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RESEARCH ARTICLE

ASSESSMENT OF CARBON STORAGE POTENTIAL OF TREES AND SOIL IN THE URBAN PARKS A STEP TOWARDS CLIMATE CHANGE MITIGATION

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ABSTRACT

Climate change is widely recognized not just as an environmental issue but one with severe socioeconomic implications across the globe. The living space in urban areas are becoming rapidly jumbled and disorganised, as concrete jungles continue to degrade the natural and aesthetic environment and turning it into heat islands. There is an urgent need to revive the urban green efforts. Urban parks and tree cover play a fundamentally important role in improving the environmental quality, energy efficiency, aesthetic appeal, biodiversity and are regulating climatic hazards. In the present investigation, carbon storage potential of trees and soil was measured encompassing the three major urban parks in Ulhasnagar.Non-destructive methods were used to study the carbon storage potential. Total AGB of the gardens was 1696.49 Kgs/2.27ha; Total BGB 441.08 Kgs/2.27 ha and total biomass was 2137.57 Kgs/2.27 ha. Total carbon stored in trees and of the soil was 51.55 tons ha-^{1}. GIS based map shows the location and value of above and below ground biomass for each tree species in the study area. *Samanea saman* was the dominant tree in the study area with large DBH and with biomass of 758.1594 Kgs, almost contributing 35% of the total biomass. This study concluded that the carbon stock value of urban parks in Ulhasnagar is thin and occasional.

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INTRODUCTION

Urbanization is widely presumed to degrade ecosystem services, but empirical evidence is now challenging these assumptions.Globally due to Industrial development and urban growth greenhouse gas emissions have increased considerably. Removal of greenhouse gases from the atmosphere into sinks (*i.e.* trees and soil) is one way of addressing climate change. In the wake of global efforts to address climate change, considerable interest has been generated about carbon storage potential of trees and soil. Tree plantations are being considered as a mitigation option to reduce the increase in atmospheric CO_2 and climate change (Kraenzel *et al.,* 2003). Soil organic carbon, being the largest terrestrial carbon pool plays a very significant role in global terrestrial ecosystem in carbon balance. Intergovernmental Panel on Climate Change IPCC (2007) estimated that the total soil carbon pool in top 1 m as 2011 Pg carbon. Trees have immense role in regulating the carbon dioxide budget in the atmosphere. However, this particular ecosystem service is poorly understood quantified although trees act as the major sink of carbon dioxide by fixing carbon during photosynthesis and storing carbon as biomass. Even the edaphic factors and soil management also influence the biomass and stored carbon in plantation.

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All trees irrespective of species store carbon in organic form which are emitted back to the atmosphere after their death and decay (through microbial decomposition) and during the entire phase of growth sequestration of carbon occurs depending on the growth pattern. Izaurralde *et al.,* 2007 defined carbon sequestration as implementation of land management practice that increased net primary productivity, reduced rate of heterotrophic respiration or both and lead to an increase in ecosystem C storage. Planting trees, reducing the intensity of tillage on cropland or restoring grasslands on degraded lands will all lead to an increase in C storage in plants, soils or both. As reported by Sundermeier *et al.,* 2005 soil carbon sequestration is the process of transferring carbon dioxide from the atmosphere into the soil through crop residue and other organic solids, and in a form that is not immediately reemitted. The present study is undertaken to assess the carbon storage potential of trees and soil in three urban parks of Ulhasnagar, dist.-Thane in the state of Maharashtra. Trees were inventoried and the rate of CO_2sequestration with respect to age of the tree annually was calculated. GIS map were generated for better understanding.

MATERIALS AND METHODS

Study area- Ulhasnagar a commercial hub in the district of Thane, Maharashtra, India. This city is part of Mumbai

