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Role of Urban Trees in Amelioration of Temperatures

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Abstract: *That trees play an vital role in an urban environment to reduce pollution and controlling the micorclimatic conditions. an urban area has varied temperature conditions in the city . In the current work the temperatures along ten streets under five most common tree species were recorded. Temperatures below the canopies of Peltoohorum inerme .Roxb, Delonix regia Bojer,Terminalia Cattapa L,Ficus religiosa L,Samanea saman Jacq. The temperatures were recorded between 12 to 2 pm in the month of October 2013 below the canopy and outside the canopy. Ten sites were selected randomly across the city based on the availability of the tree species in the study. Trees were studied for the difference in temperatures outside the tree canopy and under the canopy shade show differences in temperatures. All the tree species showed an reduced temperature under the tree canopy. Peltophorum inerme showed larger differences in reduction of temperature under its canopy. Thus Peltophorum offered maximum shade is is significantly higher than all the tree species which offer similar Temperature variations between different sites in the city were evident.*

1. INTRODUCTION

Mumbai is located along western Arabian cost of India from 18 deg. 53' north to 19 deg. 16 'north latitude and from 72 deg. East to 72 deg. 59' longitude. Mumbai experiences tropical savanna climate. It receives heavy south- west monsoon rainfall, measuring 2166 mm on an average every year. The temperature ranges from 16.5 deg. Centigrade to 34.7 deg. centigrade with marginal changes between summer and winter months. Where as relative humidity ranges between 54.5 % to 85.5%. The city has reach natural sources like lake, coastal water, Forest, Wet land and Mangroves etc.

Vegetation plays an important role in changing the climate of a city; it is also effective in controlling the microclimate. Plants, shrubs and trees cool the environment when they absorb radiation for photosynthesis. They are useful in shading a particular part of the structure and ground for reducing the heat gain and reflected radiation. By releasing moisture, they help raise the humidity level. Vegetation also creates different air flow patterns by causing minor pressure differences, and thus can be used to direct or divert the prevailing wind advantage

Trees affect the concentration of air pollutants that we breathe, affect local air temperatures and the amount of ultraviolet radiation we are exposed to. Trees also can help reduce greenhouse gas concentration and emissions that affect climate change.

Cities are generally warmer than surrounding agricultural or forest areas. The relative warmth is often referred to as the urban heat island (UHI) effect. His have been documented in cities throughout the world cities are essentially islands of warmer temperatures in a sea of rural cooler temperatures .The UHI effect is strongest after sundown when skies are free of clouds and wind speeds are low.

The magnitude of the urban-rural temperature difference and the timing of the maximum UHI depend on differences in rates of heating and cooling of the materials and soils in the urban and in the adjacent rural area that is used for the temperature comparison (Oke, T.R.1989., Golden, J.S. et.al, 2008).Trees function, as natural 'air conditioners', at least with regards to the microclimate

of the city (Rowntree, 1986). Urban trees can ameliorate environmental variables by preventing solar radiation from heating the surrounding buildings and surfaces, cooling the air by evapo-transpiration, and reducing wind speed (Akbari et al., 2001).

Although cities are generally warmer than surrounding rural areas, the patterns of air temperature across a city differ according to land use. Areas with high tree cover are usually cooler than areas with large percentages of built structures and impervious cover

Trees and parks affect air pollution by: 1. Reducing air temperatures and consequently pollutant emissions .2. Directly removing pollution from the air 3. Emitting chemicals that contribute to pollution formation (Nowak and Heisler, 2010)

Trees evaporate significant amounts of water through their leaves (transpiration), which can significantly reduce local air temperatures. Lower air temperatures can lead to lower emissions of pollutants. Current work is aimed at measuring the temperatures under the tree canopies and to study the ameliorating effects of tree canopies in urban environment.

