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RESEARCH ARTICLE

A COMPARATIVE ANALYSIS BETWEEN DEVELOPED AND UNDEVELOPED OPEN SPACES IN CONTEXT TO THERMAL COMFORT DURING SUMMER – NAGPUR CITY AS A CASE STUDY

***,[1]Yuvraj P. Meshram, [2]Prof. S. A. Deshpande and [3]Dr. Sheeba Valsson**

[1]Associate Professor and Principal, Radhikatai Pandav Institute of Architecture, Umrer Road, Nagpur
[2]Ph.D. Guide, R.T.M. Nagpur University, Nagpur & Rtd. Professor, Visvesvaraya National Inst. of Tech., Nagpur
[3]Ph.D. Guide and Professor, Shri. Datta Meghe College of Architecture, Nagpur

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ABSTRACT

Open spaces can directly or indirectly affect the microclimate and local air quality by modifying the urban climate. Well planned and maintained open spaces (parks) can improve their microclimate and thermal comfort to the users whereas undeveloped open spaces can augment their un-comfort level. Vegetation processes such as photosynthesis, Evapo-transpiration which helps to reduce the radiant temperature and anthropogenic heat generated by the built structures and hard surfaces which lead to urban heat island effect. Thus, the potential cooling effect of Developed parks are particularly important in urban areas. The process of cooling by vegetation, the relative humidity value increases with the reduction in ambient air temperature, causes human thermal comfort. The environmental conditions of urban open spaces have momentous impact on the comfort conditions experienced inside them especially in seasons of stressful climate (hot summer).The aim of this paper is to understand by a comparative analysis between Developed and Undeveloped Open Spaces in context to Thermal Comfort during summer. To understand and researching these issues field survey has been carried out with the help of Digital 4 in 1 Anemometer (Lutron - L8000A), used to recording the ambient air temperature and humidity of the open spaces.

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INTRODUCTION

Green Open Spaces (Parks) constitute a vital part of public life and are offten referred to as the lungs of an area. An attractive, safe and accessible parks deliver social, economic and environmental benefits in addition to improving public health and well being. It also mitigates the effects of climate change. In a prior study conducted in 1995, Nichol proved that the forested area in Singapore had a cooling effect compared with the dense city area (Nicol, 1996). This Study showed that grassy surfaces had a potential role for the cooling effect. In a recent study on the Urban Heat Island (UHI) phenomenon in Singapore city, Wong and Yu (Wond, 2005) found the cooling effects of the Urban Cool Island (UCI) / Park Cool Island (PCI) were reflected not only in vegetated areas but also in the surrounding areas. Johansson and Emmanuel's study in Sri Lanka also confirmed that the land cover of the city centre which had more of hard surface brought more thermal discomfort when compared with rural areas (Johanson, 2006). One of the main causes of the air temperature increase and of the energy consumption, as well as the change of the people's behaviours, is the lack of appropriate landscape treatments in urban open spaces. Different methodology used in research to confirm that the vegetation can influence in urban microclimate and improving thermal comfort and increasing the potential of health impairment of urban populations (Santamouris, 2001; Akbari, 2002; Dimoudi, 2003; Akbar, 1996). When designing sustainable green space, addressing outdoor thermal comfort and heat stress have become more a prevalent focus. Therefore, the physiological and psychological impact should have been taken into account when designing green space. Previous studies described thermal comfort as a fundamental parameter, as well as how heat stress/thermal discomfort affects these outdoor activities (Knez, 2009) (Nikolopoulou, 2003) (Vanos, 2010). These studies explained the consequences, implication and outcomes of how heat stress affected human life. (Givoni, 2003) mentioned while staying outdoors, people should have various unlimited condition like the sun and shade, changes in wind speed, and so on. Moreover, some studies stated the need of shades as an important element for outdoor spaces (Akbari, 2001; Hwang, 2010).

****Corresponding author: Yuvraj P. Meshram,***
Associate Professor and Principal, Radhikatai Pandav Institute of

Thermal comfort becomes an overall motivation as a person's well being could be related to climate and weather. Since park users would always look at weather conditions when doing outdoor activities. In addition, urban parks offer the public some release from the pressures of urban environments and everyday living Microclimatic condition wise, there may be limitations to the thermal conditions during daytime that may affect prolonged usage of the outdoor parks.

Need of the study ?

