

OXYGEN PRODUCTION AND CARBON CAPTURING CAPACITY OF VARIOUS TREE SPECIES IN COIMBATORE CITY

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 important of the trees in 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, CO₂ (eq.), net carbon sequestration and net oxygen release assessment using standard non-destructive method. Among the 58 tree species studied, *Albizia lebbbeck* (2.745 ton tree⁻¹year⁻¹), *Tamarindus indica* (2.156 ton tree⁻¹year⁻¹), *Parkia biglandulosa* (1.921 ton tree⁻¹year⁻¹), *Delonix regia* (1.027 ton tree⁻¹year⁻¹), *Kigelia Africana* (1.009 ton tree⁻¹year⁻¹), *Peltophorum pterocarpum* (1.006 ton tree⁻¹year⁻¹), *Ficus religiosa* (0.906 ton tree⁻¹year⁻¹), *Leucaena leucocephala* (0.836 ton tree⁻¹year⁻¹), *Pterospermum acerifolium* (0.827 ton tree⁻¹year⁻¹) and *Azadirachta indica* (0.804 ton tree⁻¹year⁻¹) were found to release high oxygen with more carbon capturing capacity.

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 (CO₂), carbon monoxide (CO), particulate matter (PM_{2.5} and PM₁₀), 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 CO₂ 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 (CO₂), oxygen (O₂) sulphur dioxide (SO₂), particulate matter (PM_{2.5} and PM₁₀), and ozone (O₃) [7, 8]. According to [9] a hectare *Eucalyptus tereticornis* plantation release 431 ton of oxygen per year and sequestered 161.8 ton of carbon in Dharwad, which plays a major role in improving air quality.

Coimbatore covers 4,732 km², 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 km²) which was 65.22 km² 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 sequestering, 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. MATERIAL 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) (Figure 1.) of Coimbatore city.

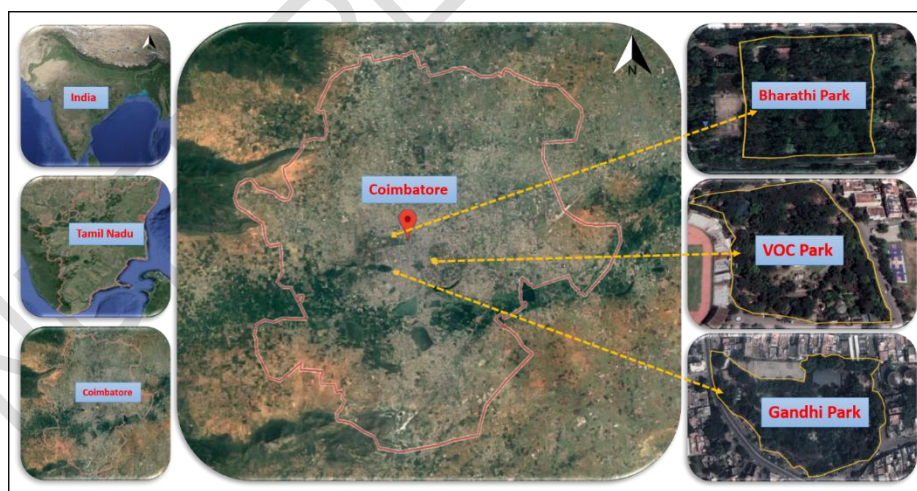


Fig. 1. Satellite view of the site of investigation

2.2 Site survey

The primary biophysical measurements (Height and DBH) of identified 58 species were done by using laser rangefinder (Bosch Gln 500 Laser Distance Measurement Device) and

measuring tape (Figure 2a). The location of the study area was recorded by Geographical Positioning System (GPS) Model (Garmin- eTrex Legend HCx) (Figure 2b).



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

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 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.

2.4 Tree height and its measurements

Tree height is a fundamental geometrical variable for trees as it has some vertical distance between the base of the tree and the highest point on the tree [13]. The tree height was measured by using a laser rangefinder (Bosch Glm 500 Laser Distance Measurement Device) (Figure 2a.). Laser rangefinder device works on the mechanism of using a laser beam, to determine the distance to an object (tree) and is kept on a tripod stand for more accuracy. The device transmits a narrow laser pulse beam towards the target 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 O₂ release and net C sequestration were calculated by the following procedure.

