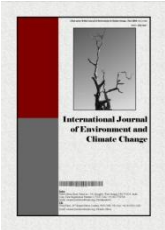

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# Oxygen Production and Carbon Capturing Capacity of Various Tree Species in Coimbatore City, India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Climate change, environment pollution, rapid urbanization and industrialization have been recognized as major environmental threats of the present-day scenario. These environmental issues cause severe socio-economic implications across the globe. The living space and human settlements are increasing rapidly in urban areas of India. Simultaneously the existing green cover and tree population are declining in the name of developments. Trees are considered to be one of the important assets in cities, they provide myriad benefits. Considering the importance of trees the cities and their role in reducing the pollution besides adding fresh oxygen to the atmosphere, the present investigation focused with the aim of documenting various tree species in Coimbatore city and to assess their carbon capturing and oxygen release potential. There are about 58 tree species comprising of 27 families, that have been documented and classified into four age classes. Further these tree species were subjected to total biomass, carbon stock, $CO_2$ (eq.), net carbon sequestration and net oxygen release assessment using standard non-destructive method. Among the 58 tree species studied, *Albizia lebbeck* (2.745 ton tree$^{-1}$year$^{-1}$), *Tamarindus indica* (2.156 ton tree$^{-1}$year$^{-1}$), *Parkia biglandulosa* (1.921 ton tree$^{-1}$year$^{-1}$), *Delonix regia* (1.027 ton tree$^{-1}$year$^{-1}$), *Kigelia Africana* (1.009 ton tree$^{-1}$year$^{-1}$), *Peltophorum pterocarpum* (1.006 ton tree$^{-1}$year$^{-1}$), *Ficus religiosa* (0.906 ton tree$^{-1}$year$^{-1}$), *Leucaena leucocephala* (0.804 ton tree-1year -1) of net oxygen were found to release, *Pterospermum acerifolium* (0.827 ton tree$^{-1}$year$^{-1}$) and *Azadirachta indica* (0.804 ton tree$^{-1}$year$^{-1}$) were found to release high oxygen with more carbon capturing capacity.

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*Keywords: Urban trees; air pollution; carbon stock; net carbon sequestration and net oxygen release.*

## 1. INTRODUCTION

Good air quality is an essential to welfare of human beings and other living things. The quality of air is deteriorating at faster rate through transportation, urbanisation, industrial and natural activities. Air pollution has adverse consequences on living things, human health, and environmental resources, either directly or indirectly [1]. Major air pollutants in the urban area are carbon dioxide ($CO_2$), carbon monoxide (CO), particulate matter ($PM_{2.5}$ and $PM_{10}$), hydrocarbons (HC), oxides of nitrogen ($NO_x$) and other fuel exhaust [2]. Carbon dioxide, the most significant of all greenhouse gases (GHGs) has gradually increased since the commencement of the industrialization, from 280 ppm to 415 ppm [3] and it is expected to rise above the level of 480 ppm by 2050 [4]. World Bank estimates, China and India have $CO_2$ emissions of 7.5 Mg and 1.6 Mg per person in a year respectively, whereas the United States has 17.5 Mg [5]. Trees are known to be more effective to combat air pollution, capture carbon and reduce ultraviolet radiation in addition to release of oxygen. [6] reported that trees control micro-climate by regulating carbon dioxide ($CO_2$), oxygen ($O_2$) sulphur dioxide ($SO_2$), particulate matter ($PM_{2.5}$ and $PM_{10}$), and ozone ($O_3$) [7,8]. According to [9] a hectare *Eucalyptus tereticornis* plantation release 431 ton of oxygen per year and sequestrated 161.8 ton of carbon in Dharwad, which plays a major role in improving air quality.

Coimbatore covers 4,732 $km^2$, of which 34.4% is under rapid urbanisation with more than 25,000 industries comprising textile mills, electroplating and manufacturing of industrial equipment, spares, motor pump sets [10]. Owing to the rapid urbanisation, the vegetation cover declined about 25.28% (9.60 $km^2$) which was 65.22 $km^2$ in 2003 and urban area coverage changed from 18.07% in 2003 to 54.32% [11]. In this regard, the government has initiated Smart City project emphasizing the increase of green cover. To successfully implement this project, an action plan with list of trees which has high carbon sequestrating, large canopy and high oxygen releasing capacity is vital. Hence, this study aims to screen the trees in a local region based on their carbon capture and oxygen release potential, and help the policy makers along with urban planners to understand the role of trees in global carbon cycle and climate change mitigation and for healthy living of people.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study area, Coimbatore city (11° 01' 2" N, 76° 57' 31" E), is the second-largest city located in Tamil Nadu. It is an upcoming smart city with a projected 2 million residents and is also known as the textile capital and the Manchester of South India, one of the most industrialized cities in Tamil Nadu. The annual rainfall is about 618 mm, and the average monthly temperature varies between 20.6 and 38.4°C. The carbon sequestration and oxygen production of the selected 58 tree species were carried out from three strategic locations Bharathi park (11°01'12" N, 76°56'50" E), Gandhi Park (11°00'03" N, 76°57'03" E) and VOC park (11°00'24" N, 76°58'12" E) (Fig. 1.) of Coimbatore city, India.

### 2.2 Site Survey

The primary biophysical measurements (Height and DBH) of identified 58 species were done by using laser rangefinder (Bosch Glm 500 Laser Distance Measurement Device) (Fig. 2a) and measuring tape (Fig. 2b). The location of the study area was recorded by Geographical Positioning System (GPS) Model (Garmin- eTrex Legend HCx) (Fig. 2c).

### 2.3 Tree DBH and Its Measurements

Tree DBH is a standard and the most common method of measuring the diameter of a tree trunk measured at breast level by using measuring tape (Fig. 2b.) as a convenient way of measurement during which one does not need to bend the waist or climb up a ladder to take the measurement. DBH or circumference of the tree was measured by tightly wrapping tape around the tree's main trunk at a height of 1.37 m from the ground [12]. During measurement, the tape was loosened and re-tighten a couple of times or slide around the trunk to ensure the tape lies flat and was not obstructed by any swollen parts of the trunk**.**