Urbanization due to rapid growing population has led to unplanned and uncontrolled expansion of city which resulted in the continuous replaces of open spaces, vegetation and water bodies. By continuously ignoring towards the nature, city has been developing its infrastructures and built environment to meet the demand of Urbanization. Due to this there is gradual loss in the open spaces and unfortunately there are very few existing open spaces, many of which are not well maintained and also lack of vegetation, as a result adversely affecting the micro-climate of the city. Due to this, it is very necessary to investigate the performance of open spaces pertaining to a varied range of aspects. Among these aspects, research needs to be carried out to clearly determine the effect of open spaces on the microclimate control and thermal comfort within the open spaces.

METHODOLOGY

Step – I (Literature Review)

To Study and Understand the climatic behaviour of different Treated and untreated open spaces with various types of surface treatment and its impact on microclimate. Also the influence of each park in terms of ground cover configuration on human thermal comfort level from different papers, journals, books, articles, etc.

Definition

Open space is publicly owned land that is set aside primarily for recreation, nature conservation, passive outdoor enjoyment and public gatherings. This includes public parks, gardens, reserves,waterways, publicly owned forecourts and squares. These open spaces are accessible for all and having well maintened infrastructure facilities.

Outdoor thermal comfort, thermal comfort can be defined as a condition in which individuals prefer neither warmer nor cooler temperatures i.e., the prefered temperature. While neutrality temperature is the temperature at which people feel comfortable, prefered temperature is the temperature people wantThermal comfort standards (Staiger et al., 2012).

Vegetation means the plants of an area or a region. According to David, (2009) vegetation increases the oxygen and moisture in the air, absorbs sun's radiation, gives shade, cools the surrounding environment and gradually improves the micro-climate of a given area.

A **microclimate** is a local atmospheric zone where the climate differs from the surrounding area. The term may refer to areas as small as a few square feet (for example a garden bed) or as large as many square miles. There are two main parameters to define a microclimate within a certain area are temperature and humidity.

Step – II (Field Survey)

Nagpur city as a case study

The most common problem in Indian cities is continuous increase in temperature. This calls for monitoring of temperature changes, especially in urban areas. The study area, Nagpur the best city to live in India, incidentally also beats to the rhythm of India's heart because of its geographical location 'Zero Mile'. Nagpur the 'Garden City' of Maharashtra is having 18% of its area under forest and plantation. As per the ABP News Best City Awards Research in March 2013, Nagpur is India's most Livable City with the Best Public Transport, the Best Green City and the Best City for Health Care Services. It is the second capital of Maharashta with municiple area 220.8 km^2. It is the third populous city (2.398 million residents) of Maharashtra state with the population density 11,000 persons / km^2. In today's situation, the vacant lands are getting converted into layouts. There is no strict provision for incorporation of open spaces. The dense old city is becoming more dense and western Nagpur is becoming multi-storied. This is creating a problem for citizen as there are no such open spaces to socialize. Some of the open spaces which are properly maintained are overflowing (example- Children's traffic park, Ambazari) while some are unutilized or dead (London street). There is no balance between user's population and the space provided; there is no balance between open spaces needed in various parts of the city and provided.

Total Area of Nagpur Municipal Corporation is **21756.00** Hect. Out of which Total Area under Residential use is **5900.00** Hect. and Total Land Area for the provision of Open Spaces is **1024.70** Hect. i.e. **4.70%** of total area.

Total no. of Open Spaces are 376 out of which 60 are Private Open Spaces. Open Spaces under the authority of NMC/NIT are 316 out of which Developed Open Spaces are only 92 i.e. 29.11% and 70.89% are in Un-developed condition.

Climatic behaviour of Nagpur city

The city of Nagpur enjoys a very dry and semi humid in general is composite climate throughout the year excepting monsoon season (June to September) annual rainfall (based on 30 years data) is about 1161.5 mm. The winter (November to February) in general is mild. Temperature during the month of March, April, May and June is more beyond the comfort zone. Nagpur climate witness a very hot weather during the month of summer. It reaches the pinnacle in the month of May. A meteorological observatory is situated at Nagpur airport, which represent the climate of Nagpur. Daily Meteorological data of this observatory have been used to prepare the climatology of Nagpur.

