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A study on sequestration of carbon by trees in Eastern Ghats Lambasingi, Chinthapalli Mandal, Visakhapatnam District, Andhra Pradesh, India

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ABSTRACT

The increase in earth's average temperature is the results of increase in the concentration of greenhouse gases (GHGs). The present study was conducted by estimating the aboveground and belowground carbon sequestration potential of tree species growing in forests of Lambasingi, Chinthapalli, area of Visakhapatnam District, Andhra Pradesh, India. 155 tree species which belong to 11 families were selected in quadrates by random sampling. The diameter at breast height (DBH) of each tree was determined by using ground measurements. The species with large canopy were selected for the estimation of biomass with the DBH of the tree height. The aboveground and belowground organic carbon (tC) and total organic carbon (ton) of each species was calculated. The total biomass and carbon sequestrated by the tree species was estimated using non-destructive method and allometric equations. The study showed that the lowest carbon storage value was recorded in *Bambusa vulgaris* species, i.e. 0.0197tC, and *Seema accidentalis* i.e. 0.0411tC and the maxmum storage value was recorded in *Mangifera indica speces*, i.e. 5.2729tC and *Tamerindus indica* i.e 4.2252tC. The tree species which were experimented are very essential and major components of tribal forestry and agro forestry.

Key words: *Carbon sequestration, Biomass, Non-destructive method, Total organic carbon, Tree species etc.*

Introduction

The major problem faced by human race is global warming; the global temperature is rising due to anthropogenic activities. Carbon sequestration is a process of mining the carbon dioxide from the environment and storing in the global ecosystems for a long period of instance. The major causes were believed to be burning of fossil fuel, which is releasing increasing of carbon dioxide levels in the atmosphere. Developmental man made activities and the enhancement of modern transportation is also rising the levels of air pollutants such as greenhouse gases, especially CO_2 (Chavan and Rasal, 2010). Carbon dioxide is the major greenhouse gas responsible to be precipitating global warming. Carbon released from the land use patterns which contributes to the increasing of atmospheric carbon in the air releases from land-use change may also contribute to increasing atmospheric carbon, i.e through the change of land using patterns from forest land converting to agricultural or crop land. Even though land-using patterns are commonly known to be the secondary source of net carbon releasing into the atmosphere. It was estimated that over the last 10,000 years, 20–40% of ecosystem biomass have been vanished due to anthropogenic activities. This suggests an upper limit of the sequestration potential is in the order of

600—1,200 billion tons (Gts) of carbon (Watson *et al.,* 2000). Carbon is stored in different ways in the natural stocks of the environment. The natural stocks of the environment are like oceans, deposits of fossil fuels, terrestrial ecosystems and the atmosphere of the earth. In terrestrial ecosystem sequestration of carbon takes place in forests, rocks, sediments, wet lands and in the soil of the forest, grassland, and agricultural lands. Plants and trees store carbon in them as long as they survive n the earth, in terms of live biomass. The plant biomass becomes a part of food chain when they die and assimilate in to the soil as soil organic carbon. When the biomass is incinerated the carbon from plants is reemitted in to the atmosphere. Trees act the stock of CO_2 by the intake of carbon dioxide during the process of photosynthesis and store excess of them as biomass. Forest ecosystem of the globe plays a vital role in the total carbon cycle by sequestering a significant quantity of carbon dioxide from the environment (Vashum and Jay Kumar, 2012). Trees, unlike annual plants that die and decompose yearly, are long-lived plants that develop a large biomass, thereby capture more amount of carbon over a growth cycle of many years. Thus, a forest ecosystem can capture and retain large volumes of carbon over long periods.

The Intergovernmental Panel on Climate Change (IPCC) estimates that appropriate policy would increase the level of carbon sequestered as a carbon pool in the terrestrial system by up to 100 Gts over the level of carbon that would be sequestered without that policy (IPCC, 2001). Believed to have existed in much earlier times or that is estimated under certain circumstances (IPCC, 2001). The increasing carbon emission is of major concerns, and addressed in Kyoto Protocol (Ravindranath *et al.,* 1997).