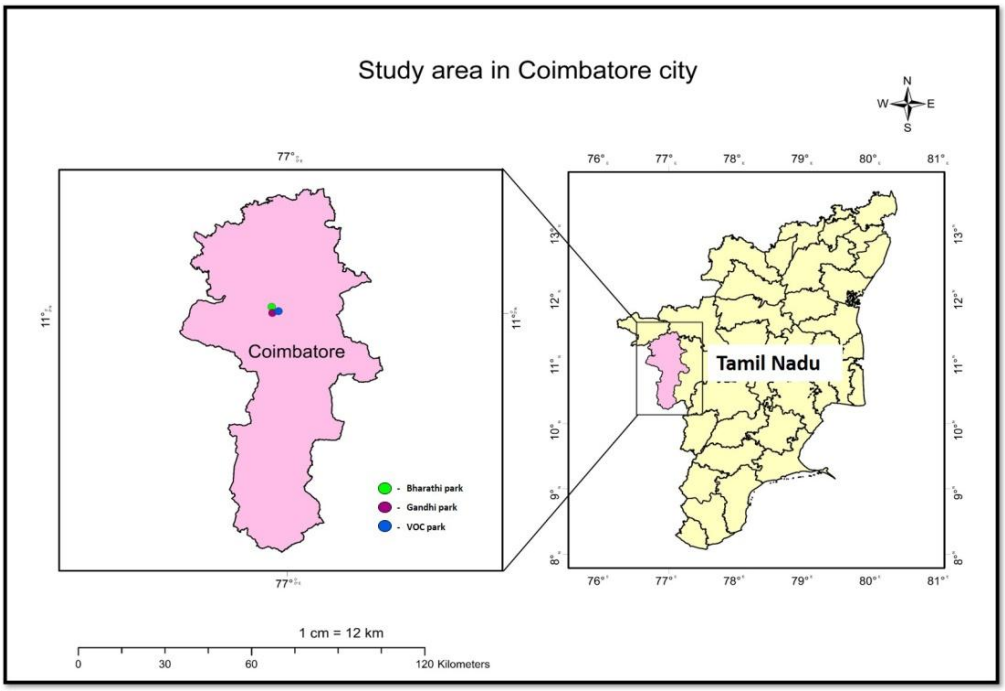


**Fig. 1. Location of the study area**

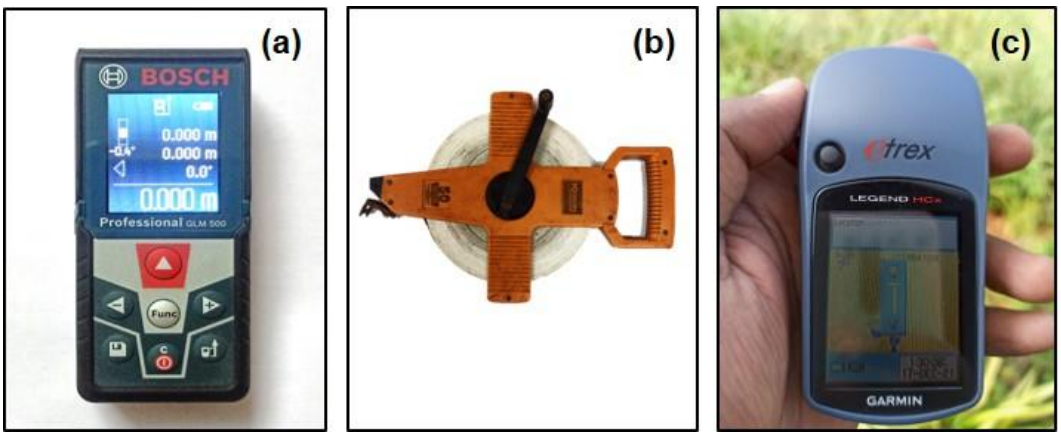


**Fig. 2. (a) Laser rangefinder (Bosch Glm 500 Laser Distance Measurement Device), (b) Measuring tape (c) Geographical Positioning System (GPS)**

## 2.4 Tree Height and Its Measurements

Tree height is a basic geometrical variable for trees as it has some vertical distance between the base of the tree and the foremost point on the tree [13]. The tree height was measured by using a laser rangefinder (Bosch Glm 500 Laser Distance Measurement Device) (Fig. 2a.). Laser rangefinder device works on the principle of using a laser beam, to determine the distance to an object (tree) and the device kept on a tripod stand for more accuracy. The device transmits a narrow laser beam towards the target (tree) and measures the time it takes for the pulse to be reflected off the target (tree) and returned to the sender. In order to make correct calculations of the vertical distance between any two points automatically as it works with one point at the top of the tree and another point at the base of the tree and thereby generates the tree height. After arriving tree DBH and height, net $O_2$ release and net C sequestration were calculated by the following procedure.

The basic parameters required for estimating net $O_2$ release (kg $yr^{-1}$) and net C sequestration (kg $yr^{-1}$), includes tree DBH, tree height, Total biomass, Carbon stock and $CO_2$ (eq.).

### 2.5.1 Measuring the tree volume

By using tree DBH and height, the volume of the tree was estimated [14].:

$$V = \pi r^2 h$$

Where,

V = Volume of the tree in $m^3$
r = Radius of the trunk in m
h = Height of the tree in m

### 2.5.2 Above ground biomass and below ground biomass

The Above Ground Biomass (AGB) was calculated by multiplying the volume of biomass and wood density, [15].

$$AGB = V \times D$$

Where,

AGB = Above Ground Biomass
V = Volume of tree in $m^3$
D = Wood density of the tree species*

*Wood density was obtained from the global wood density database [16]. The standard average density of 0.6 g/$cm^3$ is applied wherever the density value is not available for tree species. The Below Ground Biomass (BGB) was calculated by multiplying above-ground biomass with 0.26 as the root shoot ratio [14].

$$BGB = AGB \times 0.26$$

Total Biomass (TB) was calculated by summing the ABG and BGB [17].

$$\text{Total Biomass (TB)} = AGB + BGB$$

Where,

AGB = Above Ground Biomass.
BGB = Below Ground Biomass

### 2.5.3 Carbon sequestration potential of selected tree species

According to various scientific research reports, For any tree species, 50% of its biomass is considered as its carbon stock [18]. By using the following formula, the carbon stock of the tree species was calculated:

$$\text{Carbon stock} = \text{Total Biomass} \times 0.5$$

After arriving the Carbon stock of each tree, the carbon sequestrated potential in terms of $CO_2$ (eq.) was calculated by using the following formula:

$$CO_2\,(\text{eq.}) = (\text{Carbon stock} \times 44) / 12$$

$CO_2$ is composed of 2 molecules of Oxygen($O_2$) and 1 molecule of Carbon(C). The atomic weight of carbon is 12. The atomic weight of Oxygen is 16. Therefore, the weight of $CO_2$ is Carbon + (2 x Oxygen) = 44. The ratio of $CO_2$ to C is 44/12 = 3.666. So, to evaluate the carbon dioxide equivalent in the tree, multiply the carbon stock in the tree by 3.666.

The quantity of total $CO_2$ sequestered in terms of $CO_2$ (eq.) of the tree during its entire lifespan is represented by the above equation. To obtain a yearly C sequestration rate, the overall $CO_2$ equivalent by the tree was divided by its age [19].

$$\text{Net C sequestration} = CO_2\,(\text{eq.}) / \text{age of the tree}$$

### 2.5.4 Oxygen release by trees

The amount of oxygen produced during photosynthesis is subtracted from the amount of oxygen absorbed during plant respiration to calculate net oxygen production by trees [20].