The basic parameters required for estimating net O₂ release (kg yr⁻¹) and net C sequestration (kg yr⁻¹), includes tree DBH, tree height, Total biomass, Carbon stock and CO₂ (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 m³

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].

$$\mathbf{AGB = V \times D}$$

Where,

AGB = Above Ground Biomass

V = Volume of tree in m³

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/cm³ 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].

$$\mathbf{BGB = AGB \times 0.26}$$

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

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

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:

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

After arriving the Carbon stock of each tree, the carbon sequestered potential in terms of CO₂ (eq.) was calculated by using the following formula:

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

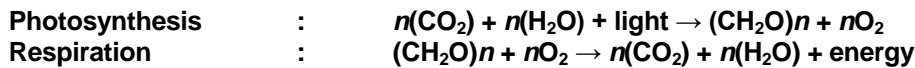
CO₂ is composed of 2 molecules of Oxygen(O₂) and 1 molecule of Carbon(C). The atomic weight of carbon is 12. The atomic weight of Oxygen is 16. Therefore, the weight of CO₂ is Carbon + (2 x Oxygen) = 44. The ratio of CO₂ to C is 44/12 = 3.666. So, to evaluate the carbon dioxide equivalent in the tree, multiply the carbon stock in the tree by 3.666.

The quantity of total CO₂ sequestered in in terms of CO₂ (eq.) of the tree during its entire lifespan is represented by the above equation. To obtain a yearly C sequestration rate, the overall CO₂ equivalent by the tree was divided by its age [19].

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

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].



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.

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

$$\text{Net O}_2 \text{ release (kg yr}^{-1}\text{)} = \text{Net C sequestration (kg yr}^{-1}\text{)} \times 32 / 12$$

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 species 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), *Berberis 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 lebbek* (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) where 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 O₂ 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 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 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) (Figure 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].

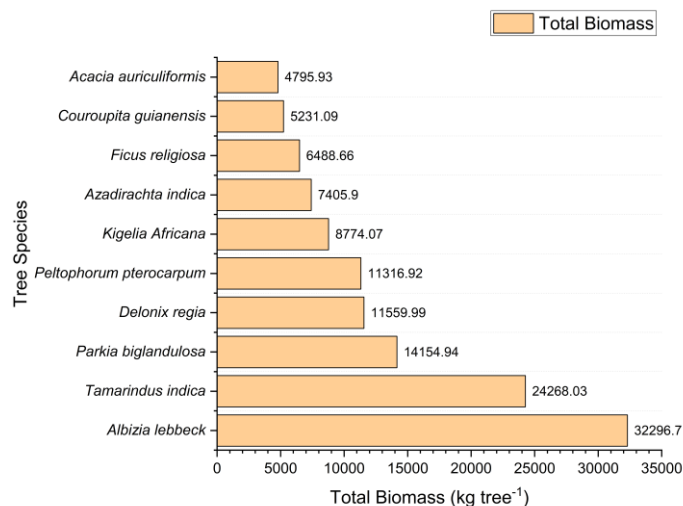


Fig. 3. Top ten tree species of Coimbatore city with the highest biomass.

3.2 Carbon stock and CO₂ (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 CO₂ (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 CO₂ (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 CO₂ (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

