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Carbon pool analysis of standing trees in urban parks in Jabalpur city of Madhya Pradesh

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Abstract

Urban parks and gardens are considered as lungs of the cities and urban areas play significant role in global carbon cycle. Under the current examination, a study was carried out in one park and two gardens of cantonment area of Jabalpur, Madhya Pradesh. Carbon sequestration by standing trees were estimated in two gardens namely Tagore Garden (3 ha.) and Suramya Garden (1.25 ha.) alongwith one Children's Park (1.0 ha.) monitored and governed by the Jabalpur Cantonment Board. Carbon pool analysis is also taken into account for tree species in these three gardens. Total standing trees inside these two gardens and one park are 197, 86 and 132 respectively. Carbon sequestration in Tagore Garden was recorded highest 132.067 tons followed by 56.771 tons in Children's Park and 27.67 tons in Suramya Garden. Number of different tree species found were maximum in Tagore garden (37) followed by Children's Park (22) and Suramya Garden (16). Among 37 different species in Tagore Garden, Fishtail Palm (*Caryota urens*) was in maximum number (33) followed by Mango (*Mangifera indica*) 29 and Jackfruit (*Artocarpus heterophyllus*) and Bottle Palm (*Hyophorbe lagenicaulis*) both 18.Total carbon sequestration by these species are 10.78, 20.08 and 18.82 tons, respectively. In Children's Park, Jamun (*Syzygium cumini*) was found maximum in numbers (38) followed by Mango (*Mangifera indica*) and Bottle Palm (*Hyophorbe labenicaulis*) both 20. Total Carbon sequestration by these species are 19.49, 6.90 and 1.60 tons, respectively. Suramya Garden is dominantly spread by one species i.e. Fish tail Palm (*Caryota urens*) as there are 47 trees found in the garden, next in terms of number is Kachnar *(Bahunia variegata*) as there were only 10 trees. Benefits from trees in climate mitigation and value of urban parks to well being of local communities in terms of health and other benefits are discussed in this paper. Carbon pool analysis was done to observe rate of carbon sequestration by each species.

Key words: *Carbon sequestration, parks and garden, climate change mitigation, Public health.*

Introduction, scope and main objectives

Urban forestry means managing of trees for their contribution to the physiological, sociological and economic well being of the urban society (FAO, 2010). Rapid urbanization in the country will be one of the most dominant trends in the coming years. As population expands and incomes grow, this shift will likely be realized alongside demographic changes

that will exponentially increase the demand for urban amenities like housing, energy, transport, water, waste and disposal (GoI, MoSPI 2015). By 2030, urban areas are projected to increase by an estimated 50 percent. High population density will lead to several challenges and a significant impact on environment is expected.

Green spaces in the form of gardens, parks and roadside plantations will have to be created on all available spaces to offset carbon emissions. Besides, tree canopies provide a cooling effect by shading the areas. The net saving in carbon emissions that can be achieved by urban planting can be up to 18 kg CO_2/ year per tree and this benefit corresponds to that provided by 3 to 5 forest trees of similar size and health (Ferrini and Fini, 2011).

As far as Madhya Pradesh is concerned, it has a total population of 72.63 million (Census, 2011) accounting to 6 percent of India's population. The rural and urban population stands at 72.37% and 27.63% respectively (FSI, 2019). Cities perform an important role in global carbon cycle by emitting larger amounts of CO2 due to more energy consumption, transportation, and conversion of natural land to constructed environment (Churkina, 2008). Development of sustainable green cities is the need of today's fast urbanizing world. Nearly half of India's population will soon be living in urban areas.

Trees are important basis for atmospheric carbon i.e., carbon dioxide, as 50% of their standing biomass is carbon itself (Ravindranath *et al.*, 1997).

Waran and Patwardhan (2005) estimated carbon sequestration potential in urban plantations of Pune city. The rate of carbon sequestration by the trees was estimated to be 15,000 tons per year.

Study by Kiran and Kinnary, (2011) on carbon sequestration by urban trees revealed that trees in Vadodara city sequestered 73.59 tones of carbon which amounted 22% of estimated total CO_2 production in the city. Total CO_2 emission at major roads was found around 159.47 tons.