Natural forests, forest plantations, agro forestry practices and some other agricultural activities act as a sink for carbon dioxide (CO_2) through photosynthesis and store carbon as biomass (David and Crane, 2002; Thangata and Hildebran, 2012). They reduce the amount of CO_2 in the atmosphere, and provide benefit to the global climate. Biomass is an essential aspect of studies of carbon cycle (Cairns *et al*., 2003; Ketterings *et al.,* 2001). There are two methods to calculate forest biomass, one is direct method and the other is indirect method (Salazar *et al*., 2010). Direct methods, also known as destructive methods, involves of felling trees to determine biomass (Parresol, 1999; Salazar *et al.,* 2010). Indirect means of estimation of stand biomass are based on allometric equations using measurable parameters.

The use of circumference or girth at breast height alone (expressing the basal area) for above-ground biomass estimation is common to many studies that showed that diameter at breast height (DBH) is one of the universally used predictors, because it shows a high correlation with all tree biomass components and easy to obtain accurately (Razakamanarivo *et al*., 2012; Antonio *et al*., 2007; Heinsoo *et al.,* 2002; Zianis, 2008).

The work was conducted by finding the diameter and breast height for the available trees species in Lambasingi of Visakhapatnam district Andhra Pradesh. The study was aimed in estimation of biomass and the amount of carbon sequestrated in different tree spices found in this area and accordingly to conclude the reasons of low temperature during winter as low as to 0 ^{0}C.

Materials and Methods

Sampling Area

The sampling area is a remote tribal area with green vegetation and thick forest. Situated on the Eastern Ghats of Visakhapatnam District, Andhra Pradesh. India. The geographical location lies between 17^{o}44′22" North latitude to 18^{o}04′29" East to 82^{o}38′04", Altitude of 2834 feet of Visakhapatnam district. The climate in this region is tropical climate with 23.4 °C mean annual temperature. The maximum temperature exceed 39 ^{o}C, and minimums is around 30 ^{o}C in summer and this place is recorded to be the coldest place in Andhra Pradesh, temperatures as low as 0 °C during December – January. The area receives an average rainfall of 1231mm and comprises of tropical semi-evergreen forests, which are moist deciduous forests. The Eastern Ghats of Andhra Pradesh is one of the most unique landscapes in India and comprised of complex geological formations and deposits. Soils found to be black and red type on hills and ranges. Vegetation includes coffee plantation, understory of evergreen trees and an emergent canopy of taller deciduous trees. The most common plant genera are *Michelia champaca, Artocarpus lakoocha, Dillenia pentagyna, Bridelia tomentosa, Xylia xylocarpa, Psychortia fulva, Leea crispa and Boehmeria platyphylla.*

Sampling method

Quadrats method

The study was carried in Chinthapalli range, Lambasingi area, during October and November of 2019, the total carbon sequestration of plant species was done by using non destructive methods such as field survey, Species identification, laboratory analysis and calculations by using allometric equations. Small square plots, which are named as quadrats are taken randomly to avoid choosing unrepresentative. To estimate the tree population quadrat method was adopted, plotted area was subdivided into 40m x 40m quadrats to facilitate the different types of species for data collation. To determine the density, basal area, above below ground biomass (AGB) and below ground biomass (BGB) of the tree was used.

The Size of Quadrat: 40m x 40m

No. of Quadrats: 4

Total Area Studied: 6400m^2

For the estimation of above the ground biomass the following parameters were measured

Height measurement

To determine the biomass from selective tree species in the local forest non destructive method was adopted by not cutting the tree or plant. The Biomass was estimated by measuring the diameter at breast height (DBH) directly and the girth at DBH of the tree Girth considered is the DBH (Chavan *et al.*, 2010).

Above Ground Biomass of Tree

Above Ground Biomass of Tree include all living biomass which is above the ground. The biomass above ground of the tree (AGB) was calculated by multiplying volume of biomass and wood density the volume was calculated based on diameter and height (Pandya *et al*., 2013). The wood density value for the species obtained from web (www.worldagroforestry.org)

The diameter (D) of the tree was measured (3.14) to the actual marked girth of species, i.e. GBH/3.14. Biomass was calculated by bio-statistics based allometric equations. Above ground Biomass (AGB) of the tree was calculated by multiplying the bio-volume to the wood density of the plant species. The bio-volume (TBV) of the tree was determined by multiplying the diameter and height of tree to factor 0.4.

Bio-volume (T) = 0.4 X (D) x H

AGB=Wood density x Bio-volume T

Where; (meter) calculated from GBH, assuming the trunk of the tree to be cylindrical,

H = Height in meters. Wood density is used from Global wood density database, (Zanne *et al*., 2009). The standard average density of 0.6 g/ cm is applicable, wherever the density value is not available for tree species.