2. MATERIAL AND METHODS

The method adopted to measure the canopy was as follows: An Abney's Level was used to calculate the height of the tree. The instrument is a horizontal tube with mirrors inside and a protractor fitted outside to measure the angle (Hale et al, 1980). There is a small tube with water and bubble to show correct level. To measure the height, the tip of the tree was viewed through the tube. The angle was adjusted in such a way that the bubble appeared to be in the centre of the view. The angle was noted along with the distance of the person from the tree to the point where he is standing. This distance is d. The above Angle was noted. In a similar manner the point from where the canopy starts is viewed and the angle noted. The distance would remain the same. The advantage of this method is that only the height of the canopy is considered so there is less or no error in considering the height of an individual (who is taking the measurement). After the above observations, the approximate shape was noted down. (E.g. Round, oval, etc.). These shapes were then converted into three dimensional shapes like Spherical, ellipsoidal etc.The height of the tree is first calculated, where this height is further used as either the radius or diameter for calculation of volume of tree canopy the Formula used, h=d x tanO.(R.Mishra,2012).Height was further used for calculating the volume of canopy shape.

Temperatures below the canopies of *Peltoohorum inerme.Roxb, Delonix regia Bojer,Terminalia cattapaL, Ficus religiosa L and , Samanea saman Jacq.* The temperatures were recorded between 12 to 2 pm in the month of October 2013 below the canopy and outside the canopy. Ten sites were selected randomly across the city based on the availability of the tree species in the study (Table.1.0).

Table1. *Description of sites and location*

Site no	Area
1	Western Express highway (WEH)
2	Eastern Expresws highway(EEH)
3	Bandra Kulra Complex(BKC) an main road , wide
4	Linking Road: secondary road with busy traffice
5	S.V. Road :main road
6	Carter Road: opposite sea front
7	Bandstand: seafront
8	K.C. Marg : secondary road
9	Dadar: main road
10	Lalbahadur Shastri Marg,L.B.S marg: main road , with all types of vehicles

3. RESULTS AND DISCUSSIONS

***Peltophorum Pterocarpum Roxb*:** Lowest temperatures were recorded at K.C.Marg and Carter road under the tree canopy. Highest temperatures were along the area of eastern express Highway and Dadar. Proximity to the sea wind blowing could be the reason for low temperature, while closed urban conglomeration and wide concretized road along the highway for high temperatures (Table 2.0)

Table2. *Temperature differences under the canopy of Peltophorum inerme Roxb*

Roads	Temp Under Canopy (°C)	Temp Outside Canopy (°C)	Difference Between Temp	Height (mts)	DBH (cms)
Linking Road	27.26	29.46	2.2	9	58.59
BKC	29.46	31.9	2.44	9	29.40
S.V. Road	30.53	33.6	3.07	5.5	34.39
K.C. Marg	24.6	27.43	2.83	7.5	26.96
Bandstand	25.63	28.9	3.27	10.66	45.48
Carter Road	24.96	27.76	2.8	8.33	58.17
WEH	28.4	31.1	2.7	9	30.25
LBS	28.9	32.3	3.4	9.66	58.91
EEH	30.43	33.46	3.03	7.83	28.66
Dadar	30.86	33.73	2.87	8	31.05
Average	28.103	30.964	2.861	8.448	40.21

Delonix regia Bojer.: Low temperature under the tree canopy was observed at Carter Road and K.C.Marg with temperatures around 25^0C. High temperatures were recorded at Bandra Kurla Complex(BKC) and Eastern Express Highway and Dadar with temperatures around 33^0 C. Table 3.0.

Table3. *Temperature differences under the canopy of Delonix regia.*

Roads	Temp Under Canopy(°C)	Temp Outside Canopy (°C)	Difference Between Temp	Height (mts)	DBH (cms)
Linking Road	27.8	29.6	1.8	7.16	36.09
BKC	31.96	33.63	1.67	6	39.38
S.V. Road	31.2	32.36	1.16	7.83	32.11
K.C. Marg	25.66	27.13	1.47	10.66	40.82
Bandstand	26.67	28.23	1.56	7.33	28.03
Carter Road	25.55	27.4	1.85	7.16	113.8
WEH	30.78	32.46	1.68	5.83	34.18
LBS	29.78	31.26	1.48	6.33	27.39
EEH	31.98	33.5	1.52	8.16	59.13
Dadar	31.43	32.63	1.2	10.66	68.36
Average	29.281	30.82	1.539	7.712	47.93