Metropolitan Region managed by MMRDA. It had an estimated population of 506,098 at the 2011 Census. Ulhasnagar, a colony of migrants in the aftermath of partition, is situated 58 km from Mumbai. Area of the city is 13.8 sq. meter (approximately 3336 acres/ 1351 ha). It has around 57 parks in the city (designated as gardens by Municipal Corporation). Climate in the study area is tropical in nature. The average annual temperature is 27^0C and the precipitation averageis 2958 mm. Three parks of Ulhasnagar were selected to study carbon storage potential of trees and soil. Prabhat Udyan covers an area of 1.90 acres (approx. 0.77 ha), located at 19° 20' 58" N latitude and 73° 16' 32" E longitude. Gol maidan covers area of 2.5 acres (1ha), the location of the garden is 19° 13' 10" N latitude and 73° 9' 95" E longitude. Gol maidan has zones segregated for recreational purpose *viz.* Brahmkumari's Peace Park, Peace Harmony Centre, Dadi Prakashmani Mahila Udyan and Rotary Club Garden. The adjoining area of the garden is surrounded by many shops, buildings representing overcrowded zone. Sapna garden covers an area of 1.25 acres (0.50 ha), located at 19° 23' 01" N latitude and 73° 16' 03" E longitude. All trees ≥6 inch diameter at breast height (DBH) were measured and identified up to the species level. To estimate biomass of different trees, non-destructive method was used. The biomass of trees was estimated on the basis of DBH. The above ground biomass of tree is calculated using the formula (Kulkarni *et al.,* 2010). The belowground biomass (BGB) has been calculated by multiplying the aboveground biomass (AGB) by 0.26 factors as the root: shoot ratio (Ravindranath, 2008). Total biomass is the sum of the above and below ground biomass (Sheikh *et al*, 2011) and for any plant species 50% of its biomass is considered as carbon (Pearson *et al*, 2005). The weight of carbon in the tree is multiplied by a factor 3.6663 to determine the weight of carbon dioxide sequestered in the tree (Potdar and Patil, 2016). The common trees found in more than one DBH class were assessed for annual CO_2 sequestration potential (Muhammad and Akhtar 2013). Soil samples were collected by digging 3 pits of 30 cm deep around the root zone of each tree at the site. Multiple soil samples from a park were mixed to make a composite sample and the bulk density of soil samples were analysed. The Soil Organic Carbon (%) was estimated and later the carbon stock density of soil was calculated (Walkley and Black, 1934). Arc view 10.2.1, software of Geographic Information System (GIS) was used to predict the biomass of the three parks under study (Shinde and Mahajan, 2015).

RESULTS AND DISCUSSION

Ulhasnagar has many small scale industries contributing in a major way to the economy of the country, though in the process also add up to the carbon foot print. In the study area of 2.27 ha approximately 40% is concretised for recreation purpose. In the rest 60% of land 879 trees were inventoried and identified up to the species level. There were a total of 57 species spread in 23 genera and 29 different families recorded. Trees ≥ 6 inch DBH were only considered for the study. The total number of trees from the study area accounted onlyfor 0.052% of the total trees plantation of the Ulhasnagar. When the vegetation dynamics of individual gardens were studied, it was found that there were 171 trees in Prabhat Udyan, 493 in Gol maidan and 215 in Sapna garden *i.e.* accounting to 19.45%, 56.08% 24.45% respectively of the total trees in all the three parks. Some of the tree species were abundant in the study area as compared to the others *viz Polyalthia longifolia* (24% out of total) and *Thuja orientalis* (9.55%) while of trees like *Michelia champaca, Millingtonia hortensis, Grewia asiatica, etc* were represented only single member. Members of family Leguminosae dominated and were represented by more species in the study area as compared to the other families. Leguminosae with 8 species followed by Urticaceae and Palmae (6 species each), Apocynaceae (4 species), Rutaceae (3 species), Anacardiaceae, Annonaceae, Bignoniaceae and Rubiaceae (2 species each) whereas other families like Combretaceae, Tiliaceae, Cupressaceae were represented by only single species. Of the total 879 trees, 33 tree species *ie.* 74.97% were evergreen (19 native and 14 introduced species) and 25.02% were deciduous tree species (17 were native and 7 introduced). Similarly when the tree density (number of trees in the given area) from each family were studied, family Annonaceae was recorded as the highest number of trees contributing 24.34% of 879 trees followed by Palmae (18.77%) (Fig 1).