Net carbon sequestration of selected tree species ranged from 1.03 ton tree⁻¹year⁻¹ to 0.004 ton tree⁻¹year⁻¹ (Table 3). The tree species with the highest potential for net carbon sequestration were *Albizia lebbeck* (1.03 ton tree⁻¹year⁻¹) followed by *Tamarindus indica* (0.809 ton tree⁻¹year⁻¹), *Parkia biglandulosa* (0.721 ton tree⁻¹year⁻¹), *Delonix regia* (0.385 ton tree⁻¹year⁻¹), *Kigelia Africana* (0.378 ton tree⁻¹year⁻¹), *Peltophorum pterocarpum* (0.377 ton tree⁻¹year⁻¹), *Ficus religiosa* (0.340 ton tree⁻¹year⁻¹), *Leucaena leucocephala* (0.314 ton tree⁻¹year⁻¹), *Pterospermum acerifolium* (0.310 ton tree⁻¹year⁻¹) and *Azadirachta indica* (0.302 ton tree⁻¹year⁻¹). *Caryota mitis* (0.004 ton tree⁻¹year⁻¹) and *Malpighia emarginata* (0.006 ton tree⁻¹year⁻¹) were the species with the lowest net carbon sequestration (Figure 4). The net oxygen release, of selected tree species were ranged from 2.745 ton tree⁻¹year⁻¹ to 0.011 ton tree⁻¹year⁻¹ (Table 3). The tree species with the highest potential for net oxygen release were *Albizia lebbeck* (2.745 ton tree⁻¹year⁻¹), *Tamarindus indica* (2.156 ton tree⁻¹year⁻¹), *Parkia biglandulosa* (1.921 ton tree⁻¹year⁻¹), *Delonix regia* (1.027 ton tree⁻¹year⁻¹), *Kigelia Africana* (1.009 ton tree⁻¹year⁻¹), *Peltophorum pterocarpum* (1.006 ton tree⁻¹year⁻¹), *Ficus religiosa* (0.906 ton tree⁻¹year⁻¹), *Leucaena leucocephala* (0.836 ton tree⁻¹year⁻¹), *Pterospermum acerifolium* (0.827 ton tree⁻¹year⁻¹) and *Azadirachta indica* (0.804 ton tree⁻¹year⁻¹). *Caryota mitis* (0.011 ton tree⁻¹year⁻¹) and *Malpighia emarginata* (0.015 ton tree⁻¹year⁻¹) were the species with the lowest net oxygen release (Table 3; Figure 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].

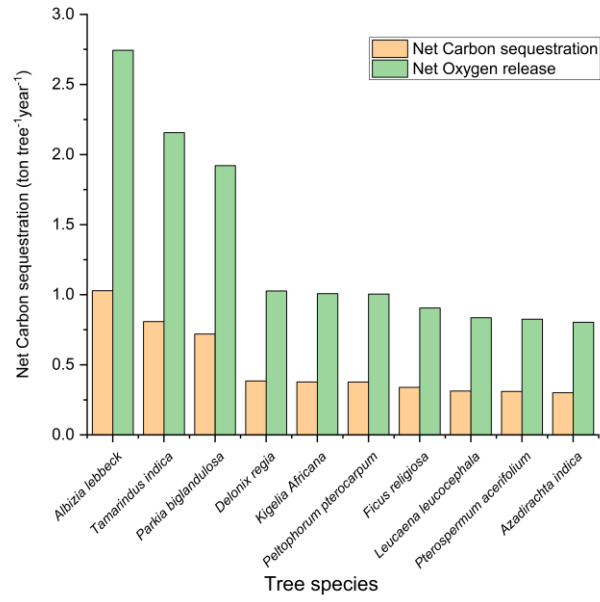


Fig. 4. Top ten tree species of Coimbatore city with the highest Net carbon sequestration and Net oxygen release.

