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ROLE OF TREES IN MITIGATING URBAN TEMPERATURE

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Abstract

Nowadays**,** cities and towns are facing challenges related to urbanization. Among the challenges, Urban-induced warming and climate change are the two main important environmental issues that cities around the world are experiencing. Fortunately, trees exert positive impact on urban climate through temperature and humidity control. In particular, heritage trees owing to their magnificent structure are identified as potential tree species that can effectively reduce surface temperature. Therefore an attempt was made to assess the temperature mitigation potential of 20 trees based on their physical factors such as tree height, diameter breast height (DBH) and canopy size. Big tree formula was computed based on three essential criteria such as height (meter), girth diameter at breast height (DBH)in meter and canopy spread (meter). Among the twenty trees chosen for the study, *Ficus benghalensis* was identified as the biggest tree followed by S*amanea saman* and *Ficus religiosa*. The big morphology of these trees could be attributed due to girth diameter at breast height (meter).It was observed that *Ficus benghalensis, Ficus religiosa*, *Azadirachta indica* and *Samanea saman* are the best shade providing trees as far as temperature measurement is concerned. *Ficus benghalensis*, *Azadirachta indica* and *Ficus religiosa* were identified to provide cooling effect as far as relative humidity is concerned. It is also understood from the present study that the locality of the trees determine their temperature mitigating ability. Trees present in heavily vegetated area is found to provide more shade and cooling effect compared to same species of trees present in less vegetated area. Thus , this study clearly emphasis the role of trees in mitigating urban heat island and their potentiality in making the atmosphere cool. Hence, it could be concluded that trees are natural assets that need to be preserved to create a healthy, livable and sustainable city.

Key words : Urban Heat Island (UHI), heritage trees, temperature mitigation, relative humidity and vegetated area.

Introduction

Trees constitute an integral component of urban environment. They provide an array of ecosystem services including biodiversity conservation, removal of atmospheric pollutants, oxygen generation, mitigation of urban heat island effect, microclimate regulation, stabilization of soil, groundwater recharge, prevention of soil erosion and carbon sequestration. Thus, benefits rendered by urban trees could be categorized into five groups. They include Social, Aesthetic and architectural, Climatic and Physical, Ecological and Economic benefits. Urbanization and industrialization have resulted in the increased reflectance of heat by urban surfaces. Consequently, urban area experiences increased temperature compared to the surrounding area. This phenomenon is known as Urban Heat Island (UHI). Many researchers have emerged with the adaptive strategies to mitigate Urban Heat Island (Kong *et al.,* 2016). One of the adaptive strategies is to increase the amount of vegetation cover in the urban area because it is understood that trees could effectively control urban climate through mitigation of temperature and in the enhancement of humidity. Literature survey records that trees and vegetation lower surface air temperature by providing shade and through evapotranspiration. Shaded surfaces may be -7^{0}C to 7^{0}C cooler than the peak temperature of unshaded materials. Evapotranspiration, can help reduce peak summer temperature by -17^{0}C to -13^{0}C.Air temperature of differences of approximately -17^{0}C to -15^{0}C have been observed across urban areas having variable tree cover, with approximately 1^0C of temperature difference being associated with10 % canopy cover difference (Karin and Wolf, 2007). Hence, it is evident that tree planting is one of the most cost-effective means of mitigating urban heat islands.

It is learnt that characteristics of a tree such as canopy spread, leaf size and arrangement, tree height and bole height are the critical factors in determining the cooling effect it could provide (Lin *et al.,* 2017). Moreover, among the evergreen species, Heritage trees are identified as potential species in mitigating surface temperature in urban areas. A heritage tree is typically a large, individual tree with unique value, which is considered irreplaceable. The major criteria for heritage tree designation are age, rarity and size as well as aesthetic, botanical, ecological and historical value (Coates and Peter, 2006).

Heritage trees can be simply defined as trees that are appearance of historical and cultural significance, besides giving a unique historical and landscape roles in cities. Furthermore, the heritage trees produce thermal cooling effect based on their tree characteristics. The features of the heritage trees such as large structures, high density coverage, large canopy volume and their ability to excel even in urban stress can contribute to their cooling effect in urban areas (Rogan *et al.,* 2013). Hence, present study elucidates the role of heritage trees in mitigating urban air temperature and improving urban climate.

Materials and Methods

Three basic parameters commonly used to characterize the size of a single trunk tree were height, girth and crown spread.

Tree height is defined as the vertical distance between the base of the tree and the highest youngest branch at the top of the tree. Tree height can be measured in a number of ways with varying degrees of accuracy. One among such methods, is the measurement of trees height remotely from the ground. The most basic remote height methodology is *stick measurement* (Champion Trees of Pennsylvania, Measurement, 2013). The height was calculated using the principle of similar triangles. A short stick was held out pointing vertically at arm's length by its base pointing vertically. The surveyor need to move in and out towards a tree until the base of the stick above the lower hand aligns with the base of the tree and the top of the stick aligns with the top of the tree. The distance from the lower hand to the surveyor's eye was measured. Similarly the distance from the lower hand to the top of the stick was measured and the distance from the eye to the base of the tree was measured with a tape. The ratio of distance from the eye to the hand is to the distance from eye to the base of the tree, as is equal to the ratio of the length of the stick to the height of the tree provided that the top of the tree is positioned vertically over the base.