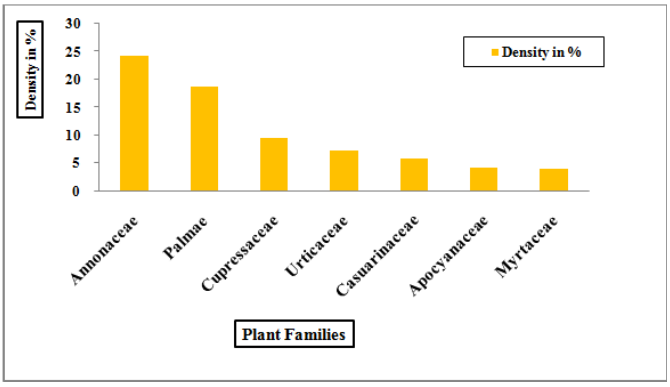

Fig. 1. Density of trees belonging to eachPlant families in the study area

Biomass represents latest organic pool in mature forest ecosystem (Cannell, 1982). In the present study, the trees ≥ 6 inches diameter were inventoried and grouped into various DBH classes. Class I (6-12 inches) (trees below 6 inches of diameter were not included in the study as they were very young), Class II (13-26 inches), Class III (25-36 inches), Class IV (37-48 inches), Class V(49-60 inches) and Class VI (> 60 inches). DBH of a tree is directly proportional to the amount of biomass stored in the tree, higher the DBH higher is the biomass. Trees from Prabhat Udyan were maximum in Class III (32.74%) and in Class I (31.57%) followed by Class II and IV (14.03%). Around 11 trees were of large diameter (> 60 inches), probably present in the area even before the park was demarcated.

This suggests that the vegetation in the garden is young and has a greater potential for storing more biomass in future. Similar observations were recorded for trees of Gol maidan. From the data presented in Table 1, DBH Class VI shows few trees than the other classes. Maximum trees were found in Class I, the number being gradually decreasing in other classes. While in Sapna garden, 35-36% of 215 trees were present in Class II and Class III. It can be concluded that efforts are taken by either the garden department of Ulhasnagar Municipal Corporation or by the NGO to plant more trees and increase the green vegetation of the city. In Gol maidan, around 38-40% of the area is being concretised for various recreational purposes which means the total of 493 trees are actually present on 0.6 ha of land as against the total of 1 ha. Among the three gardens under study, the vegetation in Gol maidan was denser than the vegetation in other two gardens (Table 1).

GIS map of Sapna garden too, there are large trees of *Samanea saman* interrupted occasionally by *Eugenia jambolana*

Table 1. Density of trees in various DBH Class

DBH class	Class I	Class II	Class III	Class IV	Class V	Class VI	Total
Prabhat udyan	54 (31.57%)	24 (14.03%)	56 (32.74%)	24 (14.03%)	2 (1.16%)	11 (6.43%)	171
Gol maidan	194 (39.35%)	111 (22.51%)	99 (20.08)	56 (11.35%)	-------	33 (6.69%)	493
Sapna garden	49 (22.79)	79 (36.74%)	76 (35.34)	4 (1.86%)	6 (2.79%)	1 (0.46)	215

Table 2. Regression Model for estimation of Total biomass and CO_2 sequestration

Regression Statistics	
Multiple R	0.9999065
R Square	0.9998132
Adjusted R Square	0.9996264
Standard Error	18.463242
Observations	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1824598.683	1824598.683	5352.435174	0.008701164
Residual	1	340.89131	340.8913183		
Total	2	1824939.574			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-28.8375889	21.29068488	-1.35446976	0.40487016	-299.36139	241.68621	-299.36139	241.686212
Biomass	1.894430633	0.02589423	73.16033881	0.008701164	1.565413247	2.223448	1.565413247	2.22344802

Table 3. Carbon sequestered by trees in different age group

C Sequestered in Kgs/yr							
	Age of the trees (yrs)						
Name of the Tree	5	10	15	25	40	50	60
Ashoka	5.63	--	-----	-----	306.55	-------	-----
Desi badam	13.03	--	-----	329.28	------	--------	-----
Raintree	----	---	35.24	------	-------	726.1	745.05
Jamun	-----	---	----	60.81	-------	333.65	----
Saptparni	9.12	---	78.2	-------	------	------	------

