IJPS INTERNATIONAL JOURNAL OF PLANT SCIENCES
Volume **9** | Issue 2 | July, 2014 | 301-305
e ISSN-0976-593X | Visit us - *www.researchjournal.co.in*

RESEARCH ARTICLE

Methods of computing carbon sequestration rate and above ground biomass carbon content of plants-modern schemes of practical ecology in geographical researches

■ SOMNATH MUKHERJEE

SUMMARY

Plants act as a sink for carbon dioxide (CO_2) by absorbing carbon during photosynthesis and by storing excess of carbon naturally as biomass in their different parts of the body such as stems, branches, leaves etc. Since the biomass of the plant experiences a continuous growth, the carbon detained by the plant also increases carbon stock. In general the rate of carbon storage increases in young ages of the species and successively declines in their middle ages. In this article an endeavour was taken to highlight two modern methods of practical ecology in geographical researches such as the computation of carbon sequestration rate (CSR) and above ground biomass carbon content (AGBCC) to understand the specific growth of plants. In addition, this article also expresses the results of a small experiment on a relatively young sal tree at the Bankura Christian College premises in Bankura district of West Bengal. Diurnal carbon sequestration rate and above ground biomass carbon content of young sal trees were nearly found half of the total biomass which is quite natural in amount. Here carbon dioxide measured with the help of an automated Vaisala made instrument called, GMP343. Further, above ground biomass stock and carbon of the selected plants measured by taking volume of biomass and specific gravity of the plants. Experimentation of computing carbon sequestration rate and above ground biomass carbon content of plants by a geographer was quite a challenging task. Plant science and practical ecology are the new terminologies presently introduced in bio-geography. Geography the discipline, being a spatial science could analyze the differences in distribution and functions of any geographical phenomena on spatial ground with respect to time. In this context, this article peeps into and scans the relative distinctions with respect to the sequestration rate and biomass carbon content of the young sal plants on spatio-temporal ground. For instance, ambient carbon dioxide of the plants determined at two locations in the study area *i.e.* inside the college premises and in and around the college gate near a busy highway. Results naturally found rich carbon content in case of the plants located near the highway, about 15 ppm more than their counterpart.

Key Words : Above ground biomass carbon content, Carbon sequestration rate, Sal tree, Gravimetric method, Specific growth, Practical ecology

How to cite this article : Mukherjee, Somnath (2014). Methods of computing carbon sequestration rate and above ground biomass carbon content of plants-modern schemes of practical ecology in geographical researches. *Internat. J. Plant Sci.,* **9** (2): 301-305.

Article chronicle : Received : 18.02.2014; **Revised :** 15.04.2014; **Accepted :** 01.05.2014

Carbon is sequestered by plant in photosynthesis process and excess of it is naturally stored as biomass in different parts of the plant. 'The net long term CO_2 source/sink dynamics of forests change through time as trees grow, die and decay. In addition, human influences on forests can further affect CO_2 source/sink dynamics of forests through such factors as fossil fuel emissions and harvesting / utilization of biomass' (Nowak, 2002). It is evident that as the plant biomass experiences a continuous growth, the carbon detained by the plant also increases carbon stock. Beside that increase of atmospheric CO_2 concentration mostly due to fossil fuel combustion, stimulates the photosynthesis rate of plants and in turn increases the growth rates and biomass productions. Results from free air CO_2 enrichment (FACE) experiments show a

AUTHOR FOR CORRESPONDENCE
SOMNATH MUKHERJEE, Department of Geography, Bankura Christian College, BANKURA (W.B.) INDIA
Email: somnathmukherjee_bcc@yahoo.com

25 per cent increase in growth in twice normal concentrations of CO_2. Growth is therefore almost always higher in air with an elevated concentration of CO_2. In India scholar like Haripriya (2003) experienced that the 'average biomass Carbon of the forest ecosystems in India for the year 1994 was 46 Mg C ha-1, of which nearly 76 per cent was in above ground biomass and the rest was in fine and coarse root biomass. The total carbon stock (wood only) for India was 1085.06 and 1083.69 Mt. in 1984 and 1994, respectively (Haripriya, 2003).