Below Ground Biomass of Tree

The below ground biomass (BGB) which are all biomass of tree below the ground, live roots (Chavan and Rasal, 2011; 2012). The below ground biomass (BGB) has been calculated by multiplying above ground biomass taking 0.26 as the root shoot ratio (Chavan and Rasal, 2011; Hangarge *et al.*, 2012). The below ground biomass has been calculated by multiplying the above ground biomass (AGB) by 0.26 factors as the root: shoot ratio (Hangarge *et al*., 2012).

BGB=AGB x 0.26

Total biomass is the sum of the above and below ground biomass. (Sheikh *et al.*, 2011)

Total Biomass (TB) = Above Ground Biomass + Below Ground Biomass

BGB (g) = 0.26 X above ground biomass (ton).

Total Biomass

Total biomass is the sum of the above and below ground biomass. (Sheikh *et al.*, 2011). Total Biomass (TB) = Above Ground Biomass + Below Ground Biomass

TB = AGB + BGB

Carbon Estimation

Generally, for any plant species 50% of its biomass is considered as carbon (Pearson *et al*., 2005), i.e. Carbon Storage = Biomass x50%or Biomass/2

Results and Discusson

The carbon sequestration assessment and storage potential of 155 trees belong to twenty (20) species selected within in sites of Lambasingi of Visakhapatnam district, Andhra Pradesh was certained for data collection. The Investigation was carried out in the study area by quadrat methods, tabulated in Table 1. The data reveal that the spices *Trichilia conneroides* and *Eucalyptus globules* are the most common and prominent in each quadrant comparatively *Delonix regia* and *caryota urens* tree spices which are less in number in each quadrat. The

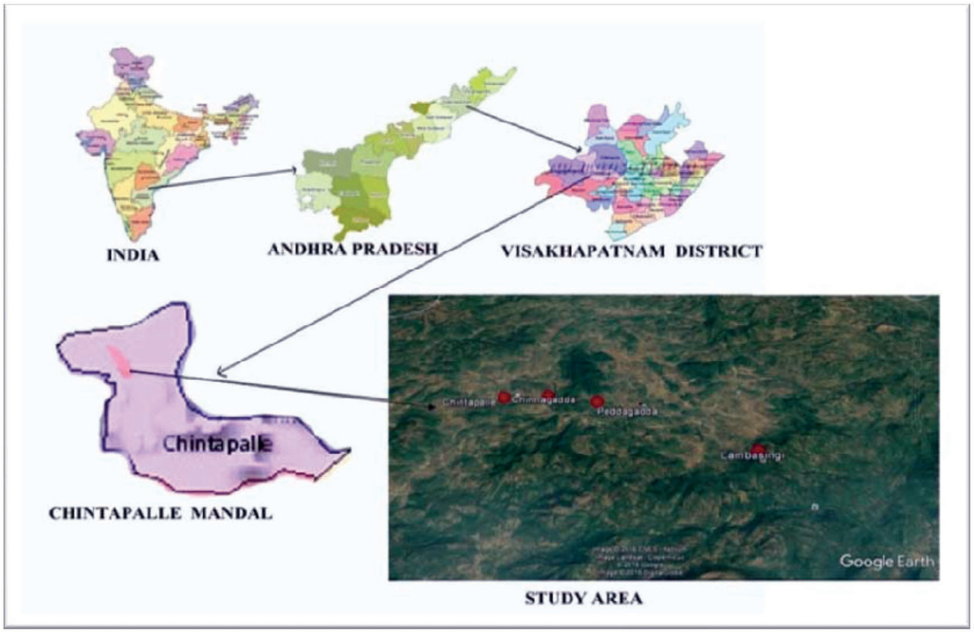

Fig. 1. Sampling Locations in the Study area.

field report was tabulated in the Table 2 in the Table below 19 spices including of 155 individual species were recorded. The average GBH biomass was calculated by the average tree high (H) of each tree species in meters. The total amount of organic carbon of each tree species was estimated in tones, the total amount of organic carbon sequestrated in 155 trees have been presented in the Table 3. The mean organic carbon (AGC) per tree (t/tree) which above the ground, and the mean organic carbon (BGC) per tree (t/tree) below the ground was calculated by using the with allometric model and the estimated total organic carbon (biomass) have been compared with other similar findings. The belowground biom-

Table 1. Tree species and their physiological data Lambasingi village, Chinthapalli