Table 1. List of tree species selected for the study

Common Name	Scientific Name	Family	App. age (In years)	Avg. age (In years)	Age class. (In years)
African tulip	<i>Spathodea campanulata</i>	Bignoniaceae	8-10	9	A
Arjuna tree	<i>Terminalia arjuna</i>	Combretaceae	5-10	8	A
Balsam apple	<i>Clusia rosea</i>	Clusiaceae	5-8	7	A
Ball badminton	<i>Parkia biglandulosa</i>	Mimosoideae	35-37	36	D
Bibhitaki	<i>Terminalia bellirica</i>	Combretaceae	10-12	11	B
Brazilwood	<i>Paubrasilia echinata</i>	Fabaceae	10-15	13	B
Butter tree	<i>Madhuca longifolia</i>	Sapotaceae	8-12	10	A
Cannon ball tree	<i>Couroupita guianensis</i>	Lecythidaceae	40-50	45	D
Casuarina	<i>Casuarina equisetifolia</i>	Casuarinaceae	8-12	10	A
Ceylon Date Palm	<i>Phoenix pusilla</i>	Arecaceae	8-12	10	A
Cluster fig	<i>Ficus racemosa</i>	Moraceae	10-15	13	B
Coconut	<i>Cocos nucifera</i>	Arecaceae	18-20	19	B
Cow itch	<i>Lagunaria patersonia</i>	Malvaceae	10-15	13	B
Cuban pink	<i>Tabebuia heterophylla</i>	Bignoniaceae	15-20	18	B
Curry leaf	<i>Bergera koenigii</i>	Rutaceae	8-12	10	A
Earleaf acacia	<i>Acacia auriculiformis</i>	Fabaceae	40-45	43	D
False Ashoka	<i>Polyalthia longifolia</i>	Annonaceae	50-55	53	D
Fishtail palm	<i>Caryota mitis</i>	Arecaceae	10-12	11	B
Geranium	<i>Cordia sebestena</i>	Boraginaceae	5-8	7	A
Golden shower	<i>Cassia fistula</i>	Fabaceae	6-8	7	A
Gooseberry	<i>Phyllanthus emblica</i>	Euphorbiaceae	10-12	11	B
Guava	<i>Psidium guajava</i>	Myrtaceae	5-8	7	A
Indian almond	<i>Terminalia catappa</i>	Combretaceae	8-10	9	A
Indian cherry	<i>Malpighia emarginata</i>	Malpighiaceae	5-8	7	A
Indian cork	<i>Millingtonia hortensis</i>	Bignoniaceae	10-15	13	B
Indian siris	<i>Albizia lebbbeck</i>	Fabaceae	55-60	58	D

Common Name	Scientific Name	Family	App. age (In years)	Avg. age (In years)	Age class. (In years)
Indian tulip	<i>Thespesia populnea</i>	Malvaceae	5-8	7	A
Jamun	<i>Syzygium cumini</i>	Myrtaceae	20-25	23	C
Kanak Champa	<i>Pterospermum acerifolium</i>	Sterculiaceae	25-30	28	C
Mango	<i>Mangifera indica</i>	Anacardiaceae	15-20	18	B
May flower	<i>Delonix regia</i>	Fabaceae	50-60	55	D
Medicine vine	<i>Hippocratea volubilis</i>	Celastraceae	12-15	14	B
Indian mulberry	<i>Morinda tinctoria</i>	Rubiaceae	8-10	9	A
Mulberry	<i>Morus spp.</i>	Moraceae	10-12	11	B
Neem	<i>Azadirachta indica</i>	Meliaceae	40-50	45	D
Norfolk Island pine	<i>Araucaria heterophylla</i>	Araucariaceae	8-10	9	A
Paradise	<i>Simarouba glauca</i>	Simaroubaceae	10-12	11	B
Parijat	<i>Nyctanthes arbor-tristis</i>	Oleaceae	5-8	7	A
Princess trees	<i>Paulownia tomentosa</i>	Paulowniaceae	5-8	7	A
Pungam	<i>Millettia pinnata</i>	Fabaceae	20-25	23	C
Purple bauhinia	<i>Bauhinia purpurea</i>	Fabaceae	10-15	13	B
Quick stick	<i>Gliricidia sepium</i>	Fabaceae	30-35	33	D
River tamarind	<i>Leucaena leucocephala</i>	Fabaceae	10-18	14	B
Royal palm	<i>Roystonea regia</i>	Arecaceae	20-25	23	C
Sacred fig	<i>Ficus religiosa</i>	Moraceae	30-40	35	D
Sandal	<i>Santalum album</i>	Santalaceae	15-20	18	B
Sapota	<i>Manilkara zapota</i>	Sapotaceae	5-8	7	A
Sausage	<i>Kigelia Africana</i>	Bignoniaceae	40-45	43	D
Spanish Cherry	<i>Mimusops elengi</i>	Sapotaceae	25-30	28	C
Tamarind	<i>Tamarindus indica</i>	Fabaceae	50-60	55	D
Teak	<i>Tectona grandis</i>	Lamiaceae	20-25	23	C
Tipu	<i>Tipuana tipu</i>	Fabaceae	12-15	14	B
Weeping fig	<i>Ficus benjamina</i>	Moraceae	15-18	17	B

