ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

"ENHANCING BHOPAL'S URBAN PARKS: SELECTING OPTIMAL TREE SPECIES TO MITIGATE ATMOSPHERIC CO_2 AND IMPROVE AIR QUALITY"

Ragni Bhargava[1], G.S. Chouhans[2], Shashank Bhargava[3], Dr.Pawan Kumar Jain[4]
[1]Department of Forestry, SAM Global University, Bhopal, Madhya Pradesh, 462001, Bharat
[2]Department of Agriculture, SAM Global University, Bhopal, Madhya Pradesh, 462001, Bharat
[3]Department of Biotechnology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, Bharat.
[4]Department of Botany, Eklavya University, Damoh470661, Madhya PradeshBharat.

Abstract
This study investigates the carbon sequestration potential of trees within specific urban parks in Bhopal, aiming to identify species with high biomass and efficient carbon fixation suitable for urban environments. Additionally, it recognizes the significance of Bhopal's parks as vital green spaces, offering recreational opportunities and respite from urban life. The aesthetic appeal of these parks is attributed to a combination of exotic and native flora. Among the tree species surveyed, Ficusbenghalensis demonstrates the highest carbon sequestration potential 42320.83 kg/tree, followed by Vacchelianilotica about 34742.7 kg per tree.. The study identifies additional species with notable carbon sequestration capacities, including Salix babylonica, Eucalyptus globulus, Tectonagrandis, Delonixregia, Dalbergiasissoo, Ficusreligiosa, Shorearobusta, and Azadirachtaindica. Conversely, Bambusa species and Dypsislutescens exhibit lower carbon sequestration capabilities. Fruit-bearing trees such as Syzygiumcumini, Mangiferaindica, Phyllanthusemblica, and Ziziphus jujube are recommended for widespread planting due to their ability to store significant amounts of CO2. The study underscores the importance of accurately measuring tree attributes, including height and diameter at breast height (DBH), for species identification and carbon sequestration estimation. It emphasizes the need for thoughtful selection of urban trees beyond mere maintenance considerations, advocating for a diverse tree mix to enhance biodiversity and maximize environmental benefits.

Keywords: Urban parks, carbon sequestration, tree species, biodiversity, environmental benefits, Bhopal.

1. INTRODUCTION

The terrestrial ecosystem plays a crucial role in regulating atmospheric carbon dioxide (CO2) levels through various carbon pools, including biomass, above-ground and below-ground biomass, dead wood, litter, and soil organic matter. Beyond directly sequestering carbon, green spaces flora and soil indirectly influence the carbon balance by modulating the urban energy balance, thereby impacting CO2 emissions associated with energy consumption

ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

(Churkina, 2016). In India, the imperative to sequester carbon dioxide to mitigate climate change hinges significantly on the country's rich biodiversity of trees. As trees mature, they absorb CO2 from the atmosphere, converting it into organic matter stored within their leaves, branches, and trunks. India's diverse geography hosts a plethora of tree species that fulfill this essential function. According to Nandal, Abhishek et al. (2023), certain iconic trees actively store carbon, thereby substantially mitigating greenhouse gas emissions. Examples include the revered banyan, the ubiquitous sal tree, and the stately teak. Moreover, India's abundance of mango, neem, peepal, and jamun trees contributes to this natural carbon capture process, underscoring the nation's commitment to environmental sustainability and climate change mitigation. From an environmental standpoint, the rapid urbanization of cities raises concerns about their ecological health and susceptibility to environmental risks. However, the presence of roadside plantations and tree-lined avenues within metropolitan areas significantly contributes to the nation's expanding vegetation cover and plays a vital role in climate amelioration. Whether intentionally planted or naturally occurring, roadside trees serve an ecological function by sequestering carbon, reducing pollution levels, and mitigating climate change (Da Silva et al., 2010; Singh and Singh, 2015). Moreover, urban environments derive manifold benefits from the presence of trees. These advantages encompass social aspects such as recreational opportunities and enhanced physical and mental well-being; aesthetic enhancements including diverse landscapes featuring varied colours, textures, and plant densities; climatic benefits such as cooling effects and wind moderation; and financial gains such as increased property values, tourism revenue, and yields from fruit production and small-scale timber (Granville, 2009).