Tree height = (distance from eye to base of tree/ distance from eye to base of stick) ´ length of stick.

Tree Girth is defined as measurement of the distance around the trunk of a tree measured perpendicular to the axis of the trunk. In the United States, it is measured at breast height, or at 4.5 feet (1.4m) above ground level. In the present study, DBH (Diameter at Breast Height) method was used (Leverett and Robert, 2008). Tree girth measurement was commonly performed by wrapping a tape around the trunk at the correct height.

The most basic crown spread measurement is the average length of two lines across the crown area. The first measurement was made along the longest axis of the crown from one edge to the opposite edge. A second measurement was taken perpendicular to the first line through the central mass of the crown. The two values were averaged to calculate crown spread (Van Pelt *et al.,* 2002).

American forests has developed a formula for calculating tree points for determining champion trees for each species based on three measurements: Trunk circumference (meter), Height (meter) and average crown spread (meter) (America's Biggest Trees – American forests, 2017).

Big tree formula = Trunk circumference (meter) + Height (meter) + 1/4 Average crown spread (meter).

Temperature was measured using wet and dry thermometer (N.S. Dimple thermometer). Temperature recorded in dry bulb was noted as it measures the air temperature. Relative humidity was computed by referring to the hydrometric table. The values in hydrometric table were based on the wet bulb and dry bulb readings.

Results

Trees were evaluated for physical factors such as Tree height, Diameter Breast Height (DBH) and Canopy size which render amenity values such as mitigation of Urban Heat Island (UHI) and improving urban climate through temperature and humidity control (Yaccob *et al.,* 2016) Twenty heritage trees were analysed in the present study (Table 1). Majority of the trees were spotted in Government Arts College Salem-7 which is completing 163 years of educational service. As the college has been established several years ago, it is quite natural that it supports many important heritage trees such as *Albizia lebbeck, Delonix regia, Holoptelea integrifolia, Milletia pinnata, Mimusops elengi, Samanea saman,* etc. Remaining heritage trees were spotted near collectorate, Ayuthapadai and Senganoor areas.

The remarkable features of heritage trees that distinguishes them from surrounding is their morphology. Three main criteria namely Tree height (Metre), Girth diameter at breast height (Metre) and canopy spread (Metre) were assessed to understand their morphology. Moreover, big tree among the surveyed heritage trees was also ranked based on big tree formula. It was found that *Ficus benghalensis* was the biggest tree among 20 trees chosen for study followed by *Samanea saman* and *Ficus religiosa* (Table 2).

In order to understand, the significance of heritage trees in reducing surface temperature, the chosen heritage trees were monitored for variation in temperature measurement based on time (Nor Suhaida Yusof *et al.*, 2007).Temperature was recorded inside and outside tree at different timings such as morning (8 am), afternoon (12 noon) and late evening (5 pm). It was noted that all heritage trees mitigate temperature at all timings as the temperature recorded was less inside trees when compared to temperature recorded outside trees (Table 3). Moreover, almost in all trees except one tree, significant variation in temperature retardation was observed at 12 noon and at 5 pm compared to temperatures recorded at 8 am. It was also observed that *Ficus benghalensis*, *Ficus religiosa*, *Azadirachta indica* and *Samanea saman* were the best shade providing trees (Fig.1a).

Relative humidity was also measured both inside and outside trees at different timings. It was noted that the value of relative humidity is greater under tree compared to outside tree in all the trees chosen for study irrespective of timings (Table 4). *Ficus benghalensis* and *Azadirachta indica* and *Ficus religiosa* were identified to provide cooling effect as far as relative humidity is concerned. Moreover, significant variation in enhancement of relative humidity was observed at morning (8am) when compared to 12 noon and late evening 5pm in majority of the trees chosen for the study (Fig. 1b).

Influence of vegetation in temperature measurement

(A)

