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Studies on the thermal comfort in relation to tree cover in Indore city

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ABSTRACT

Urban trees are able to modify the climate of a city and improve urban thermal comfort in hot climates. Individually, urban trees also act as shading and wind-shielding elements improving the ambient conditions around individual buildings. The objective of this study is to quantify the effects of trees in selected areas of Indore city on air temperature and humidity to determine the effect of trees in different areas. We used Google Earth to capture 7 distinct locations in Indore throughout the summer, and we used a temperature and humidity meter to record the conditions at each location beneath various tree canopies. Under the canopies of all trees, temperatures are lowered and humidity levels are increased. Google Earth is used to calculate tree cover as well. As Indore is also having a hot summer, studies find the relationship between temperature and tree cover, and the studies show that areas with more tree cover have a lower temperature. We also find out the number of trees in all the areas, which also states that, the greater the number of trees, the lower the temperature.

Keywords*:* - Thermal comfort, ambient temperature, humidity.

INTRODUCTION

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE). Relatively few studies on thermal comfort for outdoor environments have been conducted compared to indoor environments, although the importance of the former is increasingly recognized with the changing climate and increase in heat stress in cities. The difficulty in obtaining thermal outdoor conditions is that the climatic variables are much more diverse than in indoor settings. The largest and most populated city in the Indian state of Madhya Pradesh is Indore. Both the Indore District and the Indore Division have their headquarters there.It is regarded as the state's educational centre as well. It has the highest elevation of all the main towns in Central India and is situated on the southern edge of the Malwa Plateau, at an average elevation of 550 metres (1,800 feet)

above sea level. The city is located 190 kilometres (120 km) west of Bhopal, the state capital. According to census estimates from 2011, Indore had 1,994,397 residents (municipal corporation). Between a humid subtropical climate and a tropical savanna environment, Indore is located. Due of its high elevation and inland location even during the summer the nights are relatively cool, which is known as Shab-e-Malwa.

Indore gets average rainfall of 700 to 800 millimeters during July–September due to the southwest monsoon. Our climate is getting hotter, more unstable, and more unpredictable because of the "boiling and churning" effect caused by the heat-trapping greenhouse gases within the top layers of our atmosphere. With each increase of carbon, methane, or other greenhouse gas in the atmosphere, our local weather and global climate is further disturbed, heated, and "boiled." Global warming is measured by the increase in the average global temperature of the earth The concept of average global temperature was created because, in addition to the Earth's overall rising average temperature, some regions may actually get colder while others warm up. Urban trees can alter the climate of city and improve thermal comfort in hot climate Because outdoor environment is hot; people who involve in outdoor daytime activities tend to prefer outdoor areas shaded by trees. A benificial tree planting design provides appropriate shade and cooling functions and also improves thermal comfort. The cooling effect and shading of plants is mainly determined by the canopy density, tree cover of the area and temperature and humidity of the area. Temperature, relative humidity, tree cover and tree density of different areas are used to evaluate thermal comfort. The main aim of this study is to create a database of urban trees with reference to Indore to know there effect on outdoor environment this will help to sort out different tree species according to their efficiency in lowering the ambient air temperature. For this study the following 7 areas are selected Sukhliya, Nanda nagar, Nehru nagar, Chandan nagar, Sudama nagar, Rajwada, Tilak nagar, Cloth market which roughly covers the whole city.

MATERIAL AND METHODS

The parameters studied were tree cover, number of trees, air temperature, humidity (morning, noon, evening) at 2m, 4m, 6m distance from the base of the trees. Our study was conducted in different areas during summer in Indore city.

To calculate tree cover Google earth has been used in which we select 07 areas in which polygons were drawn of 1000 X1000 and find out the tree cover from them. To calculate relative humidity and temperature of the tree in all the areas temperature and humidity meter (HD-303) is used. Number of trees is also calculated in each area.

RESULTS AND DISCUSSION

Temperatures can be lowered and energy consumptio n can be decreased by employing the optimum arrangements of lowlying ground cover and highbranching sh ade trees to provide buildings with shade and moderat e wind flow. This may result in communities that are m ore attractive, energy-efficient, and cooler.

In accordance with Oke (1976) cities with more residents show more dramatic evidence of urbanization in their core areas, which results in more thermal modification. Trees reduce the amount of heat that surfaces and buildings gain by reflecting solar radiation. In addition to absorbing carbon dioxide from the environment, trees also reduce the need for air cooling, so lowering carbon dioxide emissions. According to Akbari and colleagues (1992), "if enough trees are planted, we may be able to lower our cooling energy enough to avoid both the expensive building of new power plants as well as their economic and environmental cost." Matzarakis and Mayer's (1998) pioneering study on outdoor thermal comfort conditions found that clothes and shading affect how hot it is for people.