Photosynthesis: $n(CO_2) + n(H_2O) + \text{light} \rightarrow (CH_2O)n + nO_2$

Respiration: $(CH_2O)n + nO_2 \rightarrow n(CO_2) + n(H_2O) + \text{energy}$

The tree will acquire carbon if carbon dioxide intake during photosynthesis exceeds carbon dioxide released during respiration over the course of the year (carbon sequestration). As a result, a tree that accumulates a net amount of carbon over the course of a year (tree growth) also produces a net amount of oxygen. Carbon sequestration produces an estimated quantity of oxygen based on atomic weights. Molecular weight of oxygen is 32 and molecular weight of carbon is 12. So, to evaluate the net $O_2$ release in the tree, multiply the net C sequestration in the tree by 32/12 [21].

Net oxygen production by trees is estimated by the following formula [21]:

Net $O_2$ release (kg $yr^{-1}$) = Net C sequestration (kg $yr^{-1}$) x 32 / 12

## 3. RESULTS AND DISCUSSION

The National Forest Policy (1988) stipulates that in order to maintain and increase the amount of forest cover, trees should cover one-third of each state's land area [22]. The government of Coimbatore has made huge initiatives to raise the number of trees in both forested and non-forested (urban) regions. The current study estimates carbon sequestration and oxygen production potential in Coimbatore city. To determine the ability of selected tree specie's carbon sequestration and oxygen production potential, a study involving field surveys, and allometric equations were employed.

About 58 tree species namely *Spathodea campanulata* (African tulip), *Terminalia arjuna* (Arjuna tree), *Clusia rosea* (Balsom apple), *Parkia biglandulosa* (Ball badminton), *Terminalia bellirica* (Bedda nut tree), *Paubrasilia echinata* (Brazilwood), *Madhuca longifolia* (Butter tree), *Couroupita guianensis* (Cannon ball), *Casuarina equisetifolia* (Casuarina), *Phoenix pusilla* (Ceylon Date Palm), *Ficus racemosa* (Cluster fig), *Cocos nucifera* (Coconut), *Lagunaria patersonia* (Cow itch), *Tabebuia heterophylla* (Cuban pink), *Bergera koenigii* (Curry leaf), *Acacia auriculiformis* (Earleaf acacia), *Polyalthia longifolia* (False Ashoka), *Caryota mitis* (Fishtail palm), *Cordia sebestena* (Geranium), *Cassia fistula* (Golden shower), *Phyllanthus emblica* (Gooseberry), *Psidium guajava* (Guava), *Terminalia catappa* (Indian almond), *Malpighia emarginata* (Indian cherry), *Millingtonia hortensis* (Indian cork), *Albizia lebbeck* (Indian siris), *Thespesia populnea* (Indian tulip), *Syzygium cumini* (Jamun), *Pterospermum acerifolium* (Kanak Champa), *Mangifera indica* (Mango), *Delonix regia* (May flower), *Hippocratea volubilis* (Medicine vine), *Morinda tinctorial* (Indian mulberry), *Morus spp.* ( Mulberry), *Azadirachta indica* (Neem), *Araucaria heterophylla* (Norfolk Island pine), *Simarouba glauca* (Paradise), *Nyctanthes arbor-tristis* (Parijat), *Paulownia tomentosa* (Princess), *Millettia pinnata* (Pungam), *Bauhinia purpurea* (Purple bauhinia), *Gliricidia sepium* (Quick stick), *Leucaena leucocephala* (River tamarind), *Roystonea regia* (Royal palm), *Ficus religiosa* (Sacred fig), *Santalum album* (Sandal), *Manilkara zapota* (Sapota), *Kigelia Africana* (Sausage), *Mimusops elengi* (Spanish Cherry), *Tamarindus indica* (Tamarind), *Tectona grandis* (Teak), *Tipuana tipu* (Tipu), *Ficus benjamina* (Weeping fig), *Sterculia foetida* (Wild almond), *Limonia acidissima* (Wood apple), *Tecoma stans* (Yellow bells), *Peltophorum pterocarpum* (Yellow flame) and *Bambusa vulgaris* (Bamboo) were documented and categorized into four age classes. As these tree species were abundant in wasteland, sides of roads and canals, lake areas and next to railroad tracks, Further investigation were carried out to assess their Carbon sequestration and $O_2$ release potential. Previous studies show long-term air purification and soot filtration are accomplished by these trees, which also serve as "green highways" for the migration of birds, insects, and other natural animals [23].

These fifty-eight-tree species of different age classes were classified into four categories based on their age class (A = 5 to 10 years, B = 11 to 20 years, C = 21 to 30 years, D = >30 years) (Table 1.). In order to avoid error while estimating the total biomass, carbon sequestration and oxygen release potential, the age of the trees was ascertained from the information available in the tree register of the different parks (Bharathi park, Gandhi park, VOC park) of Coimbatore city taken for the study.

The trees were listed in an alphabetic order with respect to their common name. The scientific name and family name were confirmed in consultation with scientists from Forest College and Research Institute (FC&RI) – Mettupalayam, Institute of Forest Genetics and Tree Breeding (IFGTB) – Coimbatore and Botanical Survey of India – Coimbatore. Then the tree species were listed and separated according to their age class – A, B, C, and D for easy comparison and interpretation of data.

### 3.1 Volume and Total Biomass of Selected Tree Species

In this study, Among these 58 species *Albizia lebbeck* (32296.70 kg $tree^{-1}$), *Tamarindus indica* (24268.03 kg $tree^{-1}$), *Parkia biglandulosa* (14154.94 kg $tree^{-1}$), *Delonix regia* (11559.99 kg $tree^{-1}$), *Peltophorum pterocarpum* (11316.93 kg $tree^{-1}$), *Kigelia Africana* (8774.07 kg $tree^{-1}$), *Azadirachta indica* (7405.90 kg $tree^{-1}$), *Ficus religiosa* ( 6488.67 kg $tree^{-1}$), *Couroupita guianensis* (5231.09 kg $tree^{-1}$) and *Acacia auriculiformis* (4795.94 kg $tree^{-1}$) were the top ten s tree species in terms of highest total biomass (Table 2). [24,25] stated that the biomass of tree species varied with their tree volume. *Albizia lebbeck* (32296.70 kg $tree^{-1}$) recorded the