Common Name	Scientific Name	Family	App. age (In years)	Avg. age (In years)	Age class. (In years)
Wild almond	<i>Sterculia foetida</i>	Malvaceae	15-18	17	B
Wood apple	<i>Limonia acidissima</i>	Rutaceae	35-40	38	D
Yellow bells	<i>Tecoma stans</i>	Bignoniaceae	5-8	7	A
Yellow flame	<i>Peltophorum pterocarpum</i>	Fabaceae	50-60	55	D
Bamboo	<i>Bambusa vulgaris</i>	Poaceae	5-15	10	A

* 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

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)
<i>Spathodea campanulata</i>	8.16	0.93	0.56	330	185.43	48.21	233.64
<i>Terminalia arjuna</i>	5.66	0.35	0.06	800	44.16	11.48	55.64
<i>Clusia rosea</i>	5.10	0.27	0.03	679	20.10	5.23	25.32
<i>Parkia biglandulosa</i>	18.31	3.47	17.55	640	11234.08	2920.86	14154.94
<i>Terminalia bellirica</i>	10.02	0.81	0.52	697	364.82	94.85	459.68
<i>Paubrasilia echinate</i>	12.23	1.13	1.24	600	746.01	193.96	939.97
<i>Madhuca longifolia</i>	9.22	0.72	0.38	790	300.63	78.16	378.79
<i>Couroupita guianensis</i>	16.36	2.71	9.57	434	4151.66	1079.43	5231.09
<i>Casuarina equisetifolia</i>	12.02	0.63	0.38	918	348.69	90.66	439.35
<i>Phoenix pusilla</i>	9.83	0.94	0.69	600	414.93	107.88	522.81
<i>Ficus racemosa</i>	23.40	1.23	2.82	375	1056.98	274.82	1331.80
<i>Cocos nucifera</i>	17.28	0.88	1.07	616	656.30	170.64	826.93
<i>Lagunaria patersonia</i>	5.23	1.29	0.69	600	415.76	108.10	523.86
<i>Tabebuia heterophylla</i>	12.71	1.920	3.73	589	2197.22	571.28	2768.50
<i>Berbera koenigii</i>	7.45	0.57	0.19	600	115.63	30.06	145.69

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)
<i>Acacia auriculiformis</i>	15.60	2.26	6.34	600	3806.30	989.64	4795.94
<i>Polyalthia longifolia</i>	17.01	0.93	1.17	563	659.46	171.46	830.92
<i>Caryota mitis</i>	8.45	0.220	0.03	600	19.54	5.08	24.62
<i>Cordia sebestena</i>	7.32	0.63	0.23	700	161.92	42.10	204.02
<i>Cassia fistula</i>	9.20	0.97	0.69	829	571.34	148.55	719.89
<i>Phyllanthus emblica</i>	10.50	1.270	1.35	728	981.61	255.22	1236.83
<i>Psidium guajava</i>	5.94	0.87	0.36	671	240.19	62.45	302.64
<i>Terminalia catappa</i>	11.08	0.56	0.28	540	149.39	38.84	188.23
<i>Malpighia emarginata</i>	3.70	0.294	0.03	610	15.53	4.04	19.57
<i>Millingtonia hortensis</i>	11.23	1.460	1.91	600	1143.53	297.32	1440.85
<i>Albizia lebeck</i>	19.23	5.30	43.01	596	25632.30	6664.40	32296.70
<i>Thespesia populnea</i>	7.20	1.31	0.98	639	628.62	163.44	792.06
<i>Syzygium cumini</i>	10.50	1.78	2.65	701	1856.77	482.76	2339.53
<i>Pterospermum acerifolium</i>	13.50	2.35	5.94	622	3692.07	959.94	4652.01
<i>Mangifera indica</i>	12.45	0.77	0.59	597	350.86	91.22	442.09
<i>Delonix regia</i>	16.42	3.42	15.29	600	9174.60	2385.40	11559.99
<i>Hippocratea volubilis</i>	9.23	0.67	0.33	875	288.65	75.05	363.70
<i>Morinda tinctorial</i>	12.03	0.72	0.50	540	268.12	69.71	337.84
<i>Morus spp.</i>	16.10	0.77	0.76	590	448.40	116.59	564.99
<i>Azadirachta indica</i>	19.03	2.310	8.08	727	5877.70	1528.20	7405.90
<i>Araucaria heterophylla</i>	3.30	0.520	0.07	548	38.93	10.12	49.05
<i>Simarouba glauca</i>	10.63	1.335	1.51	378	570.16	148.24	718.40
<i>Nyctanthes arbor-tristis</i>	3.76	0.250	0.02	880	16.46	4.28	20.75
<i>Paulownia tomentosa</i>	7.20	1.45	1.21	330	397.73	103.41	501.14
<i>Millettia pinnata</i>	16.70	1.29	2.21	619	1369.61	356.10	1725.71