Akbari *et al.* (2001) stats that the increased warmth of the city by sunlight is one effect of paving streets with dark asphalt surfaces. As light is absorbed by a dark surface, it warms up. In turn, the pavements heat the air. AliToudert *et al.* (2005) observed that in BeniIsguen, Algeria, the influence of building materials on heat stress was identified. They also discovered that shaded urban locations were more comfortable than unobstructed areas exposed to direct sun radiation. Johansson and Emmanuel (2006) computed thermal comfort conditions that are provided in PET, according to them, highlight the need of shade for improving daytime comfort PET is defined as the equivalent air temperature at which heat is generated

Table 1. ???

	Area	No of trees	TREE COVER AREA	Temperature and Humidity								
				Summer								
				Morning			Noon			Evening		
				2m distance	4m distance	6m distance	2m distance	4m distance	6m distance	2m distance	4m distance	6m distance
1	Cloth market temp. (°C)	394	64973.8	52.8 ± 0.12	53.1 ± 0.12	54.1 ± 0.12	46.5 ± 0.12	47.9 ± 0.12	48.2 ± 0.12	39.2 ± 0.12	39.5 ± 0.12	39.7 ± 0.12
	Humidity (%RH)			33.6 ± 0.12	33.1 ± 0.09	32.8 ± 0.12	34.9 ± 0.12	34.1 ± 0.12	33.6 ± 0.12	39.1 ± 0.12	38.5 ± 0.12	38.1 ± 0.12
2	Chandannagar temp. (°C)	815	81707	48.5 ± 0.12	45.8 ± 0.12	45.9 ± 0.12	41.8 ± 0.12	41.9 ± 0.12	42.1 ± 0.12	35.5 ± 0.12	35.9 ± 0.12	36.2 ± 0.12
	Humidity (%RH)			33.5 ± 0.17	34.1 ± 0.12	33.2 ± 0.12	35.3 ± 0.12	34.2 ± 0.12	34 ± 0.12	39.8 ± 0.12	38.5 ± 0.12	38.3 ± 0.12
3	Sukhliya temp. (°C)	1057	96108.3	39.5 ± 0.12	42.2 ± 0.18	42.3 ± 0.12	37.6 ± 0.12	38.5 ± 0.12	40.6 ± 0.12	36.3 ± 0.12	37.1 ± 0.12	39.3 ± 0.12
	Humidity (%RH)			37.3 ± 0.18	36.2 ± 0.18	35 ± 0.12	38.1 ± 0.12	37.5 ± 0.12	37.1 ± 0.12	36.4 ± 0.08	36.3 ± 0.12	36.2 ± 0.12
4	Tilak nagar temp. (°C)	1284	100134	37.8 ± 0.12	39.6 ± 0.12	40.1 ± 0.12	37.8 ± 0.12	38.9 ± 0.95	39.1 ± 0.12	34.3 ± 0.12	36.8 ± 0.12	37.8 ± 0.12
	Humidity (%RH)			37.8 ± 0.12	36.8 ± 0.54	35 ± 0.12	39.6 ± 0.12	38.6 ± 0.12	37.6 ± 0.12	37.8 ± 0.08	36.8 ± 0.09	35 ± 0.09
5	Sudamanagar temp. (°C)	1357	114916	51.8 ± 0.12	52 ± 0.12	52.8 ± 0.12	43.3 ± 0.12	45 ± 0.12	46.9 ± 0.12	39.9 ± 0.12	40.5 ± 0.12	41.4 ± 0.8
	Humidity (%RH)			32.3 ± 0.12	32 ± 0.12	31.8 ± 0.12	37.8 ± 0.12	37.1 ± 1.23	36.8 ± 1.23	37.5 ± 0.08	35.9 ± 0.12	35.1 ± 0.12
6	Nehru nagar temp. (°C)	1112	121258	30.6 ± 0.12	34.1 ± 0.12	37.1 ± 0.12	34.3 ± 0.12	36.1 ± 0.18	36.5 ± 0.17	33.5 ± 0.12	34.2 ± 0.12	34.5 ± 0.12
	Humidity (%RH)			40.7 ± 0.12	37.8 ± 0.69	36.2 ± 0.12	40.1 ± 0.12	39.1 ± 0.17	38.9 ± 0.17	38.5 ± 0.08	38.3 ± 0.12	37.9 ± 0.12
7	Nanda nagar temp. (°C)	949	125537	33.1 ± 0.12	33.6 ± 0.12	33.9 ± 0.12	27.5 ± 0.12	31.9 ± 0.12	32.8 ± 0.12	27.9 ± 0.12	28.9 ± 0.12	29.5 ± 0.12
	Humidity (%RH)			38.5 ± 0.12	37.5 ± 0.48	37.3 ± 0.12	42.5 ± 0.12	39.9 ± 0.12	38.9 ± 0.12	39.5 ± 0.12	38.1 ± 0.12	38.5 ± 0.12