Terminalia cattapa L: Low temperatures under the tree canopy was seen along the Carter Road,, K.C.Marg . And Bandstand with temperatures around 25^0C to 26^0C . High temperatures were seen on the Highway and BKC with temperatures of 33^0C.Table 4.0

Table4. *Temperature differences under the canopy of Terminalia cattapa L*

Roads	Temp Under Canopy (°C)	Temp Outside Canopy (°C)	Difference Between Temp	Height (mts)	DBH (cms)
Linking Road	27.23	29.22	1.99	6.66	38.42
BKC	30.8	32.33	1.53	9.66	45.22
S.V. Road	27.54	29.17	1.63	6.66	38.42
K.C. Marg	26.4	27.86	1.46	9.66	45.22
Bandstand	27.36	28.46	1.1	6.16	21.22
Carter Road	25.4	27.13	1.73	6.16	21.86
WEH	29.83	31.33	1.5	9.5	42.67
LBS	29.45	31.26	1.81	6.33	27.38
EEH	31.7	33.5	1.8	9.5	71.65
Dadar	31.76	32.86	1.1	9.16	36.62
Average	28.747	30.312	1.565	7.945	38.87

Ficus religiosa L: High temperatures were seen along eastern express highway and Lalbahdur Shastri marg (LBS). Lower temperatures under the canopy were seen at Carter Road and K.C.Marg, Table 5.

Samanea saman Jacq: Lower temperatures under the tree canopy were recorded along the Bandstand and Carter road with temperatures of 26^0C. High temperatures were seen along Highway, Dadar and more than fifty percent areas, with temperatures of 31^0C, Table 6.0

Table5. *Temperature differences under the canopy of Ficus religiosa*

Roads	Temp Under Canopy (°C)	Temp Outside Canopy (°C)	Difference Between Temp	Height (mts)	DBH (cms)
Linking Road	27.86	29.63	1.77	11.16	119.53
BKC	28.2	30	1.8	11.33	122.82
S.V. Road	27.86	29.83	1.97	11.16	119.53
K.C. Marg	26.4	28.2	1.8	11.33	122.82
Bandstand	27.63	29.12	1.49	9.33	95.646
Carter Road	26.13	27.56	1.43	8.66	95.433
WEH	29.86	31.7	1.84	14.83	83.75
LBS	30.16	31.66	1.5	10.16	136.51
EEH	32.2	33.34	1.14	10.83	124.20
Dadar	28.3	29.7	1.4	11.33	74.732
Average	28.46	30.074	1.614	11.012	109.49

Table6. *Temperature differences under the canopy of Samanea saman.*

Roads	Temp Under Canopy (°C)	Temp Outside Canopy (°C)	Difference Between Temp	Height (mts)	DBH (cms)
Linking Road	31.5	33.2	1.7	13.33	68.52
BKC	31.76	33.06	1.3	13.5	71.71
S.V. Road	31.5	33.2	1.7	13.33	68.52
K.C. Marg	27.18	28.5	1.32	13.5	71.71
Bandstand	26.86	28.56	1.7	10.5	71.71
Carter Road	26.1	27.56	1.46	12.5	78
WEH	29.13	31.1	1.97	14.83	80
LBS	30.3	32.12	1.82	13.16	97.77
EEH	31.7	33.6	1.9	9.83	43.63
Dadar	31.4	32.6	1.2	13.33	73
Average	29.743	31.35	1.607	12.781	73.5

HEIGHT OF TREES: From Fig 1. it can be seen that during the entire study tallest trees were of Samanea saman followed by ficus religiosa. The trend in height was as follows Samanaea saman >Ficus religiosa > Peltophorum inerme>Terminalia Cattapa> Delonix regia .Table 7.0

Table7.*Temperature differences under the canopy of all the tree species and volume of tree canopies*

Tree Species	Temp Under Canopy (°C)	Temp Outside Canopy (°C)	Difference Between Temp	Height in (mts)	Volume of canopy in m^3
Peltophorum pterocarpum	28.103	30.964	2.861	8.448	10550.4
Delonix regia	29.281	30.82	1.539	7.712	4435.2
Terminalia catappa	28.747	30.312	1.565	7.945	104483
Ficus religiosa	28.46	30.074	1.614	11.012	43769
Samanea saman	29.743	31.35	1.607	12.781	9859