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)
<i>Bauhinia purpurea</i>	7.99	0.910	0.53	720	379.29	98.62	477.91
<i>Gliricidia sepium</i>	7.23	0.87	0.44	684	298.02	77.48	375.50
<i>Leucaena leucocephala</i>	14.20	1.62	2.97	641	1901.90	494.49	2396.39
<i>Roystonea regia</i>	15.69	1.34	2.24	600	1345.84	349.92	1695.76
<i>Ficus religiosa</i>	18.36	2.82	11.62	443	5149.74	1338.93	6488.67
<i>Santalum album</i>	9.97	0.38	0.11	936	107.29	27.89	135.18
<i>Manilkara zapota</i>	4.10	0.237	0.02	910	16.69	4.34	21.02
<i>Kigelia Africana</i>	14.90	2.98	10.53	661	6963.55	1810.52	8774.07
<i>Mimusops elengi</i>	10.40	1.43	1.69	882	1493.43	388.29	1881.72
<i>Tamarindus indica</i>	16.40	3.86	19.45	990	19260.34	5007.69	24268.03
<i>Tectona grandis</i>	19.12	1.250	2.38	612	1455.69	378.48	1834.17
<i>Tipuana tipu</i>	11.30	1.23	1.36	587	798.98	207.74	1006.72
<i>Ficus benjamina</i>	12.20	1.620	2.55	499	1272.04	330.73	1602.77
<i>Sterculia foetida</i>	12.35	1.240	1.51	552	834.56	216.99	1051.55
<i>Limonia acidissima</i>	15.26	1.36	2.25	771	1732.60	450.47	2183.07
<i>Tecoma stans</i>	6.10	0.79	0.30	466	141.25	36.72	177.97
<i>Peltophorum pterocarpum</i>	18.30	3.20	14.92	602	8981.69	2335.24	11316.93
<i>Bambusa vulgaris</i>	11.92	0.21	0.04	600	25.11	6.53	31.64

Table 3. Total carbon stock, CO₂ eq. and Net O₂ release of the selected tree species in Coimbatore city

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)
<i>Spathodea campanulata</i>	233.642	116.821	428.266	47.59	126.862	0.127	233.642