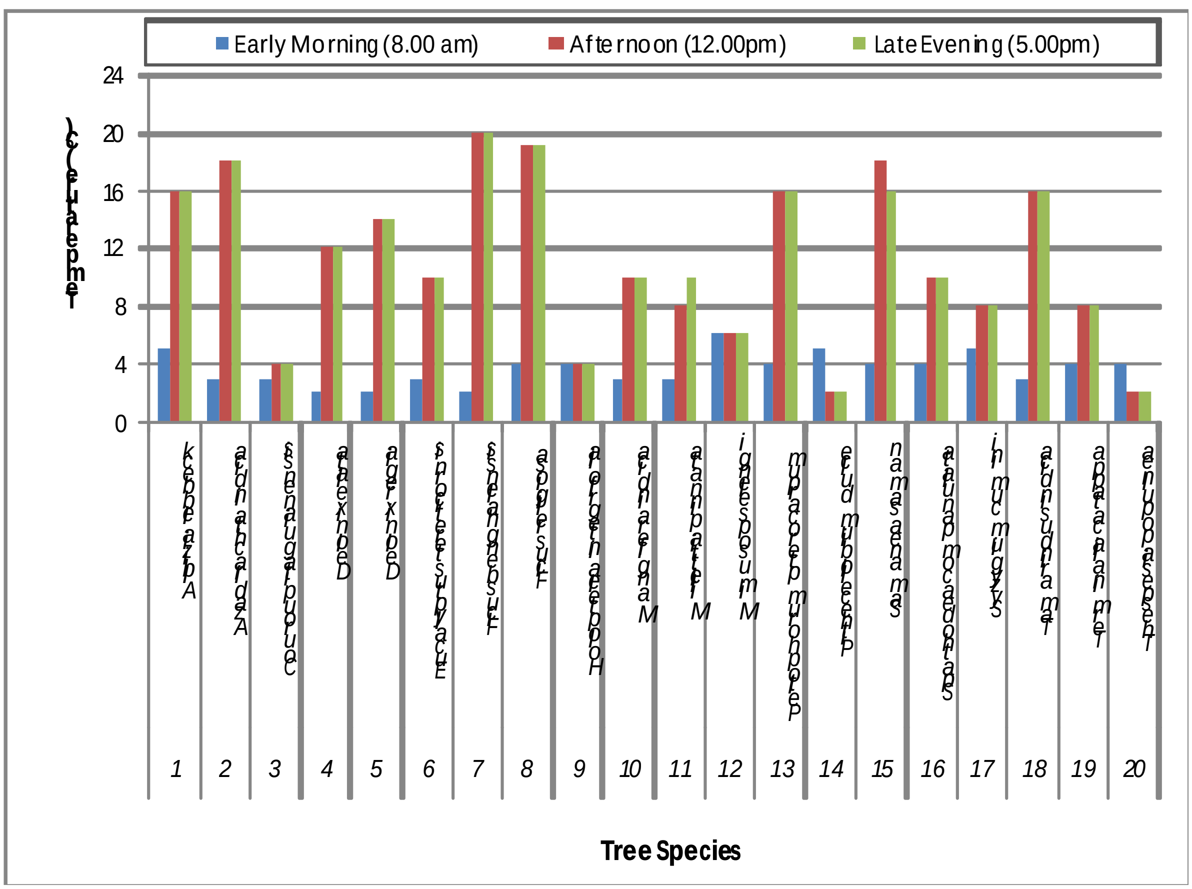

Fig. 1: The variation in (A) temperature and (B) relative humidity between inside and outside of selected tree species during the early morning, afternoon and late evening.

(B)

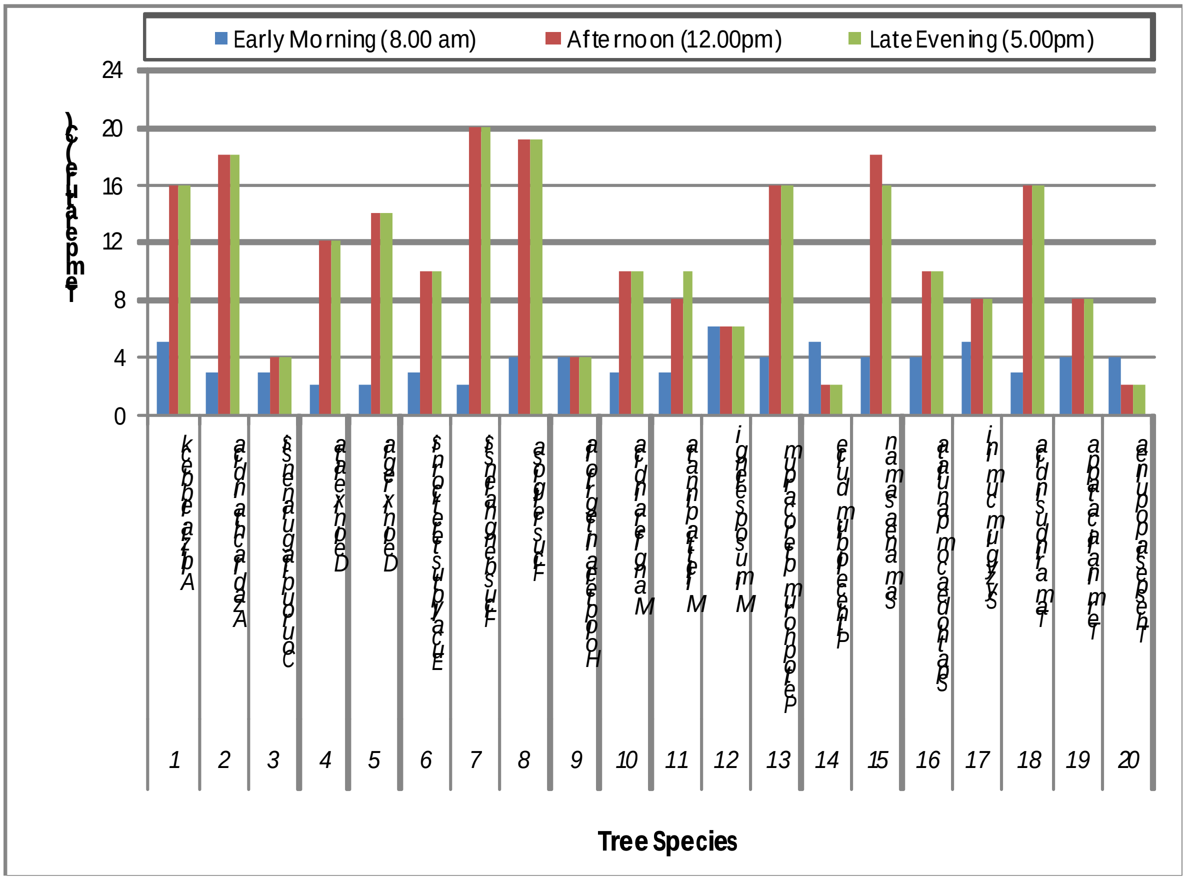

Table 1: List of heritage trees surveyed in Salem city, Tamil Nadu.