Study by Gandherwa and Bhattacharya, (2019) revealed that in parks and gardens of in South Delhi, young trees stock more carbon. Parks and gardens also perform vital function of biodiversity conservation. According to their study, they have estimated 66.93 tons of carbon stored in sample trees in Lodi garden and 14.49 tons of carbon in DDA park, Delhi. In their study, they have calculated the carbon content in tons only from sample trees in these two gardens of Delhi.

Since only few attempt have been made to study the potential of trees in carbon sequestration from urban areas in Pune and Vadodara cities. There is need for undertaking more studies.

Parks and gardens of Jabalpur

In Jabalpur Municipal Corporation there are 190 parks and gardens of different sizes between 0.2 ha. to 05 ha. There are three gardens maintained by Cantonment Board, Jabalpur

as given in Table 1. All secondary information of the parks and gardens of Cantonment Board was taken.

Table-1: List of sampled parks and gardens developed by Cantonment Board, Jabalpur

S.N.	Name of Parks/Gardens and Location	GPS location	Major tree species	Area in ha.	Total no. of trees
1.	Tagore Garden, Sadar, Jabalpur	N-23.156 E-79.948	*Hyophorbe laginicaulis, Caryota urens, Artocarpus heterophyllus*	3	197
2.	Suramya Garden, Cantt. Ridge Road, Jabalpur	N-23.158 E-79.961	*Polyalthia longifolia, Syzygium cumini*	1.25	86
3.	Children's Park, Cantt. Ridge Road, Jabalpur	N-23.160 E-79.959	*Polyalthia longifolia, Syzygium cumini*	1	132

Objective

To estimate carbon sequestration by different species in Parks and Gardens of Cantonment Board in Jabalpur.

Methodology/approach

Selection of sample trees for measurement was done in parks/gardens. Sample plots of 31.62 m x 31.62 m size were laid and four such plots were laid, one in each of the four corners of each park and garden. From the data obtained from the measurement in those four plots, the average number of trees and carbon sequestered per tree per unit area was calculated and multiplied by the total area of the park/garden to obtain the estimated values for the whole park/garden.

A non-destructive sampling approach was adopted to estimate the above ground tree biomass in different trees. An attempt was made to select sample plots in all large gardens having size of more than 05 hac and more and in all density classes. Nested two stage sampling approach was adopted to sample trees. A super plot of 250m x 250m size, was laid in each of the several sites. Four sample plots, each of 31.62m x 31.62m (0.1 ha) size, were laid within each super plot.

Results

There are one medium sized and two small sized parks/gardens. Tagore garden is medium sized garden which has sequestered 132.067 tons of carbon by 197 different trees. It is because of the larger sizes of trees both in terms of height (up to 20-22 mt.) and girth (270-300 cm). Table 2 shows the species wise list of the trees in Tagore garden with carbon content. It can be seen from the table that there are as many as 37 different species of trees of different age groups. Average carbon content per tree varies from as low as 0.003 ton in case of *Tectona grandis* to as high as 7.572 tons in case of *Ficus benghalnensis*. Tagore garden is also one of the oldest garden of Jabalpur.

The size of Suramya Garden is 1.25 ha. Children‟s Park, Cantt. has sequestered 56.771 tons of carbon, followed by Suramya Garden with 27.673 tons.

Total-2: Carbon content in Parks and Gardens of Cantonment Board, Jabalpur

S. No.	Name of Parks	Area (ha)	Total No. of trees	Total carbon (tons)
A. Large-sized Gardens				
1.	Tagore Garden, Cant., Sadar, Jabalpur	3.000	197	132.067
2.	Suramya Garden, Ridge Road, Jabalpur	1.250	86	27.67
3.	Children's Park, Cant., Ridge Road, Jabalpur	1.000	132	56.771
Total carbon (A)			**415**	**216.508**

