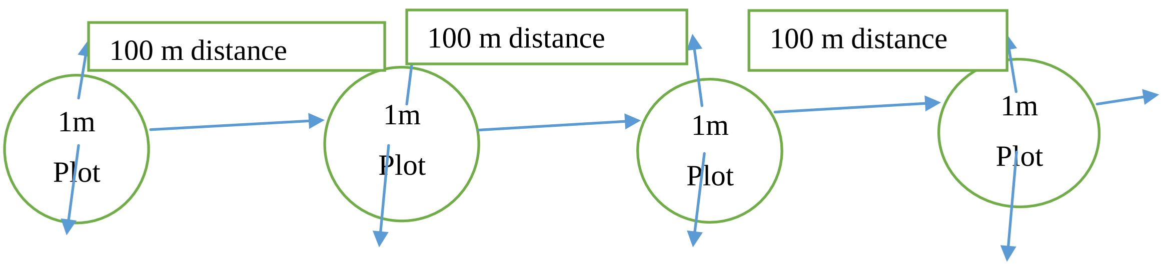

Fig. 2. Schematic representation of the arrangement of sampling plots

The sample was dried at 65^{0}C in the oven for 48 hours. Then the dry weight from oven of each sample was measured. The sample was burned at 650^{0}C for one and half hour in the muffle furnace. After cooling, the crucibles with ash were weighted and then the percentage of carbon was calculated according to the following method (Allen *et al*., 1986).

Ash (%) = W3 –W1)/ (W2-W1) ×100
C (%) = (100-Ash) ×0.58 (Considering 58% carbon in ash- free litter material)
Where,
C= Biomass carbon
W1=weight of crucibles
W2=Weight of the oven-dried grind sample and crucible,
W3= weight of ash and crucible
After calculation the carbon stock per track and total carbon stock per hectare was calculated in the area.

Statistical analysis

Analysis of Variance (ANOVA) for carbon stock per hectare were performed by using SPSS (version, 21) package to determine levels of significance. Duncan's Multiple Range Test (DMRT) was also done in different parameters.

III. Results and Discussion

The present study was conducted to estimate the biomass and carbon of litter in six forest areas. The highest biomass was 1.58 t ha^{-1} in *Gmelina arborea* and the lowest was 0.69 t ha^{-1} in *Lagerstroemia speciosa*(Table 1). On an average, litter biomass stock was 1.21 t ha^{-1} in six forest areas. The results revealed that litter biomass were greatly influenced by species to species in the same regions showed that *Gmelina arborea* > *Swietenia macrophylla* > *Dipterocarpus turbinatus* > *Acacia auriculiformis* > *Tectona grandis* >and *Lagerstroemia speciosa* respectively (Table 1).

Table 1. Estimation of litter carbon density in different tree species (t ha-1).

Name of forest tree species	Age (yrs.)	Litter carbon	Mean
Acacia auriculiformis	5	1.12±0.10	1.23*
Acacia auriculiformis	8	1.23±0.11	
Acacia auriculiformis	12	1.35±0.13	
Dipterocarpus turbinatus	15	1.15±0.10	1.26
Dipterocarpus turbinatus	20	1.20±0.12	
Dipterocarpus turbinatus	25	1.33±0.13	
Gmelina arborea	5	1.53±0.11	1.58
Gmelina arborea	7	1.58±0.14	
Gmelina arborea	10	1.63±0.14	
Lagerstroemia speciosa	12	0.63±0.05	0.69
Lagerstroemia speciosa	16	0.69±0.06	
Lagerstroemia speciosa	18	0.75±0.07	
Swietenia macrophylla	10	1.23±0.10	1.32
Swietenia macrophylla	16	1.42±0.11	
Tectona grandis	15	1.12±0.08	1.21*
Tectona grandis	20	1.18±0.10	
Tectona grandis	25	1.25±0.13	
Tectona grandis	30	1.32±0.14	
Mean			1.21

*Figures followed by the same letter in a column do not differ significantly at $p<0.001$ from each according to DMRT. The variance ratio (F-value=1.999; degree of freedom =5) was significant at $p<0.001$.

Some studies were conducted on litter biomass in the forest areas of Bangladesh. A study was conducted on litter biomass1 in Tankawati natural hill forest of Bangladesh (Ullah and Al-Amin (2012) and the range of litter biomass was 1.89 to 2.46 t ha^{-1}. Their findings were higher than the present findings due to fewer disturbances. Litter biomass was depended mainly on abiotic factors like soil erosion, precipitation, temperature, and biotic factors like anthropogenic pressure, and composition of microbial and plant species. The present study area was included of hilly region and soil erosion occurred during the rainy season. The litter was deposited on the floor of the forests which was subsequently replaced by the system through run off during the rainy season (Rawat et al., 2010). Overgrazing, indiscriminately harvesting and litter collection was observed during the research period. The local people collected litter from nearby forest areas and used it for their daily fuel demand. The study focused that anthropogenic pressure was high in the parking area. The another study was conducted on litter biomass in the Chittagong University campus forest areas of Bangladesh and the average litter biomass was found 0.77 t ha^{-1} (Miah et al., 2001). Their findings were lower than the present findings due to disturbances

The main aim of the present study was to estimate the litter carbon storage in six forests under the Kaptai National Park area of Bangladesh. The per hectare litter carbon storage values of *Acacia auriculiformis, Dipterocarpus turbinatus, Gmelina arborea, Lagerstroemia speciosa, Swietenia macrophylla* and *Tectona grandis* of different ages are presented in Table 2. The results revealed from the study area, maximum carbon stock was found in *Gmelina arborea area followed by Swietenia macrophylla, Dipterocarpus turbinatus, Acacia auriculiformis, Tectona grandis and Lagerstroemia speciosa* forest areas. The average carbon was 0.22t ha^{-1} and the maximum was 0.31 t ha^{-1} in *Gmelina arborea* forest and the lowest was 0.13 t ha^{-1} in *Lagerstroemia speciosa* forest (Table 2).