S. No.	Botanical Name	Vernacular Name	Common Name	Family
1	*Albizia lebbeck* L. Benth.	Vagai maram	Women's Tongue	Fabaceae
2	*Azadirachta indica* (A. Juss.)	Veppa maram, Vembu	Neem tree	Meliaceae
3	*Couroupita guianensis* (Aubl.)	Nagalingam maram	Cannon Ball tree	Lecythidaceae
4	*Delonix elata* (L.)	Vaadha narayana	Yellow Gul-Mohur	Fabaceae
5	*Delonix regia* (Hook.)	Cemmayir – Konrai	Peacock flower	Fabaceae
6	*Eucalyptus tereticornis* Sm. Spec. Bot.	Thaila maram	Eucalyptus	Myrtaceae
7	*Ficus benghalensis* L., SP.Pl.	Aalamaram	Banyan tree	Moraceae
8	*Ficus religiosa* L., S.PPl.	Arasa maram	Holy fig Tree	Moraceae
9	*Holoptelea integrifolia* (Roxb.)	Aavi maram	Jungle cork tree	Ulmaceae
10	*Mangifera indica*. L.SP.Pl	Mamaram	Mango tree	Anacardiaceae
11	*Millettia pinnata* (L)	Pungai Maram	Indian Beech Tree	Fabaceae
12	*Mimusops elengi* L. SP.Pl	Magizham boo maram	Bullet wood	Sapotaceae
13	*Peltophorum pterocarpum* (D.C.)	Perung - Konrai	Copper Pod.	Fabaceae
14	*Pithecellobium dulce* (Roxb). Benth.	Kodukkapuli maram	Manila Tamarind	Fabaceae
15	*Samanea saman* (Jacq.) Merr.J.	Thoongumongimaram	Aavi maram	Fabaceae
16	*Spathodea campanulata* P.Beauv., Fl.	Thaneervitan Kaai maram	Squirt tree	Bignoniaceae
17	*Syzygium cumini* (L.) Skeels Bul. Bur. Pl.	Naval maram	Indian black berry	Myrtaceae
18	*Tamarindus indica* (L).	Puliya maram	Indian dates	Fabaceae
19	*Terminalia catappa* L. Mant. Pl.	Inguti Maram	Umbrella tree	Combretaceae
20	*Thespesia populnea* (L.) Sol. ex. Correa	Poovarasu maram	Cork tree	Malvaceae

(A)

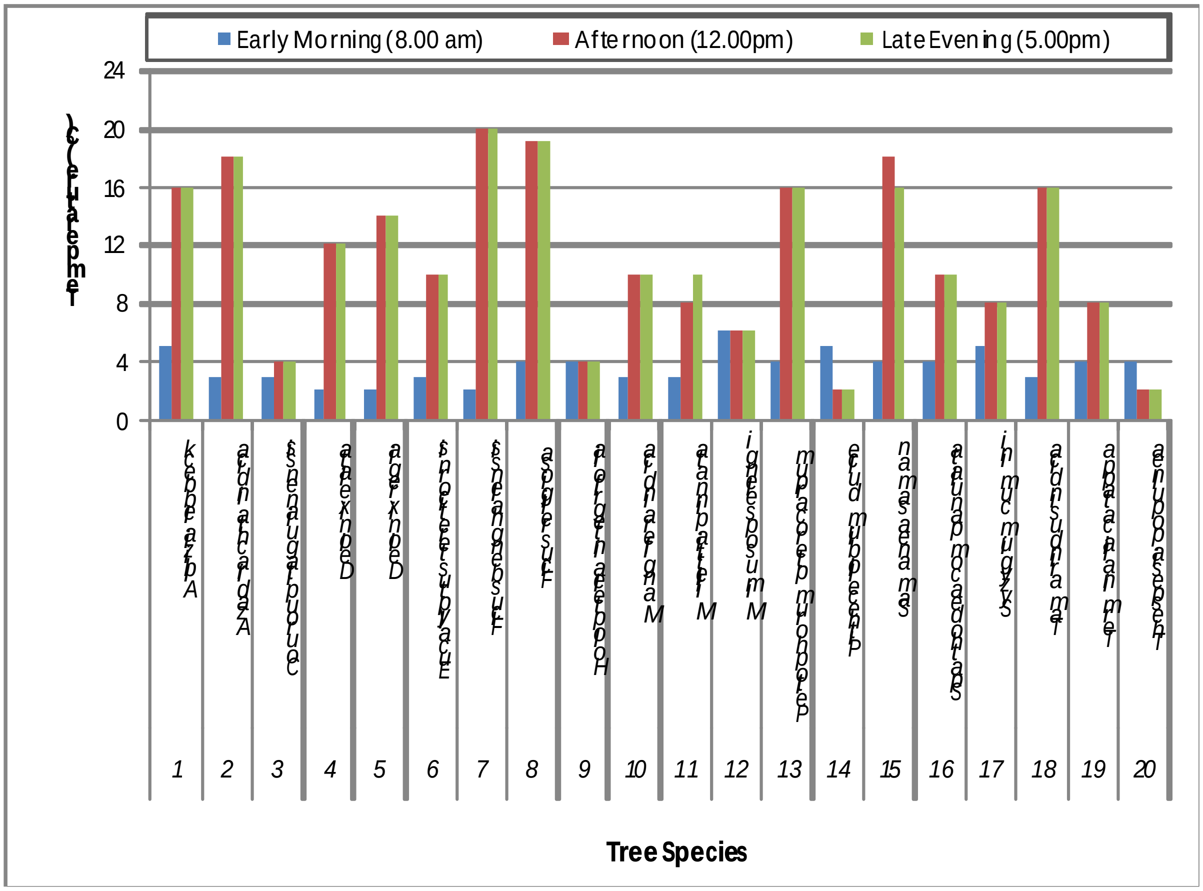

Fig. 2: The variation in (A) temperature and (B) relative humidity between inside and outside of selected tree species during the early morning, afternoon and late evening.

