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Floristic Biodiversity and Carbon Stock of Urban City with Reference to Educational Institutes of Gwalior : An Approach of Sustainability

Jasra Anjum, Avinash Tiwari, Muzamil Ahmad Sheikh, Sangeeta Sharma

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ABSTRACT

The current study was under taken to determine the role of standing vegetation in urban forestry of Gwalior city with special reference to educational institutes. The results revealed that educational institutes play a prominent role not only in mitigating atmospheric carbon dioxide but also in its regulation. The study area was assessed quantitatively with Simpson's Diversity Index, Shannon- Wiener Index, Menhinick's Richness, Evenness and Sorensen coefficient which revealed that the study sites are rich in vegetation and can prove helpful in long-term sequestration of carbon. Qualitative analysis revealed that *Azadirachta indica* dominated at Site-1 for frequency, relative frequency, relative dominance and basal area while *Tectona grandis* showed highest density relative density, abundance and Importance Value Index. At Site-II frequency was shown highest by *Phyllanthus emblica* and *Azadirachta indica.* Density, relative density, basal area and Importance Value Index was also observed highest by *Phyllanthus emblica.* Highest abundance was shown by *Tectona grandis* and highest relative dominance by*Terminalia arjuna.* The total carbon stock was observed highest at Site-1 (94.44 ton/ha) as compared to Site-II campus (89.83 ton/ha). The diversity of standing vegetation depicts that different plants of ornamental, sacred as well as medicinal plants contribute towards the mitigation of atmospheric carbon dioxide. The conclusion from the study revealed that different green patches of educational institutes play great role in sustainability of urban environment and also contribute towards aesthetic value of city.

Keywords Educational institutes, Phyto-sociological parameters, Standing vegetation, Urban area.

INTRODUCTION

The atmospheric carbon dioxide level continues to escalate with rapid industrialization and has now increased by approximately 30% which could only be due to the increased emission (Mgbemene 2011, Lal 2007) and leads to climate change (Bierwirth 2019). About half of the anthropogenic CO_2 emissions (between 1750 and 2011) have occurred in the last 40 years (Pachauri et al. 2014). Temperature of cities is elevated as compared to rural areas and this phenomenon is known as the urban heat island which can enhance the risk of heat related mortality (Chapman et al. 2017) . The patches of forest vegetation areas

Jasra Anjum*, Avinash Tiwari, Sangeeta Sharma
School of Studies in Botany, Jiwaji University, Gwalior 474001, Madhya Pradesh, India

Muzamil Ahmad Sheikh
Division of Fruit Science, SKUAST-K, Shalimar 110088, India
Email : anjum22jasra@gmail.com. tiwariavinash2@gmail.com,. muzamiljabbar11@gmail.com, sharma9.sangeeta@gmail.com
*Corresponding author

have been recorded to contribute in sequestrating of atmospheric carbon dioxide. The United Nations Framework is to alleviate the atmospheric green house gas concentration up to normal level and which has least interference with the climate system (UNFCC 1992). In order to reduce the concentration of carbon dioxide we either reduce carbon source or can increase carbon sink. Carbon sequestration is actually the mitigation potential of atmospheric carbon dioxide emitted by various industries, factories, automobiles as well as burning of fossil fuels (Arya et al. 2017). Natural vegetation especially forests play a prominent role in storing carbon dioxide and also its importance with respect to sequestration potential (FSI 2009, Tiwari and Singh 1987) has been well documented but the same has not been addressed in urban areas which reflects the importance for assessing the role as well as potential of green forest patches in urban areas. Analysis of carbon sequestration potential in urban areas provide scientific basis for tackling climate change,management of forests, planning and long-term development of established forest patches which can construct and maintain healthy urban environment (Yu et al. 2017). Urban forests comprises of all vegetation ranging from individual trees to community of different species located in urban area and peri-urban areas (Salbitano et al. 2016). Vegetation of urban forests play vital role in ecosystem services like supporting, regulating, recreational as well as cultural which directly controls the fluctuation of atmospheric carbon dioxide by acting as sink (Nowak and Crane 2002). The ecosystem services in urban areas are due to individual as well as group of trees, litter and herb vegetation that not only maintains the diurnal temperature but also reduces green house gases (Oviantari et al. 2018). Size of tree than its density is function of carbon storage so ancestral as well as heritage trees can play an important role in carbon fixation besides the small sized ones (Nero et al. 2018). Thrashing or scratching of ecosystems reduces the ability to fix and stock up atmospheric carbon therefore, maintaining and preserving natural vegetation makes a notable involvement in mitigating the climate change (Daba and Dejene 2018). Biodiversity plays an important role in sustaining and balancing the environment of urban areas (Kumari et al. 2018). Conservation of biological diversity especially plantation of urban forestry plays a great role in mitigating the climate change (Nero et al. 2018). Since Gwalior city is developing as an educational hub, so there is a need to assess the role of these educational institutes in mitigating and sustaining the environment of the city.