Reading are average of 50 samples

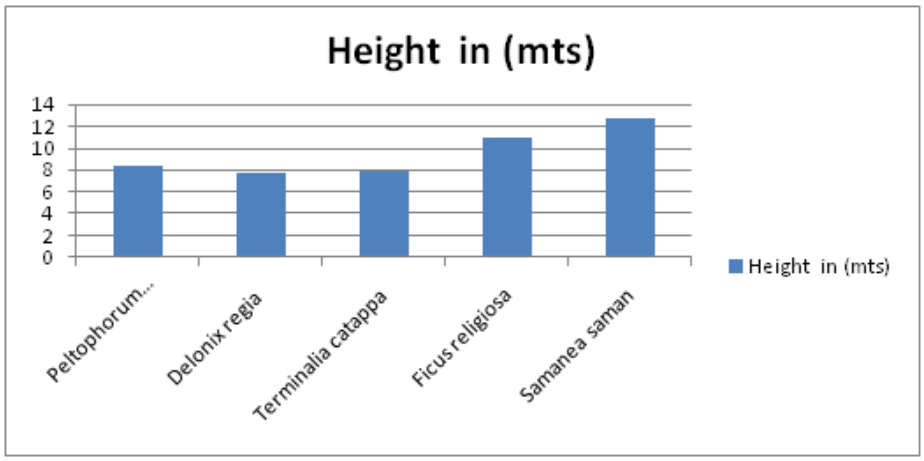

Fig1. *Average height of tree species in the study*

Volume of Tree Canopies: Maximum volumes of tree canopy was seen in Ficus religiosa. The trend in the canopy volume was was Ficus religiosa > Samanea saman>Terminalia cattapa> Peltophorum inerme>Delonix regia .Fig 2.

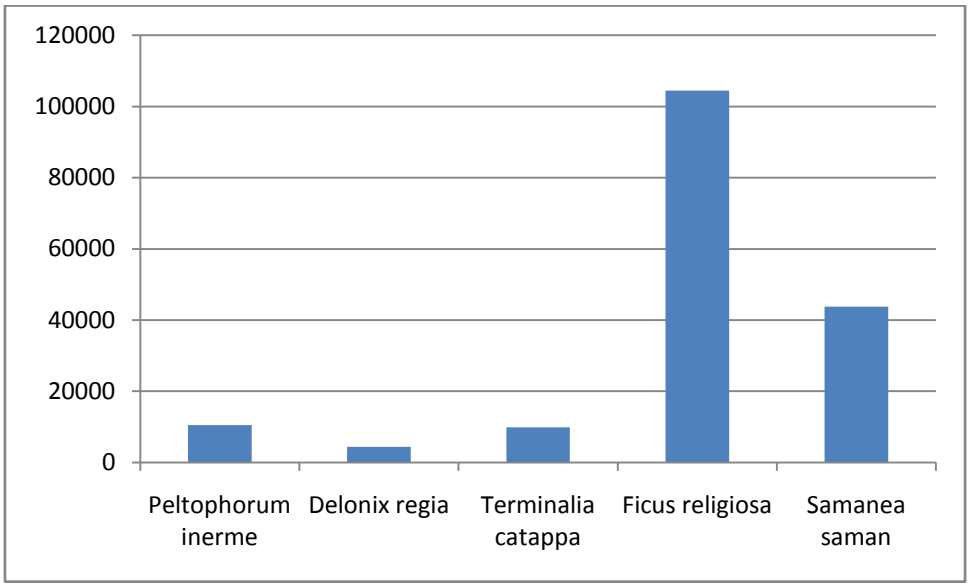

Fig2. *Average volume of tree species during the study*

4. URBAN TEMPERATURES

The average temperatures at different sites ranged between 27^0C and 33.5^0C throughout the study period. All the sites showed variations in temperatures not only between the sites but also within them. This is typical of urban environment where the temperature differ even within an distance of 10 meters. One of the possible reasons could be formation of urban heat islands within the same street itself. Highest temperature was 33.6 degrees C at Bandra Kurla Complex (BKC) 33.5^0C at EEH .the cooler area in the study was carter road with temperatures around 27^0C and bandstand and kc marg around 28^0C. Below tree canopy temperatures were lowest at K.C.Marg with temperature of 24.6^0C and bandra carter road with temperatures around 25^0C. Fig 6.0 shows the decrease in temperatures under different tree canopies.