Forest ecosystem, the living biomass of trees, the understory vegetation and the deadwood, which includes the standing deadwood and the fallen deadwood like fallen stems and fallen branches,woody debris and soil organic matters constitute the main carbon pool. Among the above mentioned carbon pools, the above-ground biomass of the tree is mainly the largest carbon pool and it is directly affected by deforestation and forest degradation Gibbs *et al*. (2007). The change in the forest areas and the changes in forest biomass due to management and regrowth greatly influence the transfer of carbon between the terrestrial forest ecosystem and the atmosphere Houghton (2005). Hence, estimating the forest carbon stocks is mainly important to assess the magnitude of carbon exchange between the forest ecosystem and the atmosphere. Assessment of the amount of carbon sequestered by a forest will give us an estimate of the amount of carbon emitted into the atmosphere when this particular forest area is deforested or degraded. Furthermore, it will help us to quantify the carbon stocks which in turn will enable us to understand the current status of carbon stocks and also derive the near-future changes in the carbon stocks Houghton (2005).

In general, maximum carbon storage is observed, when the tree is at young stage (approximately < 20 years). In this article an endeavour is taken to highlight two modern methods of practical ecology in geographical researches *i.e.* the computation of carbon sequestration rate (CSR) and above

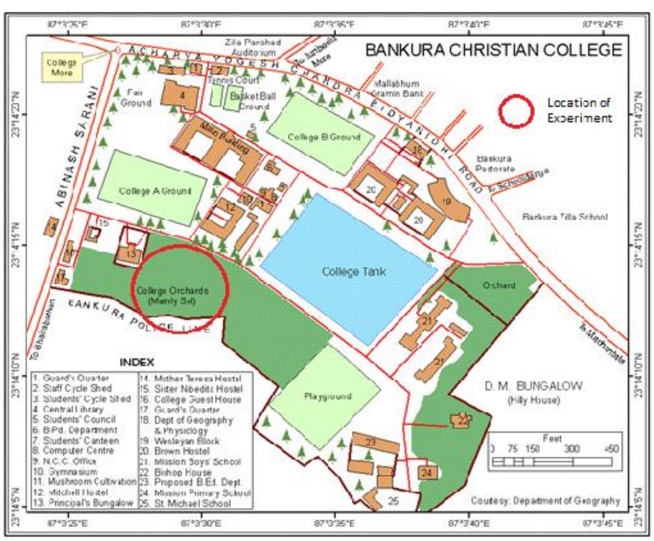

Fig. A: Location of experiment at Bankura Christian College

ground biomass carbon content (AGBCC) for understanding the specific growth of plants. In addition, this article also exhibits the results of a small experiment on a relatively young sal tree (Shorea robusta) at the Bankura Christian College (BCC) premises in Bankura district of West Bengal, India.

Study area:

Bankura Christian College (BCC),a premier educational institution in West Bengal started its academic excellence and service since 29th June, 1903. The college is situated at Bankura town with extensions between $23^0 14' 5''$ North to $23^0 14' 25''$ North latitudes and $87^0 3' 25''$ East to $87^0 3' 45''$ East longitudes (Fig. A).

MATERIAL AND METHODS

Measurement of carbon dioxide (CO_2):

Carbon dioxide (CO_2) has been measured with the aid of GMP343, an automated Vaisala made instrument. The data had been gathered in each hour of a day inside the forest area of the college. The whole process of measurement also depends upon the wind direction. The influence of humidity on carbon sequestration is not considered in this study for simplification.

Measurement of above ground biomass:

Measurement of biomass of a plant includes both above ground and below ground biomass measurements. Aboveground biomass mainly includes all parts of the tree above the earth surface such as stem, branches and leaves and below ground or root biomass includes coarse roots and stumps. Generally stem's biomass is estimated by measuring height and diameter of the plant and if possible by measuring girth size at different heights of the plant with the help of Spiegel Relascope. Moreover, volume of the plant (m^3) is calculated on the basis of the results of the height, diameter and girth sizes of the plant. After this, weight of the wood biomass is computed by multiplying volume of biomass and specific gravity (SG) of the studied wood. Specific gravity is the ratio of oven dry weight and green volume of the pieces of wood samples' (Jana, 2011). Leaf biomass is calculated by gravimetric method. Total leaves present in the plant are tallied from total branches and average number of leaves present in a single branch of that plant. Some of the leaves of the studied plant are taken to measure their fresh weight. After that those fresh leaves are kept in between pages of books for more than twenty days to get dry leaves. If the time is short then a researcher can dry the leaves at about 70°C for at least a week to a constant weight in a lavatory to measure the dry weight. Thus, after measuring both the fresh and dry weight, biomass of those laves is computed by gravimetric method.