According to the 1992 74th amendment to the Indian Constitution, the responsibility for establishing and maintaining parks and recreational areas within city limits lies with municipal and urban development authority's (Granville, 2009). However, research by Khosla and Bhardwaj (2018) indicates that Urban Local Bodies (ULBs) in India possess limited authority to address climate change and often neglect to incorporate climate change considerations into their development plans (Sami, 2017; 2018; Khosla and Bhardwaj, 2018). The quantification of carbon storage and atmospheric carbon dioxide equivalence by trees represents one of the tangible benefits of trees in mitigating the impacts of climate change, as explored in this article. Urban trees not only absorb carbon during their growth but also store it, releasing it back into the atmosphere upon their demise (Potdar et al., 2017). Furthermore, cities adorned with trees exhibit cooler ambient temperatures and reduced reliance on traditional energy sources, altering the carbon emissions profile of urban areas (Abdollahi et al., 2000). Consequently, urban trees exert a significant influence on local climate, the associated carbon cycle, and overall energy consumption, thereby aiding in the mitigation of climate change (Abdollahi et al., 2000; Wilby et al., 2006; Gill et al., 2007; Nowak, 2010; Lal et al., 2012).

2. MATERIAL AND METHODS

Bhopal, the capital of Madhya Pradesh, is a blend of old and new, with pretty lakes and diverse buildings. The old city has busy markets, mosques, and palaces, while the new part has wide streets, clean parks, and modern buildings. It's known for being clean and green,

ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

with about 11.26% of the city covered in green spacesreported by Jain (2011). Bhopal's big forest, about 1,700 hectares, soaks up a lot of carbon, about 12,000 megatons every year. But sadly,A satellite survey conducted by the Indian Institute of Science, Bengaluru, the number of trees has dropped by 44% in the last 20 years. Experts say if this keeps happening, it could go down to just 4.1% by 2030.To address this issue and contribute to India's goal of increasing tree cover to one third of its land area, as outlined in the National Forest Policy of 1988, the study focuses on nine parks in close proximity within the city. These parks serve as the study sites, where tree species will be meticulously identified and quantified for subsequent carbon sequestration assessments, with special emphasis on agroforestry species with high carbon sequestration potential.

Nine different parks have been selected for the study of different tree species in Bhopal:

1. Birla Mandir Park
2. Chinar Park
3. Kamla Park
4. Mayur Park
5. Rose Garden
6. SairSapata Park
7. ShauryaSmarak Park
8. Titli Park
9. Vann Vihar

Methodology for Carbon Sequestration Analysis (Non-Destructive Approach):

2.1 Non-Destructive Measurement Techniques:

- Utilize non-destructive measurement techniques to estimate carbon sequestration potential without harming the trees.

1. Diameter at Breast Height (DBH) Measurement: Measure the diameter of each tree at breast height using a diameter tape.
2. Height Measurement: Estimate the height of each tree using a Altimeter.
3. Above-Ground Biomass (AGB) Estimation (Potadar Vishnu R et. al, 2017).

   AGB (kg) = volume of tree (m^3) x wood density kg/m^3

   $V = \pi r^2 H$

   Where H = Height of the tree in meter,

   V= volume of the cylindrical shaped tree in m^3,

   r = radius of the tree in meter, Radius of the tree is calculated from GBH of tree.
4. **Below-Ground Biomass (BGB) Estimation:**

BGB (kg/tree) = AGB (kg/tree) x 0.26

Where:

- AGB: Above-Ground Biomass of the tree (in kilograms)

- 0.26: Root-to-Shoot Biomass Ratio (dimensionless), representing the proportion of below-ground biomass relative to above-ground biomass. This ratio is derived from literature or empirical studies (Potadar Vishnu R et al., 2017; A.N. Djomo et al., 2010).

ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

5. **Total Biomass (TB) Estimation:**

TB = AGB + BGB (kg/tree).

Where:

- AGB: Above-Ground Biomass of the tree (in kilograms or tons)
- BGB: Below-Ground Biomass of the tree (in kilograms or tons)

6. **Formula for Carbon Content Estimation:**

Carbon Content = Total Biomass * 50%

Where:

- Carbon Content: Carbon content of the tree (in kilograms or tons)
- Total Biomass: Total biomass of the tree (in kilograms or tons)
- 50%: Represents the assumed proportion of carbon content within the biomass. This value is commonly used in carbon content estimation for plants.

7. **Formula for Estimation of Sequestered Carbon Dioxide:**

Weight of CO_2 Sequestered = Carbon Content * 3.663

Where:

- Weight of CO_2 Sequestered: Amount of carbon dioxide sequestered by the tree (in kilograms)
- Carbon Content: Carbon content of the tree (in kilograms)
- 3.663: Conversion factor representing the ratio of the weight of CO_2 to the weight of carbon (43.99915/12.001118), which is derived from the molecular formula of carbon dioxide (C + 2O = 43.99915).

2.2 Sampling Procedure:

For parks where the count of individual tree species was less than or equal to ten, each tree was measured as part of the sampling process. However, in cases where a particular species exceeded ten individuals within a single park, a random sampling procedure was implemented to streamline the measurement process. This method involved selecting a representative sample size equivalent to ten percent of the total population of that tree species within the park. The selected trees were then measured, and a 95% confidence interval was calculated for the obtained measurements, following the methodology outlined by H. K Gibbs (2007).

2.3 Statistical Analysis:

We used a sample size calculator available on calculator.net to perform allometric calculations for random sampling. This helped us determine the minimum number of samples required to meet our statistical criteria, ensuring a 95% confidence interval for our observations. Additionally, we created graphs to visually compare carbon sequestration levels among different tree varieties, aiding in data analysis and interpretation.

ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

3. RESULT AND DISCUSSION

The current study conducted a comprehensive assessment of tree biomass, encompassing both above-ground and below-ground components, within urban parks accessible in specific areas of Bhopal city. In parallel, an examination of emissions revealed that Bhopal emits approximately 1.65 million tons of CO_2 annually, alongside other detrimental pollutants such as sulfur dioxide (SO_2) and carbon monoxide (CO). Notably, the urban average ambient concentration of PM2.5, a hazardous particulate matter, exceeds the WHO standard by nearly fivefold, with an estimated level of 49.9 ± 6.7 µg/m3.

ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

Table 1: Species-Wise Total Volume, Biomass and Carbon of Tree Species of Selected Park Of Bhopal City.

Ser. No	Species Name	Family	Volume (m^3)	Average Biomass (Kg/tree).	Average Carbon (kg)
1	*Saracaasoca*	Fabaceae	17.54	12882.97	23595.17
2	*Mangiferaindica*	Anacardiaceae	74.95	56440.79	103371.3
3	*Eucalyptus globules*	Myrtaceae	956.72	855009.1	1551828
4	*Azadirachtaindica*	Meliaceae	162.8	149201.1	273261.8
5	*Delonixregia*	Fabaceae	95.92	72526.11	132831.6
6	*Cassia grandis*	Fabaceae	4.57	4900.07	8974.48
7	*Dalbergiasissoo*	Fabaceae	710.74	621006.1	1137373
8	*Sterculiafoetida*	Malvaceae	8.72	6053	11086.03
9	*Neolamarckiacadamba*	Rubiaceae	63.62	38474	70465.09
10	*Pithecellobiumdulce*	Fabaceae	0.05	41.45	75.92
11	*Alnus firma*	Betulaceae	4.55	3329.66	6098.31
12	*Salix Caprea*	Salicaceae	1.92	1450.45	2656.53
13	*Dypsislutescens*	Arecaceae	7.71	5397.77	9885.99
14	*Ficusreligiosa*	Moraceae	129.5	72285.02	132390
15	*Ficusbenjamina*	Moraceae	5.1	3209.63	5878.46
16	*Serianthesgrandiflora*	Fabaceae	9.47	5851.75	10717.52
17	*Drypetesdeplanchai*	Phyllanthaceae	1.18	1131.73	2072.77
18	*Betulautilis*	Betulaceae	2.76	2009.16	3679.74

ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

19	*Ficusbenghalensis*	Moraceae	1485.8	917918.4	1681168
20	*Syzygiumcumini*	Myrtaceae	21.91	19349.12	35437.95
21	*Putranjivaroxburghii*	Putranjivaceae	3.9	3478.03	6369.96
22	*Magnolia champaca*	Magnoliaceae	15.26	10295.21	18855.65
23	*Cassia fistula*	Fabaceae	222.17	232160.8	425202.5
24	*Acacia nilotica*	Fabaceae	22.24	21414.52	39220.75
25	*Phyllanthusemblica*	Phyllanthaceae	110.41	101421	185752.6
26	*Neolamarckiacadamba*	Rubiaceae	22.88	15427.18	28254.91
27	*Bambusa vulgaris*	Poaceae	0.7	518.49	949.66
28	*Lagerstroemia speciosa*	Lythraceae	5.53	4397.12	8053.3
29	*Moringaoleifera*	Moringaceae	0.04	11.32	20.74
30	*Vachellianilotica*	Fabaceae	643.08	719346.9	1317484
31	*Salix babylonica*	Salicaceae	4.67	2352.4	4308.42
32	*Holopteleaintegrifolia*	Ulmaceae	181.68	118018.7	216151.3
33	*Pongamiapinnata*	Fabaceae	410.71	413975.9	758196.8
34	*Buteamonosperma*	Fabaceae	279.28	154839.3	283588.1
35	*Schleicheraoleosa*	Sapindaceae	30.61	35738.9	65455.84
36	*Bambusaarundinacea*	Poaceae	2.34	2318.46	4246.39
37	*Cratevareligiosa*	Capparaceae	7.03	6197.56	11350.82
38	*Ficusracemosa*	Moraceae	10.45	4960.92	9085.9

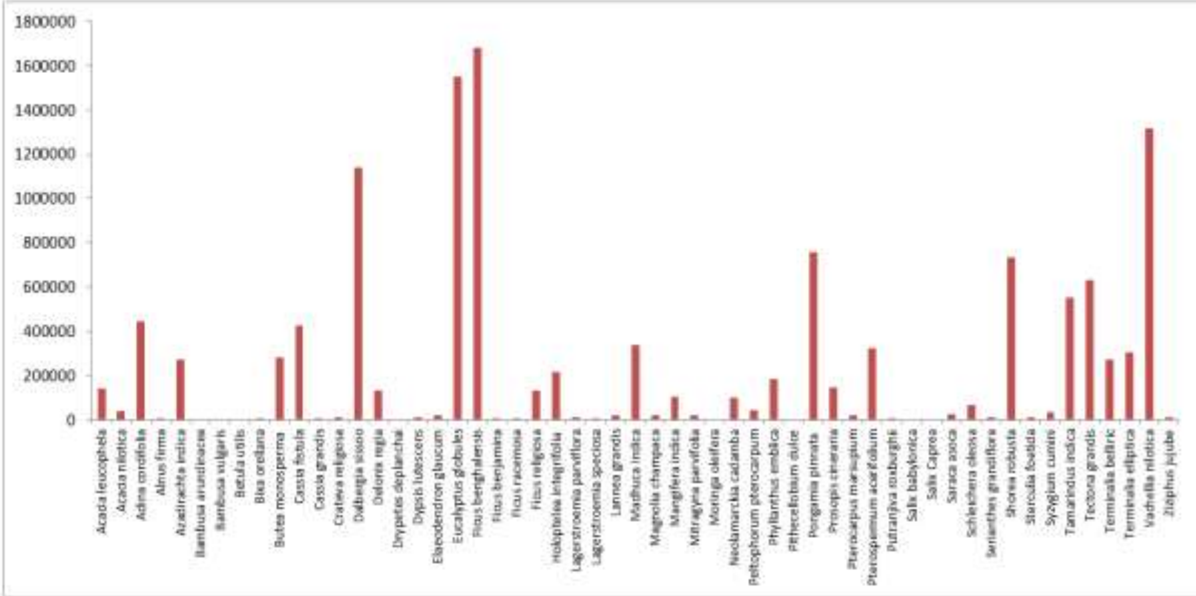
ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