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)
<i>Terminalia arjuna</i>	55.645	27.822	101.997	12.75	33.990	0.034	55.645
<i>Clusia rosea</i>	25.325	12.662	46.421	6.63	17.680	0.018	25.325
<i>Parkia biglandulosa</i>	14154.945	7077.472	25946.013	720.72	1921.446	1.921	14154.945
<i>Terminalia bellirica</i>	459.676	229.838	842.585	76.60	204.212	0.204	459.676
<i>Paubrasilia echinate</i>	939.973	469.987	1722.971	132.54	353.342	0.353	939.973
<i>Madhuca longifolia</i>	378.795	189.397	694.331	69.43	185.109	0.185	378.795
<i>Couroupita guianensis</i>	5231.094	2615.547	9588.595	213.08	568.071	0.568	5231.094
<i>Casuarina equisetifolia</i>	439.349	219.674	805.326	80.53	214.700	0.215	439.349
<i>Phoenix pusilla</i>	522.807	261.403	958.305	95.83	255.484	0.255	522.807
<i>Ficus racemosa</i>	1331.798	665.899	2441.185	195.29	520.656	0.521	1331.798
<i>Cocos nucifera</i>	826.934	413.467	1515.770	79.78	212.686	0.213	826.934
<i>Lagunaria patersonia</i>	523.858	261.929	960.231	76.82	204.798	0.205	523.858
<i>Tabebuia heterophylla</i>	2768.498	1384.249	5074.657	289.98	773.088	0.773	2768.498
<i>Berbera koenigii</i>	145.693	72.846	267.055	26.71	71.197	0.071	145.693
<i>Acacia auriculiformis</i>	4795.939	2397.969	8790.956	204.44	545.039	0.545	4795.939
<i>Polyalthia longifolia</i>	830.921	415.460	1523.077	29.01	77.343	0.077	830.921
<i>Caryota mitis</i>	24.617	12.308	45.123	4.10	10.936	0.011	24.617
<i>Cordia sebestena</i>	204.019	102.010	373.967	57.53	153.384	0.153	204.019
<i>Cassia fistula</i>	719.891	359.945	1319.560	188.51	502.564	0.503	719.891
<i>Phyllanthus emblica</i>	1236.827	618.414	2267.104	206.10	549.464	0.549	1236.827
<i>Psidium guajava</i>	302.641	151.321	554.742	85.34	227.529	0.228	302.641
<i>Terminalia catappa</i>	188.231	94.115	345.027	38.34	102.205	0.102	188.231
<i>Malpighia emarginata</i>	19.571	9.785	35.873	5.52	14.714	0.015	19.571
<i>Millingtonia hortensis</i>	1440.846	720.423	2641.071	211.29	563.288	0.563	1440.846
<i>Albizia lebbbeck</i>	32296.703	16148.351	59199.856	1029.56	2744.814	2.745	32296.703

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)
<i>Thespesia populnea</i>	792.058	396.029	1451.842	223.36	595.479	0.595	792.058
<i>Syzygium cumini</i>	2339.528	1169.764	4288.355	190.59	508.122	0.508	2339.528
<i>Pterospermum acerifolium</i>	4652.012	2326.006	8527.137	310.08	826.667	0.827	4652.012
<i>Mangifera indica</i>	442.085	221.043	810.342	46.31	123.450	0.123	442.085
<i>Delonix regia</i>	11559.992	5779.996	21189.465	385.26	1027.111	1.027	11559.992
<i>Hippocratea volubilis</i>	363.697	181.849	666.657	49.38	131.652	0.132	363.697
<i>Morinda tinctoria</i>	337.836	168.918	619.252	68.81	183.436	0.183	337.836
<i>Morus spp.</i>	564.989	282.495	1035.625	94.15	250.998	0.251	564.989
<i>Azadirachta indica</i>	7405.904	3702.952	13575.022	301.67	804.245	0.804	7405.904
<i>Araucaria heterophylla</i>	49.055	24.527	89.918	9.99	26.636	0.027	49.055
<i>Simarouba glauca</i>	718.404	359.202	1316.834	119.71	319.153	0.319	718.404
<i>Nyctanthes arbor-tristis</i>	20.746	10.373	38.027	5.85	15.597	0.016	20.746
<i>Paulownia tomentosa</i>	501.145	250.572	918.599	141.32	376.767	0.377	501.145
<i>Millettia pinnata</i>	1725.709	862.854	3163.224	140.59	374.807	0.375	1725.709
<i>Bauhinia purpurea</i>	477.907	238.953	876.003	70.08	186.834	0.187	477.907
<i>Gliricidia sepium</i>	375.503	187.752	688.298	21.18	56.462	0.056	375.503
<i>Leucaena leucocephala</i>	2396.389	1198.194	4392.581	313.76	836.473	0.836	2396.389
<i>Roystonea regia</i>	1695.761	847.881	3108.330	138.15	368.303	0.368	1695.761
<i>Ficus religiosa</i>	6488.668	3244.334	11893.728	339.82	905.962	0.906	6488.668
<i>Santalum album</i>	135.182	67.591	247.789	14.16	37.749	0.038	135.182
<i>Manilkara zapota</i>	21.023	10.512	38.536	5.93	15.806	0.016	21.023
<i>Kigelia Africana</i>	8774.071	4387.036	16082.873	378.42	1008.869	1.009	8774.071
<i>Mimusops elengi</i>	1881.720	940.860	3449.192	125.43	334.383	0.334	1881.720
<i>Tamarindus indica</i>	24268.032	12134.016	44483.303	808.79	2156.227	2.156	24268.032
<i>Tectona grandis</i>	1834.173	917.086	3362.039	149.42	398.364	0.398	1834.173