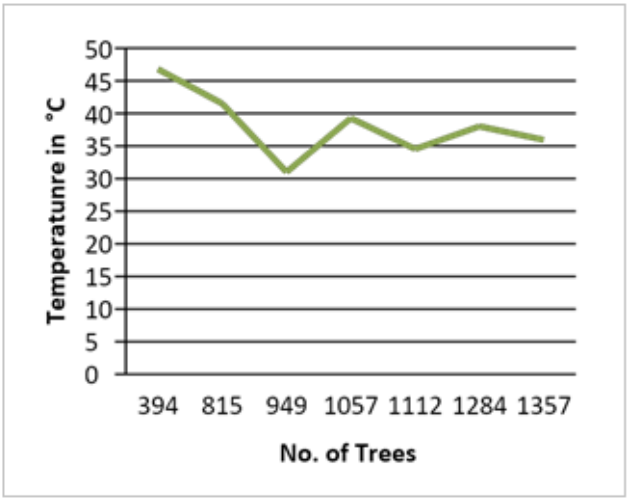

Figure 1: Showing more number of trees less temperature

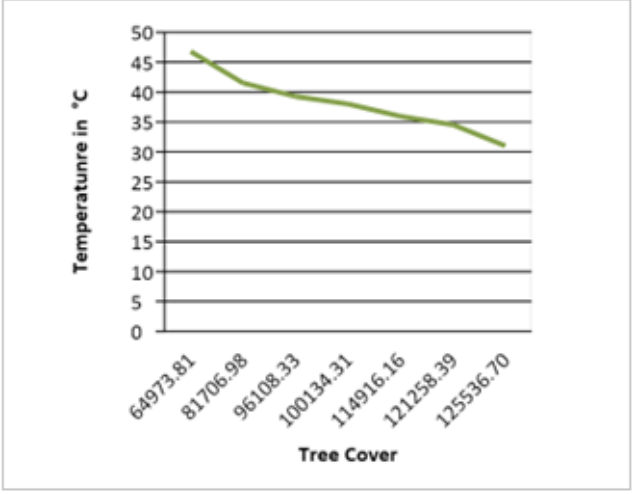

Figure 2: Showing more tree cover less temperature

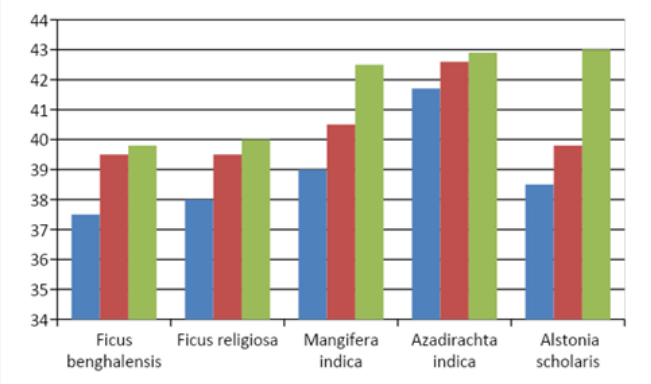

Figure 3: demonstrating the relatively low temperature of *Ficus benghalensis*

under typical indoor conditions, as per Mayer and Hoppe (1987) and Hoppe (1999). Differential roadway shadowing caused by varied street layout in Szeged, Hungary, resulted in a PET index variation of 15 to 20 degrees Celsius (Gulyas *et al.* 2006). The shading effects of trees in metropolitan settings can dramatically lower the MRT and PET values (Mayer *et al.* 2009). Additionally, a reduced SVF can greatly enhance outdoor thermal comfort (Lin *et al.* 2010). Although there is a significant association between sun access and SVF, Kruger *et al.* (2011) found that the relationship between MRT and SVF is significantly influenced by wind speed.

Hwang *et al.* (2011) suggested that seasonal shading effects should be taken into account while enhancing the comfort levels at street level. In the coastal city of Chennai, Amirtham *et al.* (2011) discovered that different microclimatic conditions were caused by differential heating as a result of the varying aspect ratios of the street canyons. They also discovered that medium rise, medium density built forms can significantly enhance the outdoor comfort conditions. As in our study we focus on how tree caopy affect the thermal comfort

This study clearly indicate that there is the relationship between canopy cover and ambient air temperature more the canopy cover less was the air temperature for example Nanda nagar has more tree cover and the temperature is low the result for number of trees for per square km also correspond to the air temperature, as less number of trees per square km is clearly related with higher temperature while area with more density experiences low temperature for example cloth market has low tree cover and the temperature is high.

Kapoor in 2014 find that Ficus benghalensis L. may readily resist the impacts of air pollution by modifying their physiological processes related to photosynthesis and respiration, as well as confirming the notion that trees play a significant part in the improvement of

urban air quality. so we also find out the temperature of 5 different plant Mangifera indica, Azadirachta indica, Ficus religiosa, Ficus benghalensis, Alstonia scholaris in which Ficus benghalensis found more effective in lowering the air temperature as compared to the Alstonia scholaris while Azadirachta indica performed moderately.

CONCLUSION

By the above study we can conclude that the more and more plantation of trees in urban areas can improve thermal comfort and the indigenous species perform better so such trees should be planted to improve the quality of urban environment.

Conflict of Interest: None of the authors have any conflicts of interest to disclose. All the authors approved the final version of the manuscript.

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