MATERIALS AND METHODS

Study area

The study was conducted at Central India of Gwalior city during the year 2019 at two different sites i.e., Laxshmi Bai National Institute of Physical Education (N 26^{0}13'17.2" and E 078^{0}11'54.39" and Jiwaji University Campus (N 26^{0}12'11.02" and E 078^{0}11'44.71") designated as Site-I and Site-II respectively. Both the sites are prmier educational institutions of the area having good vegetation. Total geographical area of the district is 303 km^2 possessing the population of about 12.7 lakh with dynamic climatic conditions changing during different seasons, summer being very hot and dry ranging temperature up to 48^{0}C and chill winter with temperature up to -2^{0}C with elevation of 197 m above Msl.

Sampling approach

The Random Quadrat sampling method was employed for above ground vegetation with 4 permanent quadrats of 20 m × 20 m for trees and 1 m × 1 m size for the herbs at both the sites. Trees with GBH ≥ 10 cm were taken into consideration for estimation of biomass using Allometric equation of (Anderson and Ingram 1989) which was subsequently converted into carbon. Herb carbon estimation was done on dry weight basis using equation of (Hairiah et al. 2001) 50% of biomass was considered as above ground carbon (Brown 1997) and 15% of above ground carbon (AGC) was taken as below ground carbon (BGC) (Mack Dicken 1997).

Data analysis

The information collected from the study sites was subjected to various phyto-sociological parameters and analysis was done both quantitatively (Density,

Table 1. Phyto-sociological parameters of tree vegetation at Site-I. D- Density, F-Frequency, A-Abundance, B-Basal Area (sq cm), RD-Relative Density, RF- Relative Frequency, RD^0-Relative Dominance, IVI-Importance Value Index.

Scientific name	Family	D	F	A	BA	RF	RD	RD^0	IVI
Zizypus sp.	Rhamnaceae	0.5	25	2	1510.82	7.14	2.46	3.22	12.82
Caesalpinia	Fabaceae	1.75	25	7	4228.26	7.14	8.64	9.01	24.79
Pongomia pinnata	Fabaceae	2.5	50	5	9508.20	14.28	12.34	20.27	46.89
Azadirachta indica	Meliaceae	4.25	100	4.25	14839.64	28.57	20.98	31.64	81.19
Albizia lebbeck	Fabaceae	0.25	25	1	2494.34	7.14	1.23	5.31	13.68
Tectona grandis	Lamiaceae	10.25	50	20.5	10755.73	14.28	50.61	22.93	87.82
Dalbergia sissoo	Fabaceae	0.25	25	1	2167.59	7.14	1.23	4.62	12.99
Polyalthia longifolia	Annonaceae	0.25	25	1	522.37	7.14	1.23	1.11	9.48
Acacia sp.	Fabaceae	0.25	25	1	861.14	7.14	1.23	1.83	10.20

Relative Density, Frequency, Relative Frequency, Abundance, Relative Dominance, Basal Area) and qualitatively (Simpson's Diversity Index, Shannon-Wiener Index, Menhinick's Richness and Sorensen coefficient) by using standard expressions. The Importance Value Index (IVI) was done by sum of relative frequency, relative density and relative dominance (Shannon and Weaver 1949, Menhinick 1964, Sorensen 1948).