(B)

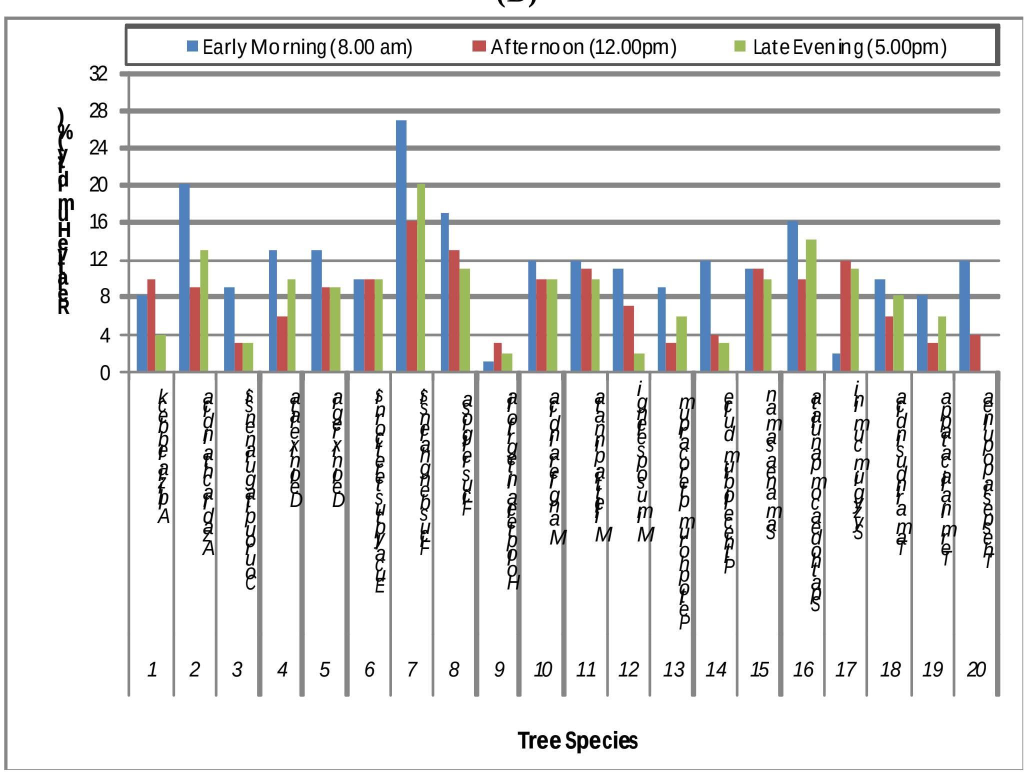

Table 2: Descending order of trees based on big tree formula.

S.No.	Botanical Name	Height (Meter)	+	Girth (Meter)	+	1/4Canopy (Meter)	Big Tree (Meter)
1	*Ficus benghalensis* L., SP.Pl.	21.33	+	7.87	+	7.62	36.82
2	*Samanea saman* (Jacq) Merr.J.	18.28	+	7.11	+	7.01	32.40
3	*Ficus religiosa* L., SP.Pl.	17.98	+	6.60	+	6.70	31.28
4	*Tamarindus indica* (L).	16.45	+	6.35	+	7.31	30.11
5	*Azadirachta indica* (A. Juss)	17.37	+	5.08	+	7.01	29.46
6	*Spathodea campanulata* P. Beauv., Fl.	22.86	+	3.20	+	3.35	29.41
7	*Eucalyptus tereticornis* Sm. Spec. Bot.	22.25	+	2.79	+	4.26	29.30
8	*Delonix regia* (Hook.)	15.24	+	5.58	+	7.62	28.44
9	*Albizia lebbeck* L. Benth.	17.67	+	3.04	+	6.70	27.41
10	*Peltophorum pterocarpum* (D.C.)	16.15	+	4.57	+	6.40	27.12
11	*Delonix elata* (L.)	17.06	+	3.30	+	6.09	26.45
12	*Millettia pinnata* (L)	14.63	+	2.69	+	5.48	22.80
13	*Mangifera indica*. L. SP.Pl.	11.88	+	4.31	+	5.79	21.90
14	*Syzygium cumini* (L.) Skeels Bul. Bur. Pl.	13.10	+	2.79	+	4.87	20.76
15	*Pithecellobium dulce* (Roxb.). Benth.	10.66	+	2.79	+	4.26	17.71
16	*Mimusops elengi* L. SP.Pl.	9.75	+	1.77	+	5.18	16.70
17	*Thespesia populnea* (L.) Sol. ex. Correa	11.88	+	1.27	+	3.35	16.50
18	*Couroupita guianensis* (Aubl.)	7.92	+	1.77	+	4.57	14.26
19	*Terminalia catappa* L. Mant. Pl.	8.53	+	2.03	+	3.04	13.60
20	*Holoptelea integrifolia* (Roxb.)	9.14	+	1.14	+	3.04	13.32

Table 3: Temperature (°C) mitigation potential of trees based on time.