A study was conducted on litter carbon in the Mehdakachhapia Forest Beat under Fulchari Forest Range, Cox's Bazar North Forest Division in Bangladesh (Haque and Pasha, 2012) and the average litter carbon stock was 2.10 t C ha^{-1}. The another study was also conducted on litter carbon in Dhoa Palong Forest Beat of Cox's Bazar South Forest Division in Bangladesh (Haque and Pasha, 2012) and the average carbon stock was 4.20 t C ha^{-1}. There was a large difference in carbon stock values between Dhoa Palong forest and Mehdakachhapia. Forest disturbance was the most important factor in the storage of litter carbon in the forest areas. Litter biomass and carbon was depended on species, climatic condition and slopes (IPCC, 2006). Litter carbon was 22.00 t C ha^{-1} in the needle shaped forest species and 13.00 t C ha^{-1} in the broadleaved species of the warm temperate moist climatic condition (Takeda et al., 1987). It was also reported that litter carbon stocks were 4.35 and 3.11 t C ha^{-1} in *Cryptomeria japonica* and *Chamaecyparis obtuse* respectively (Hirai *et al.*, 2006). Litter carbon is greatly influenced by environmental conditions and species characteristics. Litter carbon stocks were 9.49 t C ha^{-1} and 11.53 t C ha^{-1} in *Abies* spp. and *Picea* spp. of the cool temperate regions (Takeda *et al.*, 1987).

Table 2. Estimation of litter carbon density in different tree species (t ha^{-1}).

Name of forest tree species	Age (yrs.)	Litter carbon	Mean
Acacia auriculiformis	5	0.19±0.011	0.23*
Acacia auriculiformis	8	0.23±0.013	
Acacia auriculiformis	12	0.29±0.014	
Dipterocarpus turbinatus	15	0.15±0.010	0.19
Dipterocarpus turbinatus	20	0.20±0.011	
Dipterocarpus turbinatus	25	0.24±0.012	
Gmelina arborea	5	0.23±0.011	0.31
Gmelina arborea	7	0.28±0.012	
Gmelina arborea	10	0.35±0.019	
Lagerstroemia speciosa	12	0.11±0.009	0.13
Lagerstroemia speciosa	16	0.13±0.010	
Lagerstroemia speciosa	18	0.15±0.011	
Swietenia macrophylla	10	0.23±0.012	0.27
Swietenia macrophylla	16	0.32±0.014	
Tectona grandis	15	0.12±0.013	0.20*
Tectona grandis	20	0.18±0.010	
Tectona grandis	25	0.24±0.013	
Tectona grandis	30	0.27±0.019	
Mean			0.22

*Figures followed by the same letter in a column do not differ significantly at $p<0.001$ from each according to DMRT. The variance ratio (F-value=1.839; degree of freedom =5) was significant at $p<0.001$.

Broadleaved species were more influenced by climatic conditionsin litter carbon stocks. Castanopsis spp. were broadleaved evergreen forest species and their litter carbon storage capacity was 5.11 t C ha^{-1} in warmer climate regions, whereas, 9.49 t C ha^{-1} and 10.00 t C ha^{-1} were found in Fagus spp. and Betula spp. in the cool climatic conditions (Tsukamoto, 1991). Litter carbon stock is influenced by forest type and old-growth forests contain high litter carbon (Harmon and Hua, 1991; Takahashi *et al*,. 2000). Some scientists observed that litter biomass and carbon was greatly influenced by thinning (Sakai *et al*., 2008; Takahashi and Sakai, 2006).The contribution of litter carbon is about 5% of all ecosystems in the whole of the world (Pan *et al.*, 2011). Some investigators suggested that litter carbon is the end product of dead plants (Islam, 2003). Litter is the essential biotic component in the forest ecosystems of the world. Litter has an important role to improve the sustainable development and conservation of forests. Litter increases of soil nutrients and controls of temperature, humidity, bulk density, water holding capacity and provides essential elements for the growth of forest species.

IV. Conclusion

Litter is a biotic component in forest ecosystems and directly depends on biotic and abiotic factors. The present study revealed that disturbances were the most important factor in the storage of litter carbon in forest areas. In the present study, litter biomass carbon was the lowest because of anthropogenic disturbances. The tribal and encroachment people collected litter from their nearby forest to fulfil their daily fuel demand. Overgrazing and indiscriminately harvesting are the main cause of insufficient litter in the study area. Litter has important in climate change mitigation through carbon sequestration. The amount of organic carbon increases with the increasing of litter biomass. It is an urgent need to educate local people by creating awareness of litter in reducing the concentration of atmospheric carbon. The findings of the present study can be helpful to environmental scientists and related people to understand global carbon stocks which will be contributed to developing the forest resources and other tropical countries with same conditions.

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