RESULTS

A total of 9 species were found across all of the survey plots at Site-I (Table 1) and 25 species at Site-II (Table 2). At Site-I highest density was showed by *Tectona grandis* with 10.25 while lowest by *Albizia lebbeck, Dalbergia sisso, Acacia* sp. and *Polyalthia longifolia* with 0.25. Frequency and relative frequency was shown highest by *Azadirachta indica* with 100% and

Table 2. Phyto-sociological parameters of tree vegetation at Site-II. D-Density, F-Frequency, A-Abundance, B- Basal Area (sq cm), RD.- Relative Density, RF-Relative Frequency, RD^0-Relative Dominance, IVI-Importance Value Index.

Scientific name	Family	D	F	A	BA	RF	RD	RD^0	IVI
Delonix regia	Fabaceae	1.75	25	7	3737.18	3.33	3.93	8.25	15.51
Tectona grandis	Lamiaceae	5.75	25	23	4186.54	3.33	12.92	9.25	25.5
Citrus lemon	Rutaceae	0.75	50	1.5	141.87	6.66	1.68	0.31	8.65
Azadirachta indica	Meliaceae	2.75	75	3.67	6214.3	10	6.17	13.73	29.3
Terminalia arjuna	Combretaceae	0.5	25	2	842.75	3.33	1.12	18.62	23.07
Nerium indicum	Apocynaceae	0.25	25	1	23.00	3.33	0.56	0.05	3.94
Dolichandrone spathacea	Bignoniaceae	1.25	25	5	3172.77	3.3	2.81	7.01	13.15
Mimusops elengi	Sapotaceae	0.75	25	3	239.88	3.33	1.68	0.53	5.54
Albizia lebbeck	Fabaceae	2.5	25	10	4026.91	3.33	5.61	8.89	17.83
Ziziphus sp.	Rhamnaceae	0.75	25	3	2234.71	3.33	1.68	4.93	9.94
Caesal pinia	Fabaceae	0.75	25	3	597.61	3.33	1.68	1.32	6.33
Pongamia pinnata	Fabaceae	2.5	25	10	4026.91	3.33	5.61	8.89	17.83
Callistemon lanceolatus	Myrtaceae	0.25	25	1	575.23	3.33	0.56	1.27	5.16
Murrya koenigii	Rutaceae	0.5	25	2	49.12	3.33	1.12	0.108	4.55
Syzygium cumini	Myrtaceae	0.5	25	2	43.12	3.33	1.12	0.096	4.54
Phyllanthus emblica	Phyllanthaceae	20.25	75	7	8115.5	10	45.5	17.93	73.43
Aegle marmelos	Rhamnaceae	1	25	4	1111.94	3.33	2.24	2.45	8.02
Polyalthia longifolia	Annonaceae	0.5	25	2	905.17	3.33	1.12	2.00	6.45
Psidium guajava	Myrtaceae	1.25	25	5	196.89	3.33	2.80	0.43	6.56
Dalbergia sissoo	Fabaceae	0.75	25	3	5266.71	3.33	1.68	11.63	16.64
Annona squamosa	Annonaceae	0.25	25	1	45.85	3.33	0.56	0.10	3.99
Ficus hispida	Moraceae	0.25	25	1	1888.21	3.33	0.56	4.17	8.06
Butea monosperma	Fabaceae	0.25	25	1	11.46	3.33	0.56	0.02	3.91
Mangifera indica	Anacardiaceae	0.5	25	2	19.42	3.33	1.12	0.04	4.49
Artocarpus heterophyllus	Moraceae	0.25	25	1	23.00	3.33	0.56	0.05	3.94

28.57 respectively and lowest by *Ziziphus* sp., *Caesalpinia, Albizia lebbeck, Dalbergia sissoo, Acacia* sp. and *Polyalthia longifolia* with 25% and 7.14 respectively. *Tectona grandis* showed highest abundance with (20.5) and lowest by *Albizia lebbeck, Dalbergia sissoo, Polyalthia longifolia* and *Acacia* (1). Basal area was shown highest by *Azadirachta indica* with (14839.64 sq cm) and lowest by *Polyalthia longifolia* (522.37 sq cm). Highest relative density and relative dominance was recorded by *Tectona grandis* (50.61) and *Azadirachta indica* (31.64) respectively while lowest relative dominance was recorded by *Polyalthia longifolia* (1.11) and relative density by *Albizia lebbeck*, *Dalbergia sissoo, Polyalthia longifolia* and *Acacia* sp. with 1.23. Importance Value Index was shown highest by *Tectona grandis* (87.82) and lowest by *Polyalthia longifolia* (9.48) (Table 1).