S.No.	Botanical name	Morning(8 am)		Afternoon(12 noon)		Late evening(5 pm)	
		Inside	Outside	Inside	Outside	Inside	Outside
1	*Albizia lebbeck* L. Benth.	24	29	32	48	30	46
2	*Azadirachta indica* (A. Juss.)	22	19	28	46	26	44
3	*Couroupita guianensis* (Aubl.)	24	27	42	46	40	44
4	*Delonix elata* (L.)	23	25	34	46	32	44
5	*Delonix regia* (Hook)	24	26	32	46	30	44
6	*Eucalyptus tereticornis* Sm. Spec. Bot.	23	26	36	46	34	44
7	*Ficus benghalensis* L., SP.Pl.	23	25	28	48	26	46
8	*Ficus religiosa* L., S.P.Pl.	22	26	29	48	27	46
9	*Holoptelea integrifolia* (Roxb.)	24	28	40	44	38	42
10	*Mangifera indica*. L.SP.Pl	23	26	38	48	36	46
11	*Millettia pinnata* (L.)	22	25	38	46	34	44
12	*Mimusops elengi* L. SP.Pl	22	28	40	46	40	46
13	*Peltophorum pterocarpum* (D.C.)	24	28	32	48	30	46
14	*Pithecellobium dulce* (Roxb). Benth.	25	30	44	46	42	44
15	*Samanea saman* (Jacq.) Merr.J.	24	28	28	46	28	44
16	*Spathodea campanulata* P.Beauv., Fl.	25	29	36	46	34	44
17	*Syzygium cumini* (L.) Skeels Bul. Bur. Pl.	23	28	36	44	34	42
18	*Tamarindus indica* (L.).	25	28	32	48	30	46
19	*Terminalia catappa* L.Mant. Pl.	23	27	40	48	38	46
20	*Thespesia populnea* (L.) Sol. ex. Correa	25	29	44	46	42	44

Table 4: Enhancement of relative humidity (%) by trees based on time.

S.No.	Botanical name	Morning(8 am)		Afternoon(12 noon)		Late evening(5 pm)	
		Inside	Outside	Inside	Outside	Inside	Outside
1	*Albizia lebbeck* L. Benth.	60	52	79	69	72	68
2	*Azadirachta indica* (A. Juss.)	74	54	77	68	76	63
3	*Couroupita guianensis* (Aubl.)	53	44	67	64	66	63
4	*Delonix elata* (L.)	67	54	74	68	73	63
5	*Delonix regia* (Hook)	68	55	73	64	72	63
6	*Eucalyptus tereticornis* Sm. Spec. Bot.	59	49	69	59	68	58
7	*Ficus benghalensis* L., SP.Pl.	91	64	85	69	84	64
8	*Ficus religiosa* L., S.P.Pl.	66	49	78	65	70	59
9	*Holoptelea integrifolia* (Roxb.)	46	45	61	58	59	57
10	*Mangifera indica*. L.SP.Pl	67	55	75	65	69	59
11	*Millettia pinnata* (L.)	66	54	70	59	68	58
12	*Mimusops elengi* L. SP.Pl	50	39	71	64	66	64
13	*Peltophorum pterocarpum* (D.C.)	60	51	67	64	65	59
14	*Pithecellobium dulce* (Roxb). Benth.	54	42	63	59	57	54
15	*Samanea saman* (Jacq.) Merr.J.	68	57	70	59	64	54
16	*Spathodea campanulata* P. Beauv., Fl.	68	52	69	59	68	54
17	*Syzygium cumini* (L.) Skeels Bul. Bur. Pl.	59	57	75	63	68	57
18	*Tamarindus indica* (L.).	61	51	75	69	72	64
19	*Terminalia catappa* L. Mant. Pl.	52	44	72	69	70	64
20	*Thespesia populnea* (L.) Sol. ex. Correa	47	35	72	68	67	67

Table 5: Influence of tree vegetation on temperature.

S.No.	Botanical name	Temperature (°C) 12' noon			
		More vegetation area		Less vegetation area	
		Inside	Outside	Inside	Outside
1	*Albizia lebbeck* L. Benth	32	48	34	48
2	*Azadirachta indica* (A. Juss.)	28	46	30	46
3	*Couroupita guianensis* (Aubl.)	42	46	42	46
4	*Delonix elata* (L.)	34	46	36	46
5	*Delonix regia* (Hook)	32	46	36	48
6	*Eucalyptus tereticornis* Sm.Spec. Bot.	36	46	40	48
7	*Ficus benghalensis* L., SP.Pl.	28	48	30	48
8	*Ficus religiosa* L., S.P.Pl.	29	48	32	48
9	*Holoptelea integrifolia* (Roxb.)	40	44	40	44
10	*Mangifera indica*. L.SP.Pl	38	48	38	48
11	*Millettia pinnata* (L.)	38	46	40	46
12	*Mimusops elengi* L. SP.Pl	40	46	40	48
13	*Peltophorum pterocarpum* (D.C.)	32	48	36	48
14	*Pithecellobium dulce* (Roxb). Benth.	44	46	46	48
15	*Samanea saman* (Jacq.) Merr.J.	28	46	32	46
16	*Spathodea campanulata* P.Beauv., Fl.	36	46	38	46
17	*Syzygium cumini* (L.) Skeels Bul. Bur. Pl.	36	44	42	48
18	*Tamarindus indica* (L.).	32	48	36	48
19	*Terminalia catappa* L.Mant. Pl.	40	48	42	48
20	*Thespesia populnea* (L.) Sol. ex. Correa	44	46	42	48

Table 6: Influence of tree vegetation on relative humidity.