The Total AGB of the gardens was 1696.49 Kgs/2.27 ha. Total BGB was about 441.08 Kgs/2.27 ha and total biomass was 2137.57 Kgs/2.27 ha *i.e.* approximately 941.66 Kg ha^{-1}. Arc view 10.2.1, software of Geographic Information System (GIS) was used for predicting the biomass. The data helped to us analyse and interpret better, and eventually conceptualize the above and below ground biomass in the entire area of gardens. GIS based map shows the location and value of above and below ground biomass for each tree species in the study area. Green colour represents highest density of above ground and below ground biomass, yellow represents moderate while red indicates scarce or limited above and below ground biomass (Fig 2 A-F). The green colour actually represents the volume of biomass and not the density or the number of trees present in the study area. In Prabhat Udyan, (Fig 2 A and 2 B) the green colour is concentrated towards the north of the garden and it is epitomized by two large *Samanea saman* trees (> 60 inch diameter). Rest all the trees belonging to Class I-III appears as yellow or scattered in the red zone. As these trees are young, the biomass is not clearly visualized as green colour in the map but instead appears as yellow, orange or red respectively, in decreasing order of their biomass. Similarly in Gol maidan, the density of vegetation was high compared to other two gardens. Moreover, there are around 33 trees in the diameter Class VI (> 60 inches) depictinglarger area of green colour in the map (Fig 2 C and D). These trees are with huge volume of biomass and appear to be > 50 years of age.In the contributing to larger biomass (Fig 2 E and F). *Samanea saman* was the most dominant tree in the study area with large DBH and with biomass of 758.1594 Kgs, almost 35% of the total biomass. It appears that this tree is more than 60years old and has been sequestrating CO_2 since them. Organic Carbon stored by the trees in the study area was 1068.78 Kgs/2.27ha and the CO_2 sequestered was 3.971 tons/2.27ha. It has been reported that, young leaves serve as C-sink and take up carbon through photosynthesis while the older leaves export C to the other parts within tree. Thus the tree and stem, wood in its whole life span represent largest C-stock (Lorenz and Lal, 2010). To estimate the closeness and relationships using total biomass and carbon dioxide sequestered data a regression analysis was performed with the help of Minitab 17 software, which indicate that there is a positive relationship between total biomass and the CO_2sequestered (Table 2). From the above table regression equation can be written as: CO_2 sequestration = 1.8944 (Biomass) +28.838 (R^2 =0.9998). The relationship between DBH and CO_2 sequestered is always linear for all the tree species, indicating more the DBH, higher is the potential to sequester CO_2 by the tree. Similar observation has been reported earlier that volume is significant with DBH, because as DBH increased the metabolic and growth necessities would also increase (Jaiswal *et al.*, 2014). The rate of CO_2 sequestration varies with the age of the plant and also with the tree species. In the present study trees that were common in different DBH classes were selected and an attempt was made to know their approximate age from the information given by the local residents.

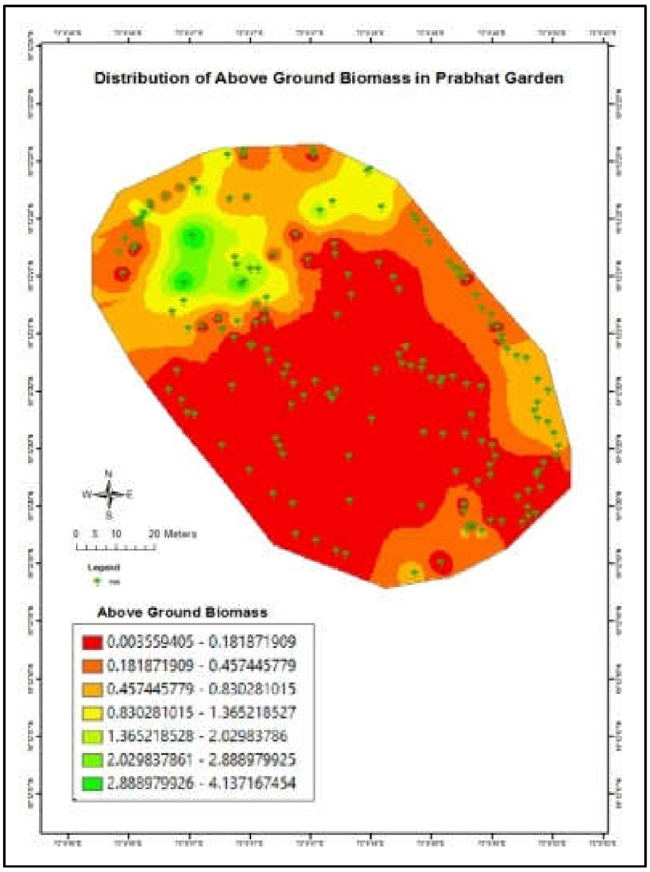

Fig. 2A. GIS Map of Prabhat Udyan (AGB)