The results of Site-II revealed that *Phyllanthus emblica* showed highest density (20.25) and lowest by *Nerium indicum, Callistemon lanceolatus, Annona squamosa, Ficus hispida, Butea monosperma* and *Artocarpus heterophyllus* (0.25). Frequency was shown highest by *Phyllanthus emblica* and *Azadirachta indica* (75%) followed by *Citrus lemon*\(50%) and rest of the species showed frequency of 25% each. *Tectona grandis* showed highest abundance with 23 and *Nerium indicum, Callistemon lanceolatus, Annona squamosa, Ficus hispida, Butea monosperma* and *Atrocarpus heterophyllus* lowest (1). Basal area was recorded highest by *Phyllanthus emblica* (8115.5 sq cm) and lowest by *Butea monosperma* (11.46 sq cm). Relative frequency was shown highest by *Phyllanthus emblica* and *Azadirachta indica* with value 10 followed by *Citrus lemon* with (6.6) and rest of the species (3.33). Relative density was shown highest by *Phyllanthus emblica* with (45.5) and lowest by *Nerium indicum, Callistemon lanceolatus, Annona squamosa. Ficus hispida, Butea monosperma* and *Atrocarpus heterophyllus* (0.56). *Terminalia arjuna* showed highest relative dominance (18.62) and *Butea monosperma* lowest (0.02). Importance Value Index (IVI) was recorded highest in *Phyllanthus emblica* (73.43) and lowest by *Butea monosperma* (3.91).

All the Phyto-sociological parameters were calculated and compared site wise which revealed that *Tectona grandis* showed highest density (10.25) at Site-I and *Phyllanthus emblica* (20.25) at Site-II. Highest relative density (50.61) was achieved by *Tectona grandis* at Site-I and by *Phyllanthus emblica* (45.5) at Site-II. *Azadirachta indica* showed highest frequency as well as relative frequency at both the sites (Tables 1 and 2). Abundance was shown highest by *Tectona grandis* at both the sites with 20.5 at Site-I and 23 at Site-II. *Azadirachta indica* showed highest basal area (14839.64 sq cm) at Site-I and *Phylanthus emblica* (8115.6 sq cm) at Site-II Relative dominance was shown highest by *Azadirachta indica* with (31.64) at Site-I and 18.62 by *Terminalia arjuna* at Site-II. Importance Value Index (IVI) was estimated highest by *Tectona grandis* with (87.82) at Site-I and *Phyllanthus emblica* with (73.43) at Site-II respectively (Tables 1 and 2).

Table 3. Above ground, below ground and total carbon of trees.

Site	AGC (ton/ha)	BGC (ton/ha)	TC (ton/ha)
Site-1	82.12	12.31	94.44
Site-2	78.5	11.68	89.83

The carbon stock of standing vegetation was estimated at both the sites and results revealed total carbon was found highest at Site-I (94.44 ton/ha) with AGC (82.12 ton/ha) and BGC (12.31ton/ha) while lowest at Site-II (89.83 ton/ha) with AGC (78.5 ton/ha) and BGC (11.68 ton/ha) (Table 3). Carbon content of herb vegetation was found highest as Site-II with TC (1.62 ton/ha), AGC (1.41 ton/ha) and BGC (0.21 ton/ha) and lowest at Site-1 with TC (0.85 ton/ha), AGC (0.74 ton/ha) and BGC (0.11 ton/ha) respectively (Table 4).

Biodiversity indices were assessed to study the current scenario of the area through different parameters were in Simpson Diversity Index was recorded 0.31 and 0.22 for Site-I and Site-II respectively. Shannon-Weiner Index (H) recorded 1.45 for Site-I and 2.16 for Site-II. Menhinick's Richness Index had values of 1 and 1.94 for Site-I and Site-II respectively.

Table 4. Above ground, below ground and total carbon of herbs.

Site	AGC (ton/ha)	BGC (ton/ha)	TC (ton/ha)
Site-I	0.74	0.11	0.85
Site- 2	1.41	0.21	1.62

Table 5. Quantitative evaluation of study sites.