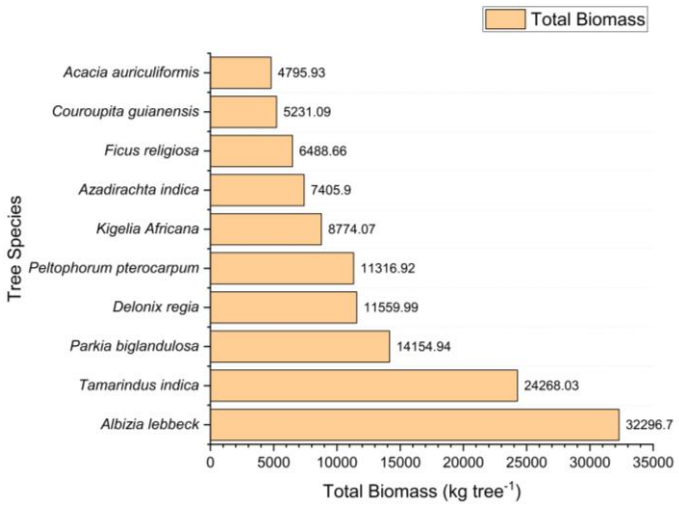


**Fig. 3. Top ten tree species of Coimbatore city with the highest biomass**

highest total biomass in the study area followed by, *Tamarindus indica* (24268.03 kg tree$^{-1}$), *Parkia biglandulosa* (14154.94 kg tree$^{-1}$) and *Delonix regia* (11559.99 kg tree$^{-1}$) (Fig. 3). *Malpighia emarginata* (19.57 kg tree$^{-1}$) had the lowest biomass in the study area followed by *Nyctanthes arbour tristis* (20.75 kg tree$^{-1}$), *Manilkara zapota* (21.02 kg tree$^{-1}$), *Caryota mitis* (24.62 kg tree$^{-1}$) and *Clusia rosea* (25.32 kg tree$^{-1}$) (Table 2). [26] stated that individual trees of the same species may develop differently and produce different amounts of biomass at various locations. Trees with huge canopies, enhance photosynthesis rates and its biomass [27].

## 3.2 Carbon Stock and $CO_2$ (eq.) of Selected tree Species

The carbon stock of selected 58 tree species were ranges from 16148.35 kg tree$^{-1}$ to 9.78 kg tree$^{-1}$ (Table 3). Among these selected 58 tree species, the highest Carbon stock was recorded in *Albizia lebbeck* (16148.35 kg tree$^{-1}$), *Tamarindus indica* (12134.02 kg tree$^{-1}$), *Parkia biglandulosa* (7077.47 kg tree$^{-1}$), *Delonix regia* (5780.00 kg tree$^{-1}$), *Peltophorum pterocarpum* (5658.46 kg tree$^{-1}$), *Kigelia Africana* (4387.04 kg tree$^{-1}$), *Azadirachta indica* (3702.95 kg tree$^{-1}$), *Ficus religiosa* (3244.33 kg tree$^{-1}$), *Couroupita guianensis* (2615.55 kg tree$^{-1}$), *Acacia auriculiformis* (2397.97 kg tree$^{-1}$) (Table 3). *Malpighia emarginata* (9.78 kg tree$^{-1}$), *Nyctanthes arbor tristis* (10.37kg tree$^{-1}$), *Manilkara zapota* (10.512 kg tree$^{-1}$), *Caryota mitis* (12.30 kg tree$^{-1}$) and *Clusia rosea* (12.662 kg tree$^{-1}$) were among the species with lowest carbon stock (Table 3). The total $CO_2$ (eq.) of these 58 tree species were ranged from 59199.85 kg tree$^{-1}$ to 35.87 kg tree$^{-1}$. *Albizia lebbeck* (59199.85 kg tree$^{-1}$) sequestered the highest $CO_2$ (eq.), followed by *Tamarindus indica* (44483.30 kg tree$^{-1}$), *Parkia biglandulosa* (25946.01 kg tree$^{-1}$), *Delonix regia* (21189.46 kg tree$^{-1}$), *Peltophorum pterocarpum* (20743.92 kg tree$^{-1}$), *Kigelia Africana* (16082.87 kg tree$^{-1}$), *Azadirachta indica* (13575.02 kg tree$^{-1}$), *Ficus religiosa* (11893.73 kg tree$^{-1}$), *Couroupita guianensis* (9588.60 kg tree$^{-1}$) and *Acacia auriculiformis* (8790.96 kg tree$^{-1}$) (Table 3). *Malpighia emarginata* (35.87 kg tree$^{-1}$), *Nyctanthes arbor tristis* (38.03 kg tree$^{-1}$), *Manilkara zapota* (38.54 kg tree$^{-1}$), *Caryota mitis* (45.12 kg tree$^{-1}$) and *Clusia rosea* (46.42 kg tree$^{-1}$) were the species with lowest $CO_2$ (eq.) (Table 3). The carbon stock is influenced by the tree species volume growth [12,28,29].

## 3.3 Net Carbon Sequestration and Net Oxygen Release of Selected Tree Species

Net carbon sequestration of selected tree species ranged from 1.03 ton tree$^{-1}$year$^{-1}$ to 0.004 ton tree$^{-1}$year$^{-1}$ (Table 3). The tree species with the highest potential for net carbon sequestration were *Albizia lebbeck* (1.03 ton tree$^{-1}$year$^{-1}$) followed by *Tamarindus indica* (0.809 ton tree$^{-1}$year$^{-1}$), *Parkia biglandulosa* (0.721 ton tree$^{-1}$year$^{-1}$), *Delonix regia* (0.385 ton tree$^{-1}$year$^{-1}$), *Kigelia Africana* (0.378 ton tree$^{-1}$year$^{-1}$), *Peltophorum pterocarpum* (0.377 ton tree$^{-1}$year$^{-1}$), *Ficus religiosa* (0.340 ton tree$^{-1}$year$^{-1}$), *Leucaena leucocephala* (0.314 ton tree$^{-1}$year$^{-1}$), *Pterospermum acerifolium* (0.310 ton tree$^{-1}$year$^{-1}$) and *Azadirachta indica* (0.302 ton tree$^{-1}$year$^{-1}$).