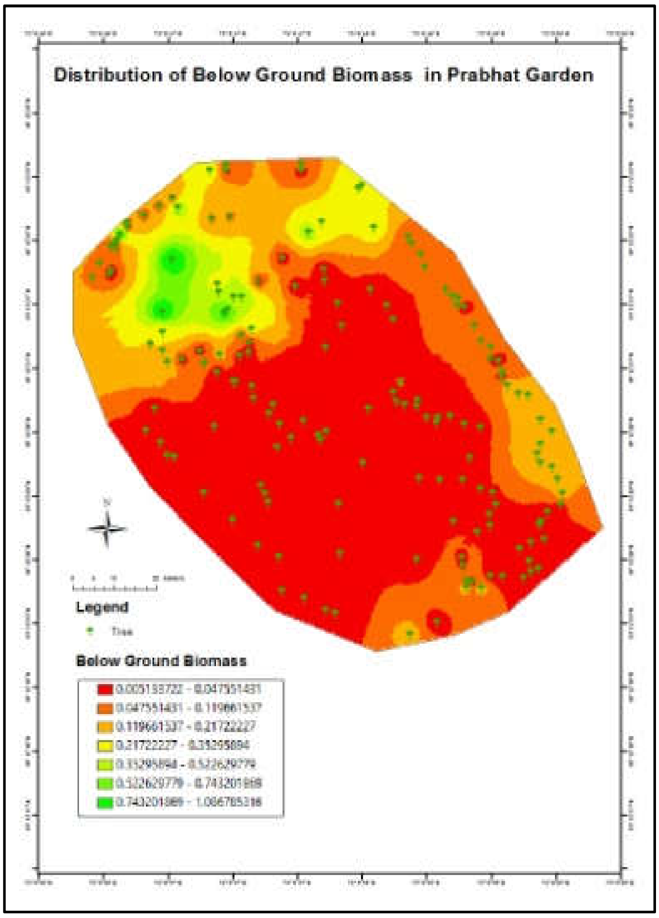

Fig. 2B. GIS Map of Prabhat Udyan (BGB)

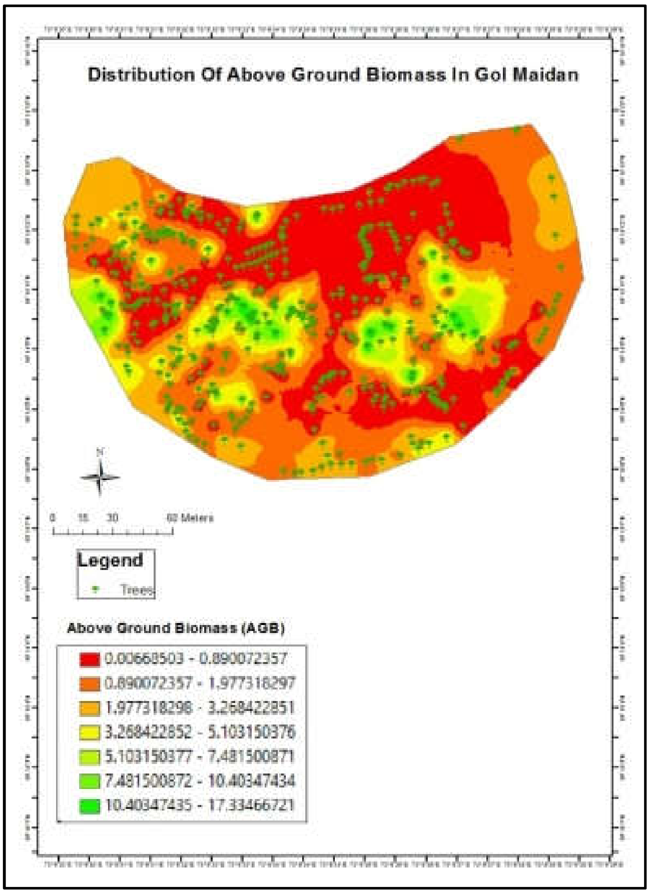

Fig. 2C. GIS Map of Gol Maidan (AGB)