S.No.	Botanical name	Relative humidity (%) 12' noon			
		More vegetation area		Less vegetation area	
		Inside	Outside	Inside	Outside
1	*Albizia lebbeck* L. Benth	79	69	74	69
2	*Azadirachta indica* (A. Juss.)	77	68	72	68
3	*Couroupita guianensis* (Aubl.)	67	64	67	64
4	*Delonix elata* (L.)	74	68	75	68
5	*Delonix regia* (Hook)	73	64	69	65
6	*Eucalyptus tereticornis* Sm. Spec. Bot.	69	59	66	60
7	*Ficus benghalensis* L., SP.Pl.	85	69	78	69
8	*Ficus religiosa* L., S.P.Pl.	78	65	73	65
9	*Holoptelea integrifolia* (Roxb.)	61	58	62	59
10	*Mangifera indica*. L. SP.Pl	75	65	70	65
11	*Millettia pinnata* (L.)	70	59	66	59
12	*Mimusops elengi* L. SP.Pl	71	64	67	65
13	*Peltophorum pterocarpum* (D.C.)	67	64	75	69
14	*Pithecellobium dulce* (Roxb). Benth.	63	59	64	60
15	*Samanea saman* (Jacq.) Merr. J.	70	59	67	59
16	*Spathodea campanulata* P. Beauv., Fl.	69	59	70	61
17	*Syzygium cumini* (L.) Skeels Bul. Bur. Pl.	75	63	71	65
18	*Tamarindus indica* (L.).	75	69	73	69
19	*Terminalia catappa* L. Mant. Pl.	72	69	70	64
20	*Thespesia populnea* (L.) Sol. ex. Correa	72	68	72	69

was carried out by choosing same species of trees in two different localities that has more and less vegetation (Hashim *et al.*, 2007). It was found that in both localities, temperature recorded was less under tree compared to outside tree in all the heritage trees selected for study (Table 5). Further, it was also noted that majority of trees present in locality of heavily vegetated area had better temperature mitigation ability than trees of less vegetated area. It was interesting to note that in locality of heavily vegetated area *Ficus benghalensis*, *Ficus religiosa*, *Samanea saman* and *Azadirachta indica* were identified as best candidates of trees in providing shadeas far as temperature measurement is concerned (Fig. 2a).

Influence of vegetation in relative humidity measurement was carried out by choosing same species of trees in two different locality that has more and less vegetation. It was found that in both locality, relative humidity recorded was more under tree compared to outside tree in all the heritage trees selected for study (table 6). Further, it was also noted that majority of the trees present in locality of heavily vegetated had better cooling ability than trees of less vegetated areas. It was noted that in locality of heavily vegetated area *Ficus benghalensis*, *Ficus religiosa* and *Syzygium cumini* were identified as best candidate of trees in providing cooling effect (Fig. 2b).

Discussion

Cities around the world are now facing two important urban problems namely urban induced warming and climate change (Childers *et al., 2015)*. So, it is high time for academicians, urban planners and engineers to focus on urban sustainability. The pace of urbanization in intricately connected to urban-induced warming. This in turn accelerates urban heat island (UHI) effect. Due to this effect, cities experiences higher ambient temperature than non-urban areas. It is understood that trees impose positive impact on urban climate through temperature and humidity control. Therefore, increasing the amount of vegetation cover in the urban area could be adopted as one of the strategies to overcome this detrimental effect of urbanization (Kong *et al.*, 2016)

Heritage trees owing to its magnificent morphology are identified as significant element in reducing surface temperature especially in urban areas Diock and Hutchings, 2013).Therefore, an attempt was made to evaluate heritage trees in terms of morphology, physical factors and amenity values such as mitigation of urban heat island (UHI).The heritage tree might look as same as ordinary tree but it possess certain unique characters such as ancient, beautiful, big, champion, elite, exceptional, famous, historic, landmark, outstanding or veteran trees (Meyer, 2001). Twenty such heritage trees were identified and majority of the trees were spotted inside campus of Government Arts College, Salem-7 which is completing 163 years of educational service. It is obvious that ancient educational institution such as Government Arts College, Salem-7 would definitely harbour valuable and irreplaceable heritage trees. Remaining trees were chosen from areas surrounding in and around college campus.