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)
<i>Tipuana tipu</i>	1006.718	503.359	1845.313	136.69	364.415	0.364	1006.718
<i>Ficus benjamina</i>	1602.770	801.385	2937.878	178.05	474.690	0.475	1602.770
<i>Sterculia foetida</i>	1051.551	525.775	1927.493	116.82	311.436	0.311	1051.551
<i>Limonia acidissima</i>	2183.070	1091.535	4001.567	106.71	284.485	0.284	2183.070
<i>Tecoma stans</i>	177.972	88.986	326.222	50.19	133.801	0.134	177.972
<i>Peltophorum pterocarpum</i>	11316.925	5658.463	20743.924	377.16	1005.515	1.006	11316.925
<i>Bambusa vulgaris</i>	31.641	15.820	57.998	5.80	15.462	0.015	31.641

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 (Figure 5 and Figure 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 (Figure 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 (Figure 6). The results showed a strong positive correlation of R^2 (0.89521) with a gradient of 0.046.

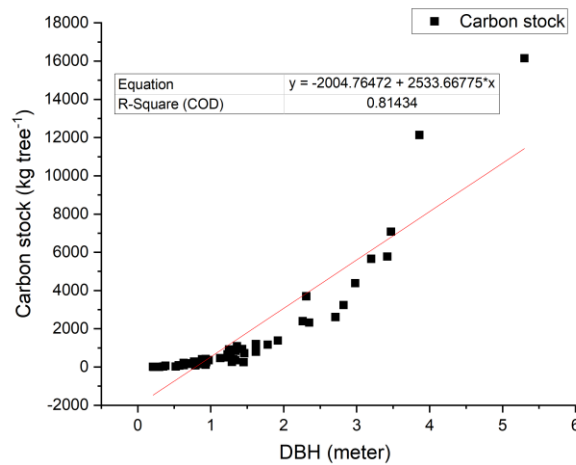


Fig. 5. Correlation coefficient (r^2 value) between DBH and Carbon stock of selected tree species

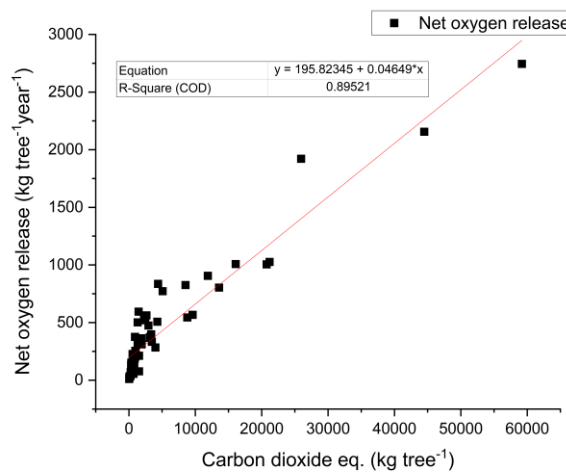


Fig. 6. Correlation coefficient (r^2 value) between Carbon dioxide eq. and Net oxygen release of selected tree species

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 lebbek* 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. 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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