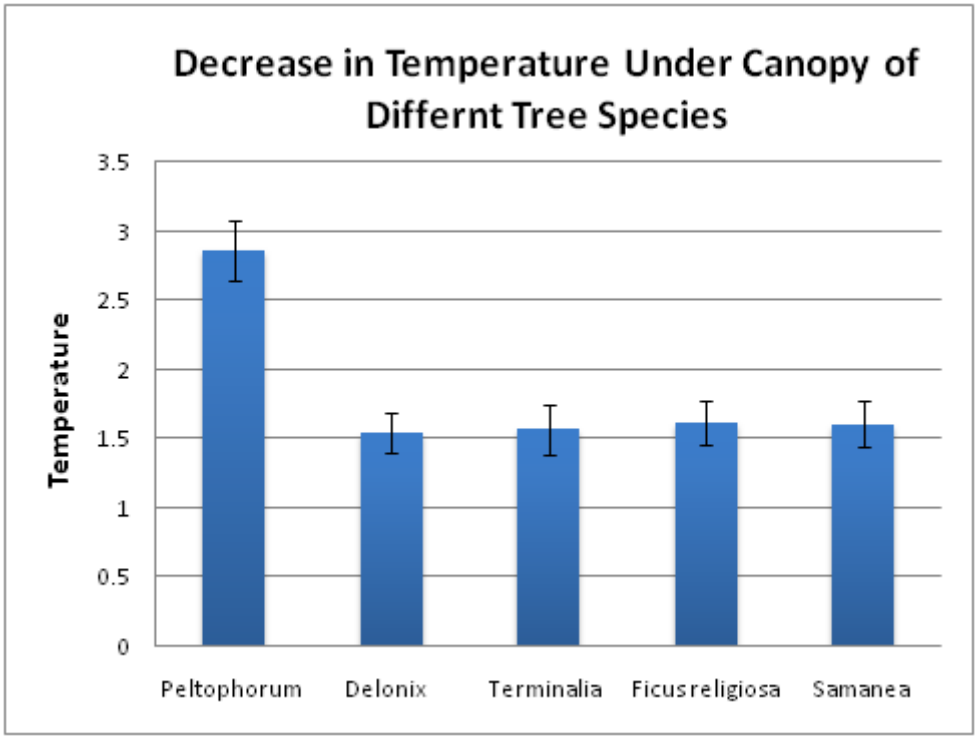

Fig6. *Average reduction of ambient temperature in degrees centigrate below the canopy of 50 individual trees of different species.*

Trees were studied for the difference in temperatures outside the tree canopy and under the canopy shade show differences in temperatures. All the tree species showed an reduced temperature under the tree canopy. Peltophorum inerme showed larger differences in reduction of temperature under its canopy. There was an significant difference in the reduction of temperatures under the tree canopy. Height of the trees seems to play an important role in ameliorating temperature. Samanea saman were the tallest trees in the study followed by Ficus religiosa and Peltophorum. The trend in reduction of temperatures iunder a tree canopy was Peltophourm inerme> Ficus Religiosa >Samanea Saman>Terminalia cattapa > Delonix regia .Table and fig 6.0 Thus Peltophorum offered maximum shade is is significantly higher than all the tree spceis which offer similar similar shade. Error bars represent 95% confidence levels. Table 7 and Fig 6.

The three tree species which offer good shade viz Peltophorum inerme, Ficus religiosa and Samanea saman also grow well in height. The plantations of these trees is highly recommended along highways. Peltophorum inerme with its vase like canopy would be suitable in residential areas and main roads. Also its flowers and fruits gives an aesthetically beautiful look. Leaf morphology, phyllotaxy, and leaf texture seems to play an important role in reducing the temperatures under the tree canopy. The microclimate of a site is affected by the following factors landform, vegetation, street width and orientation and open spaces.

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