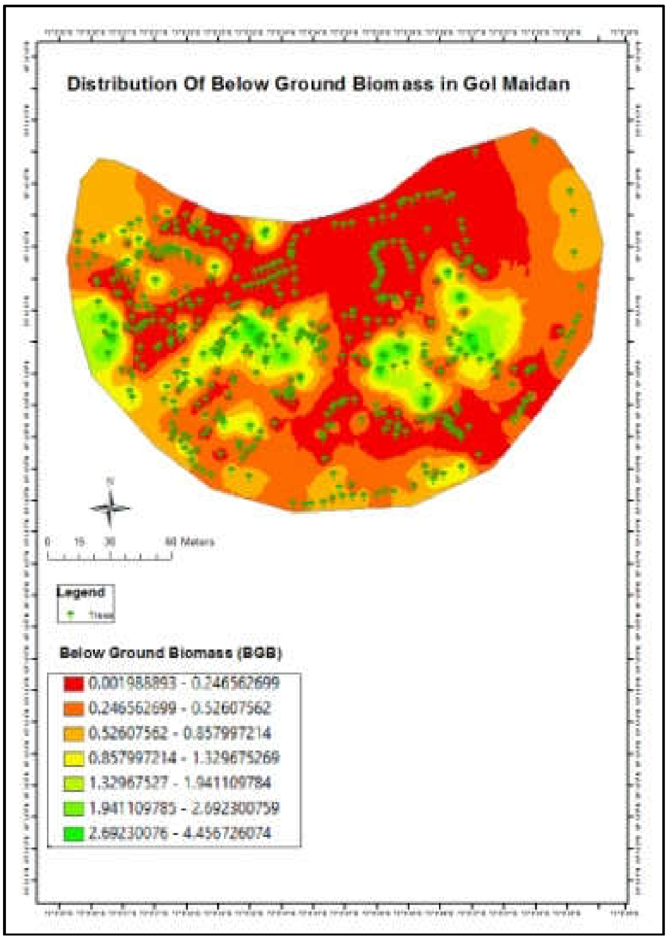

Fig. 2D. GIS Map Of Gol maidan (BGB)

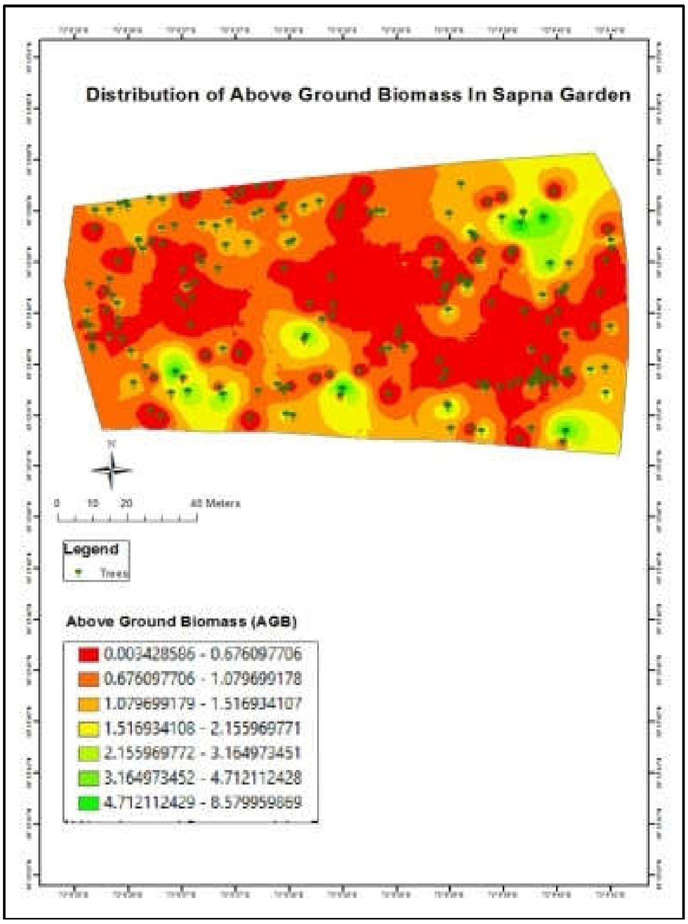

Fig. 2E. GIS Map of Sapna Garden (AGB)