39	*Acacia leucophela*	Fabaceae	77.17	77791.09	142474.3
40	*Prosopis cineraria*	Fabaceae	91.2	79050.35	144780.7
41	*Adina cordifolia*	Rubiaceae	214.04	242728.8	444557.7
42	*Tamarindusindica*	Fabaceae	242.21	302184.9	553451.6
43	*Pterospermumacerifolium*	Sterculiaceae	224.49	176026.5	322392.7
44	*MadhucaIndica*	Sapotaceae	160.25	184649.7	338186
45	*Shorearobusta*	Dipterocarpaceae	408.8	400123.2	732825.6
46	*Tectonagrandis*	Lamiaceae	446.37	344580.9	631100
47	*Terminaliaelliptica*	Combretaceae	156.74	167022.3	305901.3
48	*Peltophorumpterocarpum*	Fabaceae	30.98	23501.4	43042.82
49	*Ziziphus jujube*	Rhamnaceae	7.57	7653.5	14017.32
50	*Elaeodendronglaucum*	Celastraceae	10.52	10476.35	19187.45
51	*Pterocarpusmarsupium*	Fabaceae	12.06	10447.39	19134.36
52	*Lanneagrandis*	Anacardiaceae	15.81	11617.85	21278.08
53	*Mitragynaparvifolia*	Rubiaceae	15.15	12209.65	22361.89
54	*Lagerstroemia parviflora*	Lythraceae	7.71	6364.54	11656.75
55	*Terminaliabelliric*	Combretaceae	132.18	149916.6	274572.2
56	*Bixaorellana*	Bixaceae	10.87	5109.54	9358.16
Total			8002.63	6906795	12635674

ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023



Graph 1- Graphical representation of Carbon sequestered (in kg) by different tree species.

The study conducted a comprehensive assessment of tree biomass and carbon sequestration potential across various species in urban parks of Bhopal city. Table 1 presents the volume, average biomass per tree, average carbon content, and total carbon sequestered for each species surveyed.

Among the surveyed species,the results indicate significant variations in biomass and carbon sequestration capacities among different tree species, highlighting their diverse ecological roles and contributions to urban ecosystem services.*Ficusbenghalensis* exhibited the highest biomass and carbon sequestration potential, with an average biomass of 917918.4 m3/tree and total carbon sequestered of approximately 1681168 kg tons followed by *Eucalyptus globules* average biomass of 956.72 m3/tree and total carbon sequestered of approximately 1,551,828 tons. . This emphasizes the importance of selecting species with high carbon sequestration efficiency for urban forestry initiatives aimed at mitigating atmospheric CO2 levels. Other notable contributors to carbon sequestration include*Dalbergiasissoo*and *Tectonagrandis*,which displayed substantial biomass and carbon storage capabilities. These species could serve as valuable assets in urban greening efforts, particularly in combating air pollution and enhancing the overall environmental quality of urban areas.

Conversely, species with lower biomass and carbon sequestration rates, such as Pithecellobiumdulce and Moringaoleifera, may still provide valuable ecosystem services but may be less effective in mitigating atmospheric carbon levels.

The findings underscore the importance of selecting tree species with high carbon sequestration efficiency for urban forestry initiatives, particularly in addressing air pollution and climate change mitigation in urban areas. Strategic planning and management of urban

ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

green spaces can leverage these findings to maximize the environmental benefits of urban trees and enhance the overall sustainability and resilience of cities like Bhopal.