In the present study above ground biomass stock and above ground biomass carbon are measured on a relatively young (< 6 years of age) sal tree (*Shorea robusta*) by taking volume of biomass and specific gravity (SG) of the tree. This mechanism is taken from the writings of experiment made by Rajput (1996); Negi (2003) and Jana (2011). Thus, the equations for derivation of biomass, specific gravity and carbon are given below:

Biomass (g) = Volume of biomass (m^3) × Specific gravity (SG) ....(1)

where,

$$SG\ Z\ \frac{\text{Oven dry weight}}{\text{Green volume}} \quad ....(2)$$

Carbon = Biomass × Carbon % ....(3)

Measurement of carbon content in above ground biomass:

After getting the constant weight of dried above ground biomass of the collected stems, branches and leaves, the carbon content of such samples are estimated with the aid of above mentioned calculation. The carbon content of collected samples from stems, branches and leaves can be sent to Indian Association for Cultivation of Science to estimate the carbon content by CHN Analyzer (PerkinElmer Life and Analytical Sciences, USA).

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Ambient carbon dioxide (CO_2) level at inside and outside the sal forest:

Ambient carbon dioxide (CO_2) was measured during winter season. The measurement was done initially inside the Sal forest and then about 300 meters away from the forest near the college main gate (Fig. A). It is observed that inside the sal forest and near the college main gate average CO_2 levels in the surrounding air were recorded nearly 345 ppm and 360 ppm, respectively. It is expected that roadside ambient CO_2 level at the college gate is naturally higher than inside the sal forest.

Carbon sequestration rate (csr) by the sal plant:

Carbon sequestration rate is to measure how much carbon can be sequestered by a tree over a certain period (e.g. hour or day or month or year). In a forest ecosystem, the CSR is closely related to climatic conditions, soil properties, tree species, stand age and the forest rotation length (Graham, 1992). It is well known that during day time a plant gathers CO_2 with the help of photosynthesis to generate energy for sustenance. In day time photosynthesis and respiration processes both are active but after sunset only respiration is prevailed. Carbon sequestration rate by a plant has been evaluated by considering both amounts of intake CO_2 during photosynthesis and release of CO_2 during respiration with respect to time. The experiment is done during winter season. Carbon dioxide taken up by the selected sal plant is registered in each hour of a day (7 a.m. to 7 p.m.). Carbon sequestration rate during respiration is collected only for two hours (5 p.m. to 7 p.m.). It is observed that at 7:00 a.m. the CO_2 sequestration rate was only 0.51 g/hr. CO_2 sequestration rate gradually increases since then up to 12 O'clock. The CO_2 sequestration rates from 8:00 a.m. to 12 O'clock were 6.75 g/hr (8:00 a.m.),

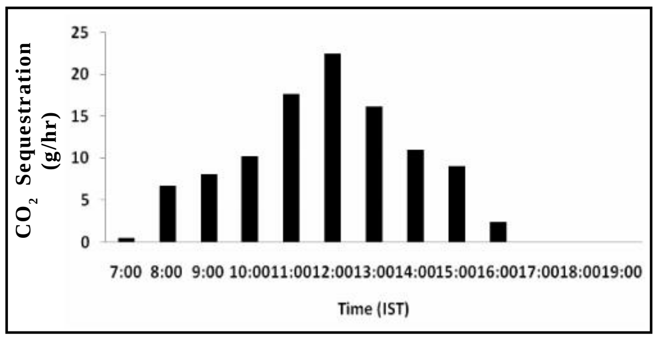

Fig. 1 : Corbon sequestration of sal plant

Table 1: Total aboveground dry biomass of a sal plant (*Shorea robusta*)

Selected plant	Total weight of dry stem and branch biomass (g)	Total weight of dry leaves biomass (g)	Total dry biomass of the plant (g)
Sal	4517.50	1593.50	6111.00

Source: Compiled by the author

Table 2: Biomass analysis results

Selected plant	Sections of the plant	C (%)
Sal	Leaf	24.55
	Stem	23.44

Table 3: Carbon content of the aboveground biomass of the selected sal plant

Selected plant	Carbon content in	Carbon content in individual sample (%)	Total carbon content in the plant (g)
Sal	Leaf	24.55	782.25
	Stem	23.44	2118.00
	Total carbon content in the plant		2900.25