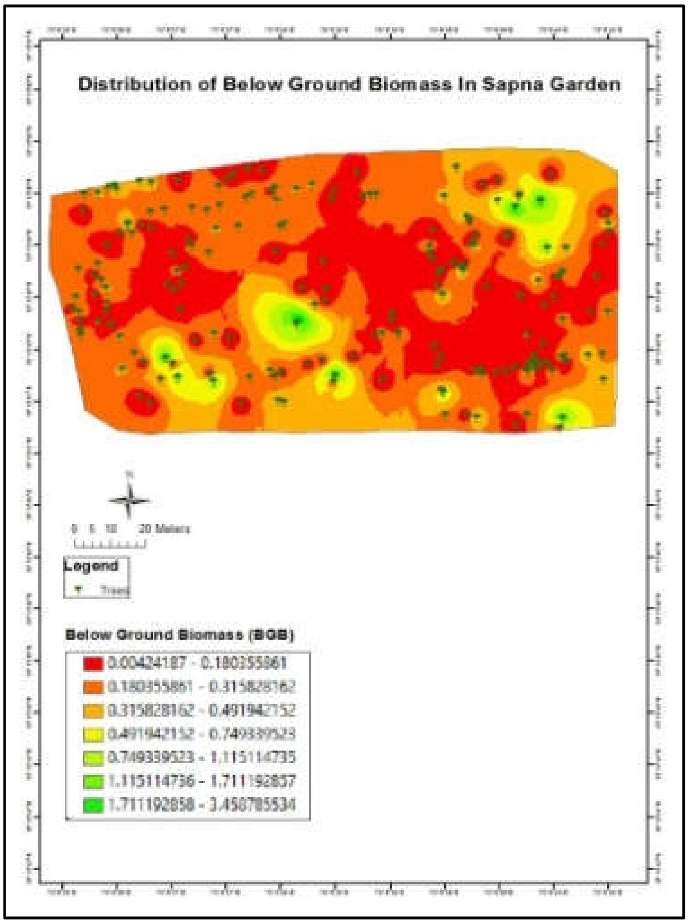

Fig. 2F. GIS Map of Sapna Garden (BGB)

When the amount of CO_2 sequestrated in Kgs per year by a tree under particularage group was compared (Table 3), it was found that a 40 years Ashoka tree (*Polyalthia longifolia*) has a potential 54 times higher than a 5 year old Ashoka tree. Similarly, Raintree (*Samanea saman)* with a age above 50 years, sequestered carbon 21 times more than a tree of 15 years of old tree. It may be noted that Ashoka tree (*Polyalthia longifolia*), Desi badam (*Terminalia catappa*) and Saptparni (*Alstonia scholaris*) are the most commonly preferred trees during any tree plantation drive, as these are fast growing and occupy comparatively lesser canopy area. Some researchers also estimated as low as 1.0 Kg (0-7 cm DBH) to as high as 92.7 Kgs (77+cm DBH) of C sequestration/tree/year for urban trees(Nowak, 1994 b).Also it may be noted that different tree species of similar age exhibited different potential for carbon sequestration. Ashoka (*Polyalthia sp.*) of age 5 years sequestered only 5.63 Kgs C/yr, half the amount as compared to Saptparni (*Alstonia sp.*) and Desi badam (*Terminalia sp.*) (Table 3). Moreover, a 15 year old Saptparni (*Alstonia sp.*) sequestered 78.2 Kgs C/year and it was almost double than the amount sequestered by Raintree of similar age (35.24 Kgs C/year). The data reflected that Desi badam (*Terminalia catappa*) appears to be one of the best candidate for tree plantation in the urban space, as this plant besides growing fast also displayed higher carbon sequestration potential compared to other trees in the study area (Table 3). The ability of Desi badam (*Terminalia catappa*) to sequester more carbon than the other trees from the study site may be attributed to the larger leaf area (leaf size) of the plant (Villers *et al.,* 2014). Stocks of organic carbon in soil vary with land use systems. The share of soil organic carbon in the total carbon stock may vary from 50% to 84% in forests to 97% in grasslands.

SOC input rates are primarily determined by the root biomass of a plant, but also include litter deposited from plant shoots. Soil C results both directly from growth and death of plant roots, as well as indirectly from the transfer of carbon-enriched compounds from roots to soil microbes. Bulk density of soil sample from the three garden under study were 0.849 g/cm^3 (Prabhat Udyan), 0.024 g/cm^3(Gol maidan) and 0.325 g/cm^3(Sapna garden)and the total soil organic carbon at the study site was 47.58 tons/ha. The values in the present study are well within the reported range. Researchers reported the soil organic carbon poll in the range of 38.9-181.7 ton ha^{-1} in Kashmir valley (Chhabra*et al*, 2003) and similar results have also been reported earlier by many other workers (Gupta and Sharma, 2010; Gupta, 2011).

Conclusion

Urban parks can play a significant role in helping to reduce atmospheric carbon dioxide levels. To protect the world from climate change and global warming, the sustainable management from urban areas with the objectives of carbon sequestration is the need of time. Establishing more properly chosen (native) urban trees, in addition to maintaining the present structure, can make urban parks a larger sink for atmospheric C, along with producing other benefits. It can be concluded that *Terminalia sp., Polyalthia sp.* and *Alstonia sp.*can be planted more in number to increase the carbon stock in the green and help to mitigate the climate change. Moreover these plants besides sequestering carbon can also provide other ecological benefits to the urban society. Long term permanent plot data are needed to assess urban forest growth, regeneration and mortality; research needs to develop better urban tree biomass equations, improve estimates of tree decomposition and maintenance emissions, and investigate the effect of urban soils on C storage and flux in cities (Nowak*et al*, 2002).

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REFERENCES

Bolin B., and Sukumar, R. 2000. Global perspective, in Watson, R. T., I. R., Bolin B., Ravindranath, N. H., Verado, D. J., Dokken, D. J. (*Ed*.), IPCC. Land-use change and forestry, Special report, Cambridge University Press, Cambridge, Chap.1.