S. No.	Vernacular Name	Scientific Name of Trees	Family names	Number of Trees	Average GBHm	Average Height
1	Bodde	*Ficus Semicordata*	*Moraceae*	5	1.15m	10m
2	Dundilam	*Oroxylum Indicum*	*Bignoniaceae*	6	57cm	12m
3	Usiri	*Phyllanthus emblica*	*Phyllanthaceae*	10	40cm	5m
4	Peddaturayi Chettu	*Delonix regia*	*Fabaceae*	4	2.56m	31m
5	Neredu	*Syzygium cumini*	*Myrtaceae*	9	2.08m	20m
6	Teak chettu	*Tectona grandis*	*Lamiaceae*	9	1m	25m
7	Kanugu	*Mellettia piunata*	*Fabaceae*	8	1.35m	17m
8	Panasa	*Artocorpus heterophyllus*	*Moraceae*	6	2.3m	25m
9	Bhutvasamu tadim	*Trichilia conneroides*	*Meliaceae*	14	50cm	7m
10	Chinta	*Tamerindus indica*	*Fabaceae*	9	2.80m	32m
11	Mamidi	*Mangifera indica*	*Anacardiaceae*	8	3.23m	30m
12	Neelagiri	*Eucalyptus globules*	*Myrtaceae*	11	2.5m	41m
13	Adda theege	*Bauhinia vahlii*	*Fabaceae*	10	60cm	15m
14	Raavi	*Ficus religiosa*	*Moraceae*	9	2.13m	19m
15	Medi	*Ficus beghalenis*	*Moraceae*	8	2.17m	21m
16	Nallajidi	*Semecurpus*	*Anacardiaceaae*	10	98cm	8m
17	Veduru	*Bambusa vulgaris*	*Poaceae*	8	20cm	30m
18	Seema regi	*Seema accidentalis*	*Fabaceae*	7	45cm	5m
19	Jeelugu	*caryota urens*	*Arecaceae*	4	1.78cm	25m

ass (BGB) has been calculated by multiplying above ground biomass taking 0.26 as the root shoot ratio (Chavan and Rasal, 2011; Hangargeet *et al.*, 2012). The lowest carbon storage efficiency was estimated in *Bambusa vulgaris* species is 0.0197 °C, and *Seema accidentalis* is 0.0411 °C and the maximum carbon storage efficiency was recorded in *Mangifera indica speces*, is 5.2729 °C and *Tamerindus indica* is 4.2252 °C. In Similar to it, a study in the agricultural fields of block Ramgarh revealed *Mangifera indica* as the most dense tree species with density value of 1.9 trees per hectare followed by *Melia azedarach* having density of 1.1 trees per hectare (Kour and Sharma, 2014). The other major carbon sequestrating species were *Syzygium cumini* (1.85 t/ha) and *Mangifera indica* (1.06 t/ha) (Kulvinder Kour and Sanjay Sharma, 2016). This difference in value of Total (°C) for all the species may be due to geographic location variances with difference in location temperature, rain pattern , soil contents and pH, which strongly effects the tree growth. From the above equations and the report one can easily estimate and calculate the ecological significance of these tree species. As the Diameter of the tree species increases its biomass and carbon storage capacity increase also sequester more carbon removes more carbon dioxide from atmosphere (Panday *et al*., 2013). Total average carbon sequestered was 25.158tC, Carbon sequestration capacity of tree increases as the age increases (Kulvinder Kour *et al*., 2016). Fig. 2 graphically rep-

Table 2. The standard densities of wood of tree species, which others wood densities are consider as 0.6 g/cm^3

Sr. No.	Vernacular name	Scientific name	Wood density g/cm^3
1	Subabhule	*Acacia nilotica*	0.6
2	Shirish	*Albizia lebbeck*	0.61
3	Neem	*Azadirachta indica*	0.69
4	Palas	*Butea monosperma*	0.48
5	Sissam	*Dalbergia sisso*	0.62
6	Gulmohar	*Delonix regia*	0.51
7	Nilgiri	*Eucalyptus citriodora*	0.51
8	Madhushevaga	*Moringa olifera*	0.39
9	Pilmohar	*Peltaforum pterocarpum*	0.62
10	Teak	*Tectona grandis*	0.55

Standard wood densities of tree species (www.worldagroforestry.Org)

Table 3. Physiological Data and calculation of Total organic carbon of each tree species