Table-3: Carbon sequestration in Tagore Garden, Sadar, Jabalpur

S.No.	Species	Total no. of trees	Avg. carbon per tree (ton)	Total carbon (tons)
1.	*Aegle marmelos*	2	0.345	0.689
2.	*Artocarpus lacucha*	9	0.769	6.921
3.	*Artocarpus heterophyllus*	18	1.046	18.822
4.	*Azadirachta indica*	2	0.248	0.495
5.	*Bombax ceiba*	3	0.635	1.904
6.	*Bridelia retusa*	2	0.580	1.159
7.	*Caryota urens*	33	0.327	10.785
8.	*Casuarina equisetifolia*	2	0.554	1.108
9.	*Ceiba pentandra*	3	0.555	1.666
10.	*Cocos nucifera*	3	0.198	0.593
11.	*Delonix regia*	2	0.344	0.687
12.	*Dypsis lutescens*	3	0.008	0.024
13.	*Eucalyptus tereticornis*	8	0.806	6.451
14.	*Ficus benghalensis*	2	5.694	11.387
15.	*Ficus racemosa*	2	3.882	7.763
16.	*Ficus religiosa*	3	0.187	0.562
17.	*Gmelina arborea*	2	0.007	0.014
18.	*Grevillea robusta*	2	0.134	0.268
19.	*Hyophorbe lagenicaulis*	18	0.490	8.824
20.	*Jacaranda mimosifolia*	2	0.189	0.377
21.	*Livistona chinensis*	2	0.073	0.146
22.	*Madhuca indica*	2	0.058	0.116
23.	*Magnolia champaca*	5	0.112	0.559
24.	*Mangifera indica*	29	0.693	20.086
25.	*Manilkara hexandra*	2	0.344	0.687
26.	*Mimusops elengi*	5	0.419	2.093
27.	*Mitragyna parviflora*	3	0.514	1.543
28.	*Neolamarckia cadamba*	2	1.172	2.343

29.	*Nyctanthes arbor-tristis*	3	0.011	0.033
30.	*Phyllanthus emblica*	5	0.258	1.290
31.	*Polyalthia longifolia*	12	0.932	11.188
32.	*Syzygium cumini*	2	0.748	1.496
33.	*Tamarindus indica*	5	1.845	9.226
34.	*Tecoma stans*	3	0.003	0.009
35.	*Tectona grandis*	3	0.196	0.589
36.	*Terminalia bellirica*	2	0.071	0.141
37.	*Terminalia catappa*	2	0.010	0.020
Total		**197**		**132.067**

Table-4: Carbon sequestration in Suramya Garden, Ridge Road, Jabalpur

S.No.	Species	Total no. of trees	Avg. carbon per tree (ton)	Total carbon (tons)
1.	*Aegle marmelos*	1	0.027	0.027
2.	*Azadirachta indica*	3	0.421	1.263
3.	*Bauhinia variegata*	10	0.026	0.260
4.	*Butea monosperma*	4	0.142	0.568
5.	*Caryota urens*	47	0.189	8.883
6.	*Dalbergia sissoo*	2	0.046	0.092
7.	*Delonix regia*	1	0.016	0.016
8.	*Ficus religiosa*	1	2.024	2.024
9.	*Hyophorbe lagenicaulis*	1	0.118	0.118
10.	*Leucaena leucocephala*	1	0.541	0.541
11.	*Mangifera indica*	2	3.042	6.084
12.	*Nyctanthes arbor-tristis*	1	0.029	0.029
13.	*Pithecellobium dulce*	1	0.408	0.408
14.	*Polyalthia longifolia*	2	2.573	5.146
15.	*Spathodea campanulata*	3	0.152	0.456
16.	*Ziziphus mauritiana*	6	0.293	1.758
Total		**86**		**27.673**

Table-5: Carbon sequestration in Children's Park, Ridge Road, Jabalpur

S.No.	Species	Total no. of trees	Avg. carbon per tree (ton)	Total Carbon (tons)
1.	*Albizia lebbeck*	1	0.560	0.560
2.	*Araucaria araucana*	3	0.003	0.009
3.	*Azadirachta indica*	6	0.325	1.950
4.	*Bauhinia variegata*	1	0.436	0.436
5.	*Bombax ceiba*	2	0.104	0.208
6.	*Bridelia retusa*	2	0.324	0.648
7.	*Cascabela thevetia*	2	0.065	0.130