Cannell, M.G.R. 1982. World forest biomass and primary production data, *Academic*, London.

Chhabra, A. Palria, S. and Dadhwal, P. K. Soil organic pool in Indian forests. *Forest Ecology and Management*, 173 : 187-199 (2003).

Gupta, M. K. and Sharma, S. D. 2010. Soil organic carbon pool under different land uses in Champawat district of Uttarakhand. *Annals of Forestry*, 18(2) : 189-196.

Gupta,M. K. (2011) Soil organic carbon pool under different land uses in Haridwar district of Uttarakhand.*Indian Forester*. 137 (1) 105-112.

IPCC, 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Fourth Assesmnt Report. M. L. Parry, O. F. Canziani, J. P. Pautikof, P. J. van der Linden and C. E. Hanson (Eds.), Cambridge University Press, Cambridge, UK.

Izaurralde R C, Williams J R, Post W M, Thomson A M, McGill WB, Qwens L, and Lal R. 2007. Long term modelling of soil C erosion and sequestration at small watershed scale. *Climatic change* 80(1):73-90.

Jaiswal, Dharmesh G., Patel, Chirag N., Patel,Yogesh B., Mankad, Archana U., and Pandya, Himanshu A. 2014. Regression Correlation Analysis between GBH and Carbon Stock of Major Tree Species in Dharoi Range, Gandhinagar Forest Division, India. *International Journal of Innovative Research in Science, Engineering and Technology,* Vol. 3(11): 17146- 17149.

Kraenzel M A, Castillo T., Moore and Potvin C. 2003. Carbon storage of harvest-age teak (*Tectona grandis*) plantations, Panama. *Forest ecology and Management*, 173:213-225.

Muhammad A. and Akhtar A.M. 2013. Factors affecting carbon sequestration in trees. *J. Agric. Res*., 51(1):61-69.

Kulkarni D. K. , Nipunage D. S., Hangarge L. M. and Kamble P. B. 2010. Natural heritage of forest conservation in Bhor region of Pune, India. *Asian Jr. of Environmental Sci.* 5(2) 94-98.

Lorenz, K. & Lal, R. 2010. Carbon Sequestration in Forest Ecosystems, Dordrecht:*SpringerNetherlands*. Available at: http://www.springerlink.com/index/10.1007/978-90-481-3266-9.

Nowak D.J. 1994 b. Atmospheric carbon dioxide reduction by Chicago's urban forest, in : McPherson, E. G., Nowak, D. J., Rowntree, R. A. (Eds.), Chicago's Urban Forest Ecosystem: Results of the ChicagoUrban Forest Climate Project. General Technical Report, NE-186, US Department of Agriculture, Forest Service, Randor, PA, 83-94.

Nowak, David J, and Daniel E. Crane, 2002. Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution* 116, 381-389.

Pearson TRH Brown S and Ravindranath N H. 2005. Integrating carbon benefits estimates into GEF projects. 1-56.

Potdar Vishnu R. and Patil Satish S. 2016. Carbon Storage and Sequestration by trees in and around University Campus of Aurangabad City, Maharashtra. *International Journal of Innovative Research in Science, Engineering and Technology*, 5 (4), 5459-5468.

Ravindranath N. H. and Ostwald M. 2008. Carbon Inventory Methods Handbook for Greenhouse Gas Inventory, Carbon Mitigation and Round wood Production Projects, 29.

Sheikh M. A., Kumar M Bussman and Wand T.N.P., 2011. Forest carbon stocks and fluxes in physiographic zones of India, *Carbon Balance and Management,* 2011, 1186-1750.

Shinde, V. R. and D. M. Mahajan , 2015.Carbon pool analysis of urban parks (Chh. Sambhaji Garden and Chittaranjan Vatika, Pune) *Journal of Basic sciences*, 2015, 1, 20-27.

Sundermeier, A. R. Reeder and R. Lal, 2005. Soil Sequestration Fundamentals. Ohio State University Extension Fact Sheet. AEX pp. 510-05.

Villers, de. C. Chen S., Jin C., Zhu Y. 2014. Carbon sequestered in the trees on a University Campus. *Sustainability Accounting, Manage and Policy Journal* 5(2), 149-171.

Walkley, A. and I. A. Black, 1934. An examination of the Degtjareff method for determining organic carbonin soils: Effect of variations in digestion conditions and of inorganic soil constituents. *Soil Sci*. 63:251-263.

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