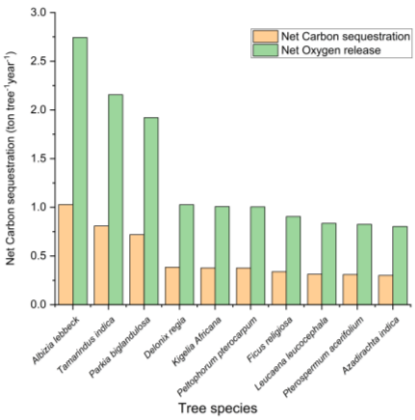


**Fig. 4. Top ten tree species of Coimbatore city with the highest Net carbon sequestration and Net oxygen release**

**Table 1. List of tree species selected for the study**

| Family | Common Name | Scientific Name | App. age (In years) | Avg. age (In years) | Age class. (In years) |
|---|---|---|---|---|---|
| Anacardiaceae | Mango tree | *Mangifera indica* | 15-20 | 18 | B |
| Annonaceae | False Ashoka | *Polyalthia longifolia* | 50-55 | 53 | D |
| Araucariaceae | Norfolk Island pine | *Araucaria heterophylla* | 8-10 | 9 | A |
| Arecaceae | Ceylon Date Palm | *Phoenix pusilla* | 8-12 | 10 | B |
| | Coconut | *Cocos nucifera* | 18-20 | 19 | B |
| | Fishtail palm | *Caryota mitis* | 10-12 | 11 | B |
| | Royal palm | *Roystonea regia* | 20-25 | 23 | C |
| Bignoniaceae | African tulip tree | *Spathodea campanulata* | 8-10 | 9 | A |
| | Cuban pink | *Tabebuia heterophylla* | 15-20 | 18 | B |
| | Indian cork tree | *Millingtonia hortensis* | 10-15 | 13 | B |
| | Sausage tree | *Kigelia Africana* | 40-45 | 43 | D |
| | Yellow bells | *Tecoma stans* | 5-8 | 7 | A |
| Boraginaceae | Geranium tree | *Cordia sebestena* | 5-8 | 7 | A |
| Casuarinaceae | Casuarina | *Casuarina equisetifolia* | 8-12 | 10 | B |
| Celastraceae | Medicine vine tree | *Hippocratea volubilis* | 12-15 | 14 | B |
| Clusiaceae | Balsom apple | *Clusia rosea* | 5-8 | 7 | A |
| Combretaceae | Arjuna tree | *Terminalia arjuna* | 5-10 | 8 | A |
| | Bibhitaki tree | *Terminalia bellirica* | 10-12 | 11 | B |
| | Indian almond | *Terminalia catappa* | 8-10 | 9 | A |
| Euphorbiaceae | Gooseberry | *Phyllanthus emblica* | 10-12 | 11 | B |
| Fabaceae | Brazilwood tree | *Paubrasilia echinata* | 10-15 | 13 | B |
| | Earleaf acacia | *Acacia auriculiformis* | 40-45 | 43 | D |

| Family | Common Name | Scientific Name | App. age (In years) | Avg. age (In years) | Age class. (In years) |
|---|---|---|---|---|---|
| | Golden shower | *Cassia fistula* | 6-8 | 7 | A |
| | Indian siris tree | *Albizia lebbeck* | 55-60 | 58 | D |
| | May flower tree | *Delonix regia* | 50-60 | 55 | D |
| | Pungam tree | *Millettia pinnata* | 20-25 | 23 | C |
| | Purple bauhinia | *Bauhinia purpurea* | 10-15 | 13 | B |
| | Quick stick | *Gliricidia sepium* | 30-35 | 33 | D |
| | River tamarind | *Leucaena leucocephala* | 10-18 | 14 | B |
| | Tamarind | *Tamarindus indica* | 50-60 | 55 | D |
| | Tipu tree | *Tipuana tipu* | 12-15 | 14 | B |
| | Yellow flame tree | *Peltophorum pterocarpum* | 50-60 | 55 | D |
| Lamiaceae | Teak | *Tectona grandis* | 20-25 | 23 | C |
| Lecythidaceae | Cannon ball tree | *Couroupita guianensis* | 40-50 | 45 | D |
| Malpighiaceae | Indian cherry | *Malpighia emarginata* | 5-8 | 7 | A |
| Malvaceae | Cow itch tree | *Lagunaria patersonia* | 10-15 | 13 | B |
| | Indian tulip tree | *Thespesia populnea* | 5-8 | 7 | A |
| | Wild almond tree | *Sterculia foetida* | 15-18 | 17 | B |
| Meliaceae | Neem | *Azadirachta indica* | 40-50 | 45 | D |
| Mimosoideae | Ball badminton tree | *Parkia biglandulosa* | 35-37 | 36 | D |
| Moracea | Cluster fig | *Ficus racemosa* | 10-15 | 13 | B |
| | Mulberry tree | *Morus spp.* | 10-12 | 11 | B |
| | Sacred fig | *Ficus religiosa* | 30-40 | 35 | D |
| | Weeping fig | *Ficus benjamina* | 15-18 | 17 | B |
| Myrtaceae | Guava tree | *Psidium guajava* | 5-8 | 7 | A |
| | Jamun tree | *Syzygium cumini* | 20-25 | 23 | C |
| Oleaceae | Parijat | *Nyctanthes arbor-tristis* | 5-8 | 7 | A |
| Paulowniaceae | Princess tree | *Paulownia tomentosa* | 5-8 | 7 | A |
| Poaceae | Bamboo | *Bambusa vulgaris* | 5-15 | 10 | B |
| Rubiaceae | Indian mulberry | *Morinda tinctoria* | 8-10 | 9 | A |
| Rutaceae | Curry leaf | *Bergera koenigii* | 8-12 | 10 | B |
| | Wood apple | *Limonia acidissima* | 15-18 | 17 | B |
| Santalaceae | Sandal tree | *Santalum album* | 15-20 | 18 | B |
| Sapotaceae | Butter tree | *Madhuca longifolia* | 8-12 | 10 | B |
| | Sapota | *Manilkara zapota* | 5-8 | 7 | A |
| | Spanish Cherry | *Mimusops elengi* | 25-30 | 28 | C |
| Simaroubacea | Paradise tree | *Simarouba glauca* | 10-12 | 11 | B |
| Sterculiaceae | Kanak Champa | *Pterospermum acerifolium* | 25-30 | 28 | C |