8.	*Dalbergia sissoo*	1	0.165	0.165
9.	*Eucalyptus tereticornis*	5	0.888	4.440
10.	*Ficus benghalensis*	3	1.670	5.010
11.	*Ficus racemosa*	2	1.028	2.056
12.	*Ficus religiosa*	3	2.054	6.162
13.	*Hyophorbe lagenicaulis*	20	0.080	1.600
14.	*Madhuca latifolia*	1	0.288	0.288
15.	*Mangifera indica*	20	0.345	6.900
16.	*Milletia pinnata*	1	0.528	0.528
17.	*Moringa olifera*	1	0.821	0.821
18.	*Phyllanthus officinalis*	5	0.065	0.325
19.	*Pithecellobium dulce*	9	0.469	4.221
20.	*Polyalthia longifolia*	1	0.670	0.670
21.	*Psidium guajava*	4	0.035	0.140
22.	*Sterculia urens*	1	0.010	0.010
23.	*Syzgium cumini*	38	0.513	19.494
Total		**132**		**56.771**

On the basis of sampled parks/gardens of Jabalpur carbon content is 216.508 ton by parks and gardens of Cantonment Board.

Discussion

Many researchers have already reported the importance of parks and gardens in urban cities. In fact, the parks and gardens are considered as lungs of the cities (Shinde and Mahajan, 2015). Another research by Choudhry and Tewari, (2010) suggested that although man made greenery can not compensate nature's green cover, yet it plays a significant role in attracting domestic tourists towards a city of parks/gardens in a developing country like India. Trees in parks and gardens not only make them beautiful but also play an important role in purifying the air. Here, we are discussing the suitable trees that should be planted in any park or garden of a city. These recommendations have been arrived on basis of earlier findings and also on basis of existing trees which are found in different parks and gardens of Jabalpur.

As can be seen from the Tables 3 to 5 52 tree species were found in the three parks. The study by Shinde and Mahajan, (2015) has already reported that Chittaranjan Vatika of Pune was dominated by *Cassia siamia, Delonix regia, Milintona hotensis, Putranjiva roxburghii, Peltoforum mermi, Saraca indica* and *Spathodea campanulata.* Trees in terms of higher carbon sequestration, *Ficus benghalensis* showed the highest carbon sequestration followed by *Albizia lebbeck, Delonix regia* and *Pithecelobium dulce*.

In our study, barring species like *Ficus benghalensis, Ficus racemosa, Ficus religiosa, Mangifera indica* and *Polyalthia longifolia,* all species have been found and *Ficus*

benghalensis, Ficus racemosa and Mangifera indica are in the list of sequestering higher carbon as compared to others.

Biodiversity has a direct link to human wellbeing (e.g., through nature experience), while it also provides an important base for ecosystem functioning and thus a range of ecosystem services. (Hooper *et al.*, 2005). Air quality and carbon sequestration: positive impacts of urban parks in terms of reducing air pollutant levels and carbon sequestration (Konijnendijk *et al.*, 2013).

Since urban centres have small spaces for greening, careful selection of tree/shrub species based on the soil type and climatic conditions should be done. Many common exotic species have been observed in Parks. The studied parks were developed with combination of both native and exotic species. Native species already existed in the area earlier during the development of these parks. They were retained and being older provided good canopy cover. In development of landscaped Parks, species providing aesthetic, environmental values-carbon sequestration, habitat to other species and other utilitarian values may be considered. Urban vegetation includes trees, shrubs and herbs on public and private lands (parks, streets, backyards), all interspersed within a landscape dominated by paved surfaces. This kind of vegetation plays a vital role in moderating micro climate, sequestering greenhouse gases (CO_2, etc.) and also in aiding the percolation of water (Ramachandra *et al.*,2014).

Conclusions

The following section, lists the tree species to be considered for planting along roadsides and parks and gardens in Jabalpur.

While considering the massive tree plantations, the indigenous species that support biodiversity should be given preference over exotic tree species like *Eucalyptus, Acacia auriculiformis*. Results obtained by working with *Anogeissus latifolia* indicates it's potential and can serve as the promising candidate for future afforestation programmes (Waran and Patwardhan, 2005).

The proximity of residential colonies to urban parks improves health and well being of communities, the physical fitness, provides clean air and climate. Communities attain well being; feel peaceful away from the busy and hurried life in urban centres. These parks and gardens play an important role in improving environment too.

In a populated country like India, these parks provide other amenities like shade of trees during the hot season; improve microclimate, besides sequestering carbon. They are also providing a habitat to wildlife especially birds and small animals. These are especially attractive to children and can be useful for connecting to nature and educational purposes.

In the coming decades Parks will emerge as important health centres. Thus cities will become sustainable only with healthy life and ample green spaces.

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