CONCLUSION

Overall, the study provides valuable insights into the carbon sequestration potential of different tree species in urban parks of Bhopal. By incorporating these findings into urban planning and management strategies, policymakers can effectively harness the benefits of urban trees to mitigate climate change, improve air quality, and enhance the well-being of urban residents.

References

[1] Abdollahi K.K., Ning Z.H., Appeaning A. 2000. Global Climate Change and the Urban Forest. GCRCC and Franklin Press, *Baton Rouge*: 31–44.

[2] Churkina G. 2016. The role of urbanization in the global carbon cycle. *Frontiers in Ecology and Evolution*, 3, 144.s.

[3] Da Silva, A.M., Alves, B.C. and Alves, S.H., 2010. Roadside vegetation: estimation and potential for carbon sequestration. iForest, 3:124-129. Doi: 10.3832/ifor0550-003

[4] Djomo, A.N., Ibrahima, A., Saborowski, J. and Gravenhorst, G., 2010. Allometric equations for biomass estimations in Cameroon and pan moist tropical equations including biomass data from Africa. *Forest Ecology and Management*, *260*(10), pp.1873-1885.

[5] Gibbs, H.K., Brown, S., Niles, J.O. and Foley, J.A., 2007. Monitoring and estimating tropical forest carbon stocks: making REDD a reality. *Environmental research letters*, *2*(4), p.045023.

[6] Gill S.E., Handley J.F., Ennos A.R., Pauleit S. 2007. Adapting cities for climate change: the role of the green infrastructure. *Built Environment* 33 (1): 115-133.

[7] Granville, A., 2009. The Indian Constitution Cornerstone of a Nation. Oxford University Press, New Delhi.

[8] Jana, B.K., Biswas, S., Majumder, M., Roy, P.K., Mazumdar, A., 2011. Carbon sequestration rate and aboveground biomass carbon potential of three young species in lower Gangetic plain. J Environ SciEng 53, 299–308.

[9] Khosla, R. and Bhardwaj, A., 2018. Urbanization in the time of climate change: Examining the response of Indian cities. Wires Climate Change. Doi: 10.1002/wcc.560

[10] Lal R., Augustine B. 2012. *Carbon Sequestration in Urban Ecosystems*. Springer, New York.

[11] Nandal, A., Yadav, S., Singh Rao, A., Meena, R.S., Lal, R., 2023. Advance methodological approaches for carbon stock estimation in forest ecosystems. Environmental Monitoring and Assessment 195.

[12] Nowak D.J. 2010. Urban biodiversity and climate change. In: Muller, N., Werner, P., Kelcey, J.G. (Eds.), *Urban Biodiversity and Design*. Wiley-Blackwell Publishing, Hoboken, NJ: 101–117.

[13] Potdar V.R, Satish S.P. 2017. Sequestration and storage of carbon by trees in and around University campus of Aurangabad city in Maharashtra, India. *International Research Journal of Engineering and Technology* (IRJFT), 04: 598–602.

ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 12, Iss 01, 2023

[14] Sami, N., 2017. Multi-level climate change planning: Scale, capacity and the ability for local action. In S. Moloney, H. Fünfgeld, and Granberg (Eds.), Local action on climate change: Opportunities and constraints (pp. 92–110). Abingdon, Oxon, England: New York, NY: Routledge.

[15] Sami, N., 2018. Localizing environmental governance in India. In A. Luque-Ayala, S. Marvin, and H. Bulkeley (Eds.), Rethinking urban transitions: Politics in the low carbon city (pp. 164–182). Abingdon, Oxon, England: New York, NY: Routledge.

[16] Singh, K. and Singh, G., 2015. Roadside vegetation diversity of Jodhpur district and its role in carbon sequestration and climate change mitigation. Advances in Forestry Science, 2(2), 23-33.

[17] Wilby R.L., Perry G.L.W. 2006. Climate change, biodiversity and the urban environment: a critical review based on London UK. *Progress in Physical Geography*, 30 (1): 73–98.

.