** A = 5 to 10 years, B = 11 to 20 years, C = 21 to 30 years, D = > 30 years*

**Table 2. Volume and total biomass of the selected tree species in Coimbatore city, India**

| Scientific Name | Height (m) | DBH (m) | Volume (kg $m^{-3}$) | Wood density (kg $m^{-3}$) | Above Ground Biomass (kg $tree^{-1}$) | Below Ground Biomass (kg $tree^{-1}$) | Total biomass (kg $tree^{-1}$) |
|---|---|---|---|---|---|---|---|
| *Spathodea campanulata* | 8.16 | 0.93 | 0.56 | 330 | 185.43 | 48.21 | 233.64 |
| *Terminalia arjuna* | 5.66 | 0.35 | 0.06 | 800 | 44.16 | 11.48 | 55.64 |
| *Clusia rosea* | 5.10 | 0.27 | 0.03 | 679 | 20.10 | 5.23 | 25.32 |
| *Parkia biglandulosa* | 18.31 | 3.47 | 17.55 | 640 | 11234.08 | 2920.86 | 14154.94 |
| *Terminalia bellirica* | 10.02 | 0.81 | 0.52 | 697 | 364.82 | 94.85 | 459.68 |
| *Paubrasilia echinate* | 12.23 | 1.13 | 1.24 | 600 | 746.01 | 193.96 | 939.97 |
| *Madhuca longifolia* | 9.22 | 0.72 | 0.38 | 790 | 300.63 | 78.16 | 378.79 |
| *Couroupita guianensis* | 16.36 | 2.71 | 9.57 | 434 | 4151.66 | 1079.43 | 5231.09 |
| *Casuarina equisetifolia* | 12.02 | 0.63 | 0.38 | 918 | 348.69 | 90.66 | 439.35 |
| *Phoenix pusilla* | 9.83 | 0.94 | 0.69 | 600 | 414.93 | 107.88 | 522.81 |
| *Ficus racemosa* | 23.40 | 1.23 | 2.82 | 375 | 1056.98 | 274.82 | 1331.80 |
| *Cocos nucifera* | 17.28 | 0.88 | 1.07 | 616 | 656.30 | 170.64 | 826.93 |
| *Lagunaria patersonia* | 5.23 | 1.29 | 0.69 | 600 | 415.76 | 108.10 | 523.86 |
| *Tabebuia heterophylla* | 12.71 | 1.920 | 3.73 | 589 | 2197.22 | 571.28 | 2768.50 |
| *Bergera koenigii* | 7.45 | 0.57 | 0.19 | 600 | 115.63 | 30.06 | 145.69 |
| *Acacia auriculiformis* | 15.60 | 2.26 | 6.34 | 600 | 3806.30 | 989.64 | 4795.94 |
| *Polyalthia longifolia* | 17.01 | 0.93 | 1.17 | 563 | 659.46 | 171.46 | 830.92 |
| *Caryota mitis* | 8.45 | 0.220 | 0.03 | 600 | 19.54 | 5.08 | 24.62 |
| *Cordia sebestena* | 7.32 | 0.63 | 0.23 | 700 | 161.92 | 42.10 | 204.02 |
| *Cassia fistula* | 9.20 | 0.97 | 0.69 | 829 | 571.34 | 148.55 | 719.89 |
| *Phyllanthus emblica* | 10.50 | 1.270 | 1.35 | 728 | 981.61 | 255.22 | 1236.83 |
| *Psidium guajava* | 5.94 | 0.87 | 0.36 | 671 | 240.19 | 62.45 | 302.64 |
| *Terminalia catappa* | 11.08 | 0.56 | 0.28 | 540 | 149.39 | 38.84 | 188.23 |
| *Malpighia emarginata* | 3.70 | 0.294 | 0.03 | 610 | 15.53 | 4.04 | 19.57 |
| *Millingtonia hortensis* | 11.23 | 1.460 | 1.91 | 600 | 1143.53 | 297.32 | 1440.85 |
| *Albizia lebbeck* | 19.23 | 5.30 | 43.01 | 596 | 25632.30 | 6664.40 | 32296.70 |
| *Thespesia populnea* | 7.20 | 1.31 | 0.98 | 639 | 628.62 | 163.44 | 792.06 |
| *Syzygium cumini* | 10.50 | 1.78 | 2.65 | 701 | 1856.77 | 482.76 | 2339.53 |
| *Pterospermum acerifolium* | 13.50 | 2.35 | 5.94 | 622 | 3692.07 | 959.94 | 4652.01 |

| Scientific Name | Height (m) | DBH (m) | Volume (kg $m^{-3}$) | Wood density (kg $m^{-3}$) | Above Ground Biomass (kg $tree^{-1}$) | Below Ground Biomass (kg $tree^{-1}$) | Total biomass (kg $tree^{-1}$) |
|---|---|---|---|---|---|---|---|
| *Mangifera indica* | 12.45 | 0.77 | 0.59 | 597 | 350.86 | 91.22 | 442.09 |
| *Delonix regia* | 16.42 | 3.42 | 15.29 | 600 | 9174.60 | 2385.40 | 11559.99 |
| *Hippocratea volubilis* | 9.23 | 0.67 | 0.33 | 875 | 288.65 | 75.05 | 363.70 |
| *Morinda tinctorial* | 12.03 | 0.72 | 0.50 | 540 | 268.12 | 69.71 | 337.84 |
| *Morus spp.* | 16.10 | 0.77 | 0.76 | 590 | 448.40 | 116.59 | 564.99 |
| *Azadirachta indica* | 19.03 | 2.310 | 8.08 | 727 | 5877.70 | 1528.20 | 7405.90 |
| *Araucaria heterophylla* | 3.30 | 0.520 | 0.07 | 548 | 38.93 | 10.12 | 49.05 |
| *Simarouba glauca* | 10.63 | 1.335 | 1.51 | 378 | 570.16 | 148.24 | 718.40 |
| *Nyctanthes arbor-tristis* | 3.76 | 0.250 | 0.02 | 880 | 16.46 | 4.28 | 20.75 |
| *Paulownia tomentosa* | 7.20 | 1.45 | 1.21 | 330 | 397.73 | 103.41 | 501.14 |
| *Millettia pinnata* | 16.70 | 1.29 | 2.21 | 619 | 1369.61 | 356.10 | 1725.71 |
| *Bauhinia purpurea* | 7.99 | 0.910 | 0.53 | 720 | 379.29 | 98.62 | 477.91 |
| *Gliricidia sepium* | 7.23 | 0.87 | 0.44 | 684 | 298.02 | 77.48 | 375.50 |
| *Leucaena leucocephala* | 14.20 | 1.62 | 2.97 | 641 | 1901.90 | 494.49 | 2396.39 |
| *Roystonea regia* | 15.69 | 1.34 | 2.24 | 600 | 1345.84 | 349.92 | 1695.76 |
| *Ficus religiosa* | 18.36 | 2.82 | 11.62 | 443 | 5149.74 | 1338.93 | 6488.67 |
| *Santalum album* | 9.97 | 0.38 | 0.11 | 936 | 107.29 | 27.89 | 135.18 |
| *Manilkara zapota* | 4.10 | 0.237 | 0.02 | 910 | 16.69 | 4.34 | 21.02 |
| *Kigelia Africana* | 14.90 | 2.98 | 10.53 | 661 | 6963.55 | 1810.52 | 8774.07 |
| *Mimusops elengi* | 10.40 | 1.43 | 1.69 | 882 | 1493.43 | 388.29 | 1881.72 |
| *Tamarindus indica* | 16.40 | 3.86 | 19.45 | 990 | 19260.34 | 5007.69 | 24268.03 |
| *Tectona grandis* | 19.12 | 1.250 | 2.38 | 612 | 1455.69 | 378.48 | 1834.17 |
| *Tipuana tipu* | 11.30 | 1.23 | 1.36 | 587 | 798.98 | 207.74 | 1006.72 |
| *Ficus benjamina* | 12.20 | 1.620 | 2.55 | 499 | 1272.04 | 330.73 | 1602.77 |
| *Sterculia foetida* | 12.35 | 1.240 | 1.51 | 552 | 834.56 | 216.99 | 1051.55 |
| *Limonia acidissima* | 15.26 | 1.36 | 2.25 | 771 | 1732.60 | 450.47 | 2183.07 |
| *Tecoma stans* | 6.10 | 0.79 | 0.30 | 466 | 141.25 | 36.72 | 177.97 |
| *Peltophorum pterocarpum* | 18.30 | 3.20 | 14.92 | 602 | 8981.69 | 2335.24 | 11316.93 |
| *Bambusa vulgaris* | 11.92 | 0.21 | 0.04 | 600 | 25.11 | 6.53 | 31.64 |