S. No.	Vernacular Name	Scientific Name of Trees	Number of Trees	Average GBHcm	Average Height meter	Average organic carbon t/individul			Organic carbon Ton/ tree
						AGB	BGB	Total	
1	Bodde	*Ficus Semicordata*	5	1.15m	10m	0.321	0.083	0.404	0.202
2	Dundilam	*Oroxylum Indicum*	6	57cm	12m	0.943	0.245	1.1883	0.5941
3	Usiri	*Phyllanthus emblica*	10	40cm	5m	0.192	0.049	0.2419	0.1209
4	Peddaturayi Chettu	*Delonix regia*	4	2.56m	31m	4.942	1.2848	6.226	3.113
5	Neredu	*Syzygium cumini*	9	2.08m	20m	2.1035	0.5469	2.6504	1.3252
6	Teak chettu	*Tectona grandis*	9	1m	25m	0.5561	0.1446	0.7007	0.3503
7	Kanugu	*Mellettia piunata*	8	1.35m	17m	1.2514	0.3253	1.5767	0.7883
8	Panasa	*Artocorpus heterophyllus*	6	2.3m	25m	3.5364	0.9194	4.4558	2.2279
9	Bhutvasamu tadim	*Trichilia conneroides*	14	50cm	7m	0.462	0.1201	0.5821	0.2910
10	Chinta	*Tamerindus indica*	9	2.80m	32m	6.7067	1.7437	8.4504	4.2252
11	Mamidi	*Mangifera indica*	8	3.23m	30m	8.3697	2.1761	10.545	5.2729
12	Neelagiri	*Eucalyptus globulus*	11	2.5m	41m	2.2995	1.3778	3.6773	1.8386
13	Adda theege	*Bauhinia vahlii*	10	60cm	15m	0.1444	0.0375	0.1819	0.0909
14	Raavi	*Ficus religiosa*	9	2.13m	20m	2.4271	0.6310	3.0581	1.52905
15	Medi	*Ficus beghalenis*	8	2.17m	21m	2.6471	0.6882	3.3356	1.6676
16	Nallajidi	*Semecurpus*	10	98cm	8m	0.2055	0.0534	0.2589	0.1294
17	Veduru	*Bambusa vulgaris*	8	20cm	30m	0.0314	0.0081	0.0395	0.0197
18	Seema regi	*Seema accidentalis*	7	45cm	5m	0.0271	0.0070	0.0341	0.0411
19	Jeelugu	*caryota urens*	4	1.78cm	25m	2.1143	0.5497	2.6633	1.3316
	Total trees		155	Total carbon sequester				25.1587	

resents the total carbon stock of each trees in t/tree.

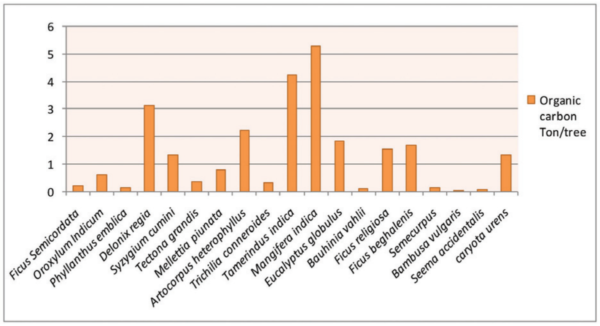

Fig. 2. Total organic carbon of trees in t/tree

Conclusion

It is concluded that older trees have higher carbon content than younger trees. The older trees are reserve banks of carbons compared to less aged trees. The Findings revealed that area has no major and minor industries located which are the sources for CO_2, the area is not a developed Village where traffic pollution exists, and this is hilly tribal area with thick green covered vegetation. The temperature tumbles down in winter may be due to more carbon sequestration by tree species, moreover the species harvest more CO_2 from the Atmosphere.

To protect the Earth from Global temperature rise and alteration of climate sustainable management of forests resources with the goal of carbon sequestration should be managed properly. Forest ecosystems play a good role in global terrestrial carbon cycle owing to their huge carbon pool and high productivity (Schlesinger *et al.,* 1997). The results of this study would be helpful for Forest Department in decision making and planning about the huge tree plantation in the greater cites industrial areas and remote hilly areas in encouraging the lay man in afforesting the hilly tribal areas of Andhra Pradesh. Planting more trees in developed cities can be a probable provider in decreasing the amount of CO_2 in the globe (Chavan and Rasal, 2010). The result has made clear guide on the type of tree species that should be planted for the sequestration of CO_2 and CO gases for effective sequestration purpose.

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