8.11 g/hr (9:00 a.m.), 10.23 g/hr (10:00 a.m.), 17.66 g/hr (11:00 a.m.) and 22.41 g/hr (12 O'clock), respectively. In the afternoon, as the sunlight reduces rapidly the rate of CO_2 emission through respiration was higher than the CO_2 absorption by the sal plant. At 5.00 p.m. after sunset due to absence of sunlight the photosynthesis process was totally stopped. Thus, during 5.00 p.m. to 7 p.m. CO_2 level increased only by respiration of the sal plant (Fig. 1).

Above ground biomass carbon content:

The above ground biomass of different sections of the selected sal plant like stem, branches and leaves were collected and dried naturally. The dry biomass of the stem, branches and leaves of the plant are presented in Table 1.

The result of biomass analysis by CHN Analyzer is represented in Table 2. It is observed that for the selected sal plant the carbon content [C (%)] of leaf and stem contained 24.55 per cent and 23.44 per cent, respectively. On the other hand, total carbon stock has been evaluated by adding all the carbon contents of stem, branches and leaves of the plant. It is to be noted that the carbon concentration of different tree parts was rarely measured directly, but generally assumed to be 50 per cent of the dry weight' (Losi, 2003). The total carbon content in *Shorea robusta* is presented in Table 3. It is observed that the total crbon content of the plant was 2900.25 g. Thus, the percentage of total carbon content in the biomass was 47.46 in the selected sal tree.

Conclusion:

The study illustrates diurnal carbon sequestration rate and above ground biomass carbon content of young sal plant of Bankura Christian College campus. Experimentation of computing carbon sequestration rate and above ground biomass carbon content of plants by a geographer was quite a challenging task. Plant science and practical ecology are the new terminologies presently introduced in bio-geography. Geography the discipline, being a spatial science could analyze the differences in distribution and functions of any geographical phenomena on spatial ground with respect to time. In this context, this article peeps into and scans the relative distinctions with respect to the sequestration rate and biomass carbon content of the young sal plants on spatio-temporal ground. For instance, ambient carbon dioxide of the plants determined at two locations in the study area *i.e.* inside the college premises and in and around the college gate near a busy highway. Results naturally found rich carbon content in case of the plants located near the highway, about 15 ppm more than their counterpart. Irrespective of insuffiency of instruments and non-technical background the major findings have come out with great level of accuracy and that is the main objective of this research.

Winter season was chosen for computation of ambient carbon dioxide for having better result. Young sal tree of less than six years of age were taken for experimentaion. It is observed that estimated results are lower than the previous works done by different scientists like Negi etc. It may be due to consideration of only a single sal plant, young age of the plant, concentrate only on above ground biomass carbon and exclusion of below ground (root) carbon sequestration, similar soil condition, realitively small study area etc. More outcomes from the experiment may be derived if the experiment can be carried out in both day and night, both winter and summer with more species of different locations.

Carbon sequestration rate (CSR) is greatly affected by climate, soil condition etc. Here in this research an endevour was taken to compute the CSR of young sal plants on the basis of considering both amounts of intake CO_2 during photosynthesis (7 A.M to 5 P.M.) and release of CO_2 during respiration (5 P.M. to 7 P.M.) with respect to time. It is observed that CSR during day time increased as time progressed. Highest CSR was recorded at 12 O'Clock about 22 g per hour and lowest at 7 A.M. only 0.51 g. per hour. Above ground biomass carbon content was observed from the dried stem, branches and leaves of the selected plants. In this experiment total dry biomass of the plants found 6111.00 g. which included 4517.50 g. weight of dry stem and branch bomass and 1593.50 g. weight of dry leaves biomass. With the aid of CHN aanlyzer, carbon content [C (%)] between leaf (24.55%) and stem (23.44%) had nearly identical results. On the otherhand, total carbon stock was the collective results of carbon contents of stems, branches and leaves of the selected plants. In this research carbon concentration in the biomass nearly 50 per cent which is quite expected and natural.

Acknowledgement:

I sincerely thank Dr. Manoranjan Chakraborty, Assistant Prof. of Botany, Bankura Christian College, Bankura (W.B.) for his kind assistance.

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