Three essential criteria that endow significance to heritage trees such as tree height (meter), girth diameter at breast height (meter) and canopy spread (meter) were monitored. Based on these criteria, big tree formula was computed to identify the biggest trees. *Ficus benghalensis* was spotted as the biggest tree followed by *Samanea saman* and *Ficus religiosa*. The big morphology of these trees could be attributed due to girth diameter at breast height (meter).Literature survey indicates that the cooling effect is mainly determined by the canopy spread, leaf size and arrangement, tree height and leaf properties (Lin *et al.*, 2017). Moreover, vegetation creates 'oasis' effect to the environment in mitigating land surface temperature (Akbari *et al.*, 2001). Special characteristic of heritage trees such as their magnificent nature, large crown spread and diameter breast height render them as a potential candidate to mitigate urban stress (Jim, 2005). Further the role of heritage trees in mitigating land surface temperature was better understood by monitoring temperature measurement and relative humidity measurement based on time (Nor Suhaida Yusof *et al.*, 2007).

Temperature was recorded inside and outside tree at different timings such as morning (8 am), afternoon (12 noon) and late evening (5 pm). It was noted that all heritage trees mitigate temperature at all timings as the temperature recorded was less inside trees when compared to temperature recorded outside trees. Moreover, among 20 trees chosen for the study, except one tree, significant variation in temperature retardation was observed at 12 noon and 5pm compared to temperatures recorded at 8 am. It was also observed that *Ficus benghalensis, Ficus religiosa, Azadirachta indica* and *Samanea saman* are the best shade providing trees. Temperature reduction by trees is mainly caused by two factors namely direct shading and evapo-transpirational cooling (Monteiro *et al.*, 2019). During this process, some of the energy absorbed by the plants was used to evaporate water within their leaves, cooling them. The resultant water vapour is then transpired through the leaf pores (stomata) into the air without warming the air around them. It was also found that the indirect cooling effect of evapotranspiration is greater than the direct effect of shading.

Regarding monitoring of Relative humidity, it was noted that the value of relative humidity is greater under tree compared to outside tree in all the trees chosen for study irrespective of timings. *Ficus benghalensis*, *Azadirachta indica* and *Ficus religiosa* were identified to provide cooling effect as far as relative humidity is concerned.

Research findings expounds that the variation in the performance of trees in providing cooling effect depends on the shape and size of the trees (Abreu – harbich *et al.*, 2015). It is also reported that trees with high typical transpiration rates, high reflectivity and trees with dense and large canopies reduce the surface temperature more than others (Leuzinger *et al.*, 2010).Moreover, significant variation in enhancement of relative humidity was observed at morning (8am) when compared to 12 noon and late evening 5pm in majority of the trees chosen for the study. Thus, it is understood that trees are the most promising vegetative component that could reduce overheating especially in urban areas (Pauleit and Duhme, 2000 a).

Influence of vegetation in temperature measurement was carried out by choosing same species of trees in two different localities that has more and less vegetation. It was found that in both localities, temperature recording was less under tree compared to outside tree in all the heritage trees selected for study. Further, it was also noted that majority of the trees selected for the study that are present in locality of heavily vegetated area had better temperature mitigation ability than trees of less vegetated area. The concept that the locality of the trees also plays a key role in determining their temperature mitigating ability was understood from the present study. The reason is that the vegetated areas reflect more solar radiation away from the surface than dark artificial surfaces. Consequently, less solar radiation will be absorbed rendering vegetated areas to be cooler than non-vegetated areas. It was noted that in locality of heavily vegetated area *Ficus benghalensis, Ficus religiosa, Samanea saman* and *Azadirachta indica* were the best candidates of trees in providing shade as far as temperature measurement is concerned.

The influence of vegetation in relative humidity measurement was carried out by choosing same species of trees in two different localities that had more and less vegetation. It was found that in both localities, relative humidity recorded was more under tree compared to outside tree in all the heritage trees selected for study. Further, it was also noted that majority of the trees present in locality of heavily vegetated had better cooling ability than trees of less vegetated areas (Tyrvainen *et al*., 2003). The reasons might be that, as the number of trees in an area increase, relative contribution of evapotranspiration to overall cooling goes up, mitigating the urban heat effect (Solecki *et al*.,2005) It was identified that in locality of heavily vegetated area *Ficus benghalensis, Ficus religiosa* and *Syzygium cumini*, were the best candidate of trees in providing cooling effect.

Conclusion

Urban-induced warming and climate change are the two main challenges that cities around the world are facing now-a-days.Trees exert positive impact on urban climate through temperature and humidity control. Heritage trees owing to their magnificent structure are identified as potential tree species that can effectively reduce surface temperature. Twenty such heritage trees were chosen for the present study. Big tree formula was computed based on three essential criteria such as height (meter), girth diameter at breast height (DBH)in meter and canopy spread (meter). Among the twenty trees chosen for the study *Ficus benghalensis* was identified as the biggest tree followed by S*amanea saman* and *Ficus religiosa*. The big morphology of these trees could be attributed due to girth diameter at breast height (meter).

It was observed that *Ficus benghalensis*, *Ficus religiosa*, *Azadirachta indica* and *Samanea saman* were the best shade providing trees as far as temperature measurement is concerned. *Ficus benghalensis*, *Azadirachta indica* and *Ficus religiosa* were identified to provide cooling effect as far as relative humidity is concerned.It is also understood from the present study that the locality of the trees determine their temperature mitigating ability. Trees present in heavily vegetated area was found to provide more shade and cooling effect compared to same species of trees present in less vegetated area. Thus , this study clearly emphasis the role of trees in mitigating urban heat island and their potentiality in making the atmosphere cool and conducive. Hence, it could be concluded that green infrastructure planning and development within city premises should be given priority. This will include trees which provide maximum cooling effect to make life in urban areas more comfortable.

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