**Table 3. Total carbon stock, $CO_2$ eq. and Net $O_2$ release of the selected tree species in Coimbatore city, India**

| Scientific Name | Total biomass (kg tree$^{-1}$) | Carbon stock (kg tree$^{-1}$) | $CO_2$ (eq.) (kg tree$^{-1}$) | Net carbon sequestration (kg tree$^{-1}$ year$^{-1}$) | Net carbon sequestration (ton tree$^{-1}$ year$^{-1}$) | Net $O_2$ release (kg tree$^{-1}$ year$^{-1}$) | Net $O_2$ release (ton tree$^{-1}$ year$^{-1}$) |
|---|---|---|---|---|---|---|---|
| *Spathodea campanulata* | 233.642 | 116.821 | 428.266 | 47.59 | 0.048 | 126.862 | 0.127 |
| *Terminalia arjuna* | 55.645 | 27.822 | 101.997 | 12.75 | 0.013 | 33.990 | 0.034 |
| *Clusia rosea* | 25.325 | 12.662 | 46.421 | 6.63 | 0.007 | 17.680 | 0.018 |
| *Parkia biglandulosa* | 14154.945 | 7077.472 | 25946.013 | 720.72 | 0.721 | 1921.446 | 1.921 |
| *Terminalia bellirica* | 459.676 | 229.838 | 842.585 | 76.60 | 0.077 | 204.212 | 0.204 |
| *Paubrasilia echinate* | 939.973 | 469.987 | 1722.971 | 132.54 | 0.133 | 353.342 | 0.353 |
| *Madhuca longifolia* | 378.795 | 189.397 | 694.331 | 69.43 | 0.069 | 185.109 | 0.185 |
| *Couroupita guianensis* | 5231.094 | 2615.547 | 9588.595 | 213.08 | 0.213 | 568.071 | 0.568 |
| *Casuarina equisetifolia* | 439.349 | 219.674 | 805.326 | 80.53 | 0.081 | 214.700 | 0.215 |
| *Phoenix pusilla* | 522.807 | 261.403 | 958.305 | 95.83 | 0.096 | 255.484 | 0.255 |
| *Ficus racemosa* | 1331.798 | 665.899 | 2441.185 | 195.29 | 0.195 | 520.656 | 0.521 |
| *Cocos nucifera* | 826.934 | 413.467 | 1515.770 | 79.78 | 0.080 | 212.686 | 0.213 |
| *Lagunaria patersonia* | 523.858 | 261.929 | 960.231 | 76.82 | 0.077 | 204.798 | 0.205 |
| *Tabebuia heterophylla* | 2768.498 | 1384.249 | 5074.657 | 289.98 | 0.290 | 773.088 | 0.773 |
| *Bergera koenigii* | 145.693 | 72.846 | 267.055 | 26.71 | 0.027 | 71.197 | 0.071 |
| *Acacia auriculiformis* | 4795.939 | 2397.969 | 8790.956 | 204.44 | 0.204 | 545.039 | 0.545 |
| *Polyalthia longifolia* | 830.921 | 415.460 | 1523.077 | 29.01 | 0.029 | 77.343 | 0.077 |
| *Caryota mitis* | 24.617 | 12.308 | 45.123 | 4.10 | 0.004 | 10.936 | 0.011 |
| *Cordia sebestena* | 204.019 | 102.010 | 373.967 | 57.53 | 0.058 | 153.384 | 0.153 |
| *Cassia fistula* | 719.891 | 359.945 | 1319.560 | 188.51 | 0.189 | 502.564 | 0.503 |
| *Phyllanthus emblica* | 1236.827 | 618.414 | 2267.104 | 206.10 | 0.206 | 549.464 | 0.549 |
| *Psidium guajava* | 302.641 | 151.321 | 554.742 | 85.34 | 0.085 | 227.529 | 0.228 |
| *Terminalia catappa* | 188.231 | 94.115 | 345.027 | 38.34 | 0.038 | 102.205 | 0.102 |
| *Malpighia emarginata* | 19.571 | 9.785 | 35.873 | 5.52 | 0.006 | 14.714 | 0.015 |
| *Millingtonia hortensis* | 1440.846 | 720.423 | 2641.071 | 211.29 | 0.211 | 563.288 | 0.563 |
| *Albizia lebbeck* | 32296.703 | 16148.351 | 59199.856 | 1029.56 | 1.030 | 2744.814 | 2.745 |
| *Thespesia populnea* | 792.058 | 396.029 | 1451.842 | 223.36 | 0.223 | 595.479 | 0.595 |
| *Syzygium cumini* | 2339.528 | 1169.764 | 4288.355 | 190.59 | 0.191 | 508.122 | 0.508 |
| *Pterospermum acerifolium* | 4652.012 | 2326.006 | 8527.137 | 310.08 | 0.310 | 826.667 | 0.827 |

| Scientific Name | Total biomass (kg tree$^{-1}$) | Carbon stock (kg tree$^{-1}$) | $CO_2$ (eq.) (kg tree$^{-1}$) | Net carbon sequestration (kg tree$^{-1}$ year$^{-1}$) | Net carbon sequestration (ton tree$^{-1}$ year$^{-1}$) | Net $O_2$ release (kg tree$^{-1}$ year$^{-1}$) | Net $O_2$ release (ton tree$^{-1}$ year$^{-1}$) |
|---|---|---|---|---|---|---|---|
| *Mangifera indica* | 442.085 | 221.043 | 810.342 | 46.31 | 0.046 | 123.450 | 0.123 |
| *Delonix regia* | 11559.992 | 5779.996 | 21189.465 | 385.26 | 0.385 | 1027.111 | 1.027 |
| *Hippocratea volubilis* | 363.697 | 181.849 | 666.657 | 49.38 | 0.049 | 131.652 | 0.132 |
| *Morinda tinctoria* | 337.836 | 168.918 | 619.252 | 68.81 | 0.069 | 183.436 | 0.183 |
| *Morus spp.* | 564.989 | 282.495 | 1035.625 | 94.15 | 0.094 | 250.998 | 0.251 |
| *Azadirachta indica* | 7405.904 | 3702.952 | 13575.022 | 301.67 | 0.302 | 804.245 | 0.804 |
| *Araucaria heterophylla* | 49.055 | 24.527 | 89.918 | 9.99 | 0.010 | 26.636 | 0.027 |
| *Simarouba glauca* | 718.404 | 359.202 | 1316.834 | 119.71 | 0.120 | 319.153 | 0.319 |
| *Nyctanthes arbor-tristis* | 20.746 | 10.373 | 38.027 | 5.85 | 0.006 | 15.597 | 0.016 |
| *Paulownia tomentosa* | 501.145 | 250.572 | 918.599 | 141.32 | 0.141 | 376.767 | 0.377 |
| *Millettia pinnata* | 1725.709 | 862.854 | 3163.224 | 140.59 | 0.141 | 374.807 | 0.375 |
| *Bauhinia purpurea* | 477.907 | 238.953 | 876.003 | 70.08 | 0.070 | 186.834 | 0.187 |
| *Gliricidia sepium* | 375.503 | 187.752 | 688.298 | 21.18 | 0.021 | 56.462 | 0.056 |
| *Leucaena leucocephala* | 2396.389 | 1198.194 | 4392.581 | 313.76 | 0.314 | 836.473 | 0.836 |
| *Roystonea regia* | 1695.761 | 847.881 | 3108.330 | 138.15 | 0.138 | 368.303 | 0.368 |
| *Ficus religiosa* | 6488.668 | 3244.334 | 11893.728 | 339.82 | 0.340 | 905.962 | 0.906 |
| *Santalum album* | 135.182 | 67.591 | 247.789 | 14.16 | 0.014 | 37.749 | 0.038 |
| *Manilkara zapota* | 21.023 | 10.512 | 38.536 | 5.93 | 0.006 | 15.806 | 0.016 |
| *Kigelia Africana* | 8774.071 | 4387.036 | 16082.873 | 378.42 | 0.378 | 1008.869 | 1.009 |
| *Mimusops elengi* | 1881.720 | 940.860 | 3449.192 | 125.43 | 0.125 | 334.383 | 0.334 |
| *Tamarindus indica* | 24268.032 | 12134.016 | 44483.303 | 808.79 | 0.809 | 2156.227 | 2.156 |
| *Tectona grandis* | 1834.173 | 917.086 | 3362.039 | 149.42 | 0.149 | 398.364 | 0.398 |
| *Tipuana tipu* | 1006.718 | 503.359 | 1845.313 | 136.69 | 0.137 | 364.415 | 0.364 |
| *Ficus benjamina* | 1602.770 | 801.385 | 2937.878 | 178.05 | 0.178 | 474.690 | 0.475 |
| *Sterculia foetida* | 1051.551 | 525.775 | 1927.493 | 116.82 | 0.117 | 311.436 | 0.311 |
| *Limonia acidissima* | 2183.070 | 1091.535 | 4001.567 | 106.71 | 0.107 | 284.485 | 0.284 |
| *Tecoma stans* | 177.972 | 88.986 | 326.222 | 50.19 | 0.050 | 133.801 | 0.134 |
| *Peltophorum pterocarpum* | 11316.925 | 5658.463 | 20743.924 | 377.16 | 0.377 | 1005.515 | 1.006 |
| *Bambusa vulgaris* | 31.641 | 15.820 | 57.998 | 5.80 | 0.006 | 15.462 | 0.015 |