Site	Simpson Diversity Index	Shannon-Weiner Index	Menhinick's Richness Index	Evenness	Sorensen coefficient (Ss)	Dissimilarity coefficient (Ds)
Site-I	0.31	1.45	1	0.75	0.34	0.66
Site-II	0.22	2.16	1.94	0.95		

Sorensen coefficient (Ss) was recorded 0.34 between the two sites and the dissimilarity coefficient (DS) 0.66 (Table 5).

DISCUSSION

Different workers have studied phytodiversity of different regions in Central India and revealed results more or less similar to the current findings (Sharma et al. 2019, Kumari et al. 2018, Sheikh et al. 2017). The study revealed that *Azadirachta indica* showed highest frequency as well as relative frequency which are in accordance with Bhat et al. (2016). *Tectona grandis* showed the highest density at Site-I which are justified by Kumari et al. (2018) who also worked in the same area and revealed similar results. *Azadirachta indica, Phyllanthus emblica, Tectona grandis* were the most predominant species at both the sites and possess the maximun basal area as native species are more widespread than the exotic species as reported by Bhat et al. (2018). The reason may be that the native species are adapted to the hot and humid climate conditions of the region while the same climatic conditions hampers the acclimatization of exotic species. Shannon Diversity Index is usually associated with species diversity of an area which accounts for abundance as well as evenness of the species present (Sheikh et al. 2017) and was found to be less than (Kumari et al. 2018) Simpson Index was revealed highest than (Sheikh et al. 2017) but lowest than (Kumari et al. 2018, Sheikh et al. 2017, Sharma et al. 2019) which may be due to edaphic factors, structure of vegetation (Hubbell et al. 1999), influence of anthropogenic as well as environmental factors on different regions of the area (Kharkwal et al. 2005). Species evenness reveals closeness of different species in an area which had great impact on diversity and was recorded highest than Sharma et al. (2019). Different species were closely associated in the study area and gives idea about richness of species which refers to the presence of different species in a particular area and was found highest than (Sheikh et al. 2017) and lowest than (Kumari et al. 2018, Sharma et al. 2019).

The study revealed that trees with large diameter produce maximum biomass with majority of tall trees and trees with a larger diameter (Day et al. 2014) holding largest stocks of carbon within biomass (Gibbs et al. 2007). The observations of current study are in accordance with Thompson et al. (2009) who suggested mature forests to be long-term persistent of carbon as shown by our study.

The estimation showed remarkable results with total carbon 94.44 ton/ha which are in accordance with Sharma et al. (2019) who worked in the same region on sacred groves. At Site-II the total carbon was 89.83 ton/ha which is more than (Kumari et al. 2018) the reason for increment in total carbon is growing in nature of the standing vegetation which depicted that institute plays an important role in providing regulating ecosystem service hence, mitigating carbon dioxide from the atmosphere. Diversity of species in the area play a prominent role in carbon sequestration (Catovasky et al. 2002, Kirby and Potvin 2007) and are positively correlated with tree diversity and biomass formation (Tilman et al. 1997, Midgley et al. 2010). Relation between plant diversity and carbon stock has been studied extensively and showed impact of diversity in carbon dynamics (Fornara and Tilman 2008, Ruiz-Jaen and Potvin 2010) which shows relevance in terms of growth, density and storage of carbon.

The study revealed that sustainability and management of these forest patches of institutes can lead a major role in biodiversity conservation as well as carbon mitigation because anthropogenic disturbance can change structure of these patches hence species composition (Malik et al. 2016) which can lead to decrease in tree species richness and diversity. Stability of an ecosystem is directly proportional to the diversity of that area (Shafi and Yarranton 1973).

CONCLUSION

Floristic biodiversity plays an important role in maintaining the climate of a region by utilizing the carbon dioxide thereby decreasing the global warming. Different green patches of vegetation present within locations of educational institutions plays prominent role a lowering the atmospheric temperature as well as sequestration of atmospheric carbon dioxide thus initiatives must be taken to enrich as well as conserve these valuable patches of floral vegetation. Moreover different approaches must be followed to pay absolute attention towards the conservation of biodiversity in urban forestry of Gwalior city which can help in mitigation of carbon dioxide as well as sustains the environment of the area for long time.

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