*Caryota mitis* (0.004 ton tree$^{-1}$year$^{-1}$) and *Malpighia emarginata* (0.006 ton tree$^{-1}$year$^{-1}$) were the species with the lowest net carbon sequestration (Fig. 4). The net oxygen release, of selected tree species were ranged from 2.745 ton tree$^{-1}$year$^{-1}$ to 0.011 ton tree$^{-1}$year$^{-1}$ (Table 3). The tree species with the highest potential for net oxygen release were *Albizia lebbeck* (2.745 ton tree$^{-1}$year$^{-1}$), *Tamarindus indica* (2.156 ton tree$^{-1}$year$^{-1}$), *Parkia biglandulosa* (1.921 ton tree$^{-1}$year$^{-1}$), *Delonix regia* (1.027 ton tree$^{-1}$year$^{-1}$), *Kigelia Africana* (1.009 ton tree$^{-1}$year$^{-1}$), *Peltophorum pterocarpum* (1.006 ton tree$^{-1}$year$^{-1}$), *Ficus religiosa* (0.906 ton tree$^{-1}$year$^{-1}$), *Leucaena leucocephala* (0.836 ton tree$^{-1}$year$^{-1}$), *Pterospermum acerifolium* (0.827 ton tree$^{-1}$year$^{-1}$) and *Azadirachta indica* (0.804 ton tree$^{-1}$year$^{-1}$). *Caryota mitis* (0.011 ton tree$^{-1}$year$^{-1}$) and *Malpighia emarginata* (0.015 ton tree$^{-1}$year$^{-1}$) were the species with the lowest net oxygen release (Table 3; Fig. 4). Oxygen production varies by tree size, age and type of species. Oxygen production regulates the metabolic process of living things, it is clear that the production of oxygen by trees is a crucial ecological service [30]. Similar results were reported by [9].

### 3.4 Correlation between DBH and Carbon Stock, Carbon Dioxide eq. and Net Oxygen Release of Selected Tree Species

The significant correlations and trends that have been identified in this study (Fig. 5 and Fig. 6). The DBH, age and height of the tree are the important factors that determine carbon sequestration and oxygen production. The correlation relationship between DBH and carbon stock was analysed (Fig. 5). The results showed a positive correlation of $R^2$ (0.81434) with a gradient of 2533.66 showing a strong relationship between DBH and Carbon stock. The relationship between Carbon dioxide (eq.) and Net oxygen release was also analysed (Fig. 6). The results showed a strong positive correlation of $R^2$ (0.89521) with a gradient of 0.046.

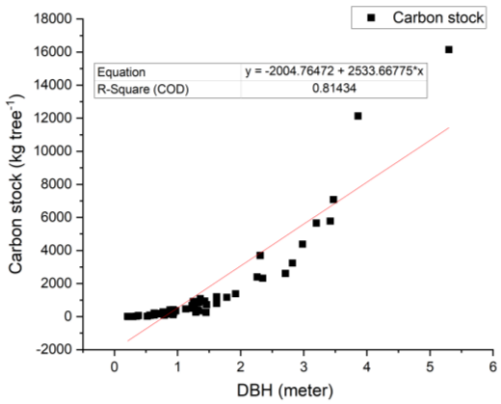


**Fig. 5. Correlation coefficient ($r^2$ value) between DBH and Carbon stock of selected tree species**

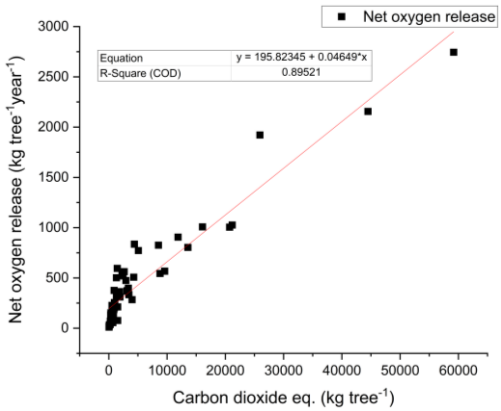


**Fig. 6. Correlation coefficient ($r^2$ value) between Carbon dioxide eq. and Net oxygen release of selected tree species**

## 4. CONCLUSION

The present study confirms that species with higher biomass, resulted in high carbon sequestration and high oxygen release. Among 58 tree species evaluated, Fabaceae species were abundant, with larger tree volumes, biomass, carbon stocks resulting in high net carbon sequestration and net oxygen release. Similarly, growth of *Albizia lebbeck* was noticeably supreme when compared to others, followed by *Tamarindus indica*, *Parkia biglandulosa*, *Delonix regia*, *Kigelia Africana*, *Peltophorum pterocarpum*, *Ficus religiosa*, *Leucaena leucocephala*, *Pterospermum acerifolium* and *Azadirachta indica.* Green cover development projects with the above-mentioned trees could improve the carbon capture, oxygen release and air quality of Coimbatore city, India. In order to improve air quality along with substantial economic benefits in urban areas, appropriate number of trees, age of planting and spacing must be ascertained in future studies.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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