Extreme temperature (Analysis)

The highest maximum temperature during summer for the period from 1969 to 2010 is shown in Table 1. The highest maximum temperature of 45°C or more was most frequent during most of the years. The highest maximum and minimum temperature in March is 42.5°C (23,24/3/2010) and 28.0°C

(29/3/1996) resp. The highest maximum and minimum temperature in April is 47.1°C (30/4/2009) and 31.9°C (23/04/1973) respectively and in May is 47.6° C (23/5/2005) and 34.3° C (15/5/1970) respectively. However, extreme recorded maximum temperature is 47.7° C on 26/05/1954. The lowest maximum and minimum temperature in March is 20.6° C (11/03/2006) and 10.1° C (10/03/1979) respectively. The lowest maximum and minimum temperature in April is 30.8° C (19/04/2000) and 16.2° C (02/04/1996) respectively and in May is 24.8° C (13/05/1990) and 20.4° C (06/05/1997) respectively. May is the most discomfort and hot month during summer season whereas January reaches at lowest temp.

Table 1. Extreme Temperatures at Nagpur (1969-2010)

Months	Maximum Temperature				Minimum Temperature			
	Highest	Date	Lowest	Date	Highest	Date	Lowest	Date
Mar.	42.5	23,24/ 2010	20.6	11/ 2006	28.0	29/ 1996	10.1	10/ 1979
April	47.1	30/ 2009	30.8	19/ 2000	31.9	23/ 1973	16.2	02/ 1996
May	47.6	23/ 2005	24.8	13/ 1990	34.3	15/ 1970	20.4	06/ 1997
	47.7	26/ 1954						

Strategies for the provision of open spaces

In order to understand the current provisions for protection of existing open spaces and generation of new ones, the following regulations were Studied. The DC Regulations and various Acts were studied with respect to their scope and relevance to open spaces, their positive and negative aspects, etc.

Desirable land use pattern as suggested in the manual of Town and Country Planning Organisation, (TCPO) New Delhi

Table 2. Land use pattern, Town and Country Planning Organisation, (TCPO), New Delhi

No.	Land Use Particulars	Land Percentage
1	Residential	40 %
2	Industrial	8 %
3	Commercial	3.5 %
4	Parks, playgrounds and open spaces	10 %
5	Transportation and Communication	24 %
6	Public and semi-public	10 %
7	Others	4.5 %
	Total	100 %

Area analysis of land use as on 25/9/1984 in nagpur

S. No.	Major Land use Purpose	Area in Ha.	% To Dev. Area	% To Total Area
1	Residential	3500	41.966	16.08
2	Commercial	185	2.218	0.85
3	Industrial	225	2.697	1.03
4	Public Purpose	2100	25.179	9.66
5	Roads	555	6.654	2.55
6	Railway	440	5.275	2.03
7	Airport	525	6.294	2.42
8	Garden & Playground	150	1.798	0.69
9	Developable Vacant Land	660	7.919	3.03
10	Agriculture	8000	------	36.78
11	Forest	225	------	1.03
12	Water Tank	456	------	2.09
13	Nallah (River tributaries)	380	------	1.74
14	Non-developable vacant land	4355	------	20.02
	Total	21,756	100.00	100.00

NOTE: Green spaces in Institutional Areas are included as Public Purpose.

Extract from revised development plan of nagpur (1986-2011)

Environmental Planning

Environment in the context of city should be considered as encompassing every aspect which would provide the citizens with safer and comfortable living conditions and greater opportunities to lead a dignified community life. Pathetic living conditions without even the basic amenities for a very large number of citizens, constant feeling of unsafety on roads and anxiety at home channelising the young and comforting the old are some of the matters having the greatest effect on the level of social and cultural life of the citizens as a whole. In addition to the social facilities, which would provide the citizens with the most essential amenities at the standards considered as the minimum, the Development plan should also aim at making the maximum use of natural features such as hills, rivers, nallahs, open spaces and man-made objects such as canals etc. This will give them frequent opportunity to be in contact with nature.

Field Survey has been carried out in randomly selected Eight urban open spaces: Four Developed and Four Un-developed each having an Area more than 1.00 Hect. of Nagpur city as mentioned: -

Developed Open Spaces

1)Dr. Ambedkar Park, Vaishali Nagar – 27239.39 sq.m
2)Dayanand Park, Jaripatka – 25253.33 sq.m.
3)Shivaji Park, Shivaji Nagar – 14449.75 sq.m.
4)NIT Park, Suyog Nagar – 27149.49 sq.m.

Un- Developed Open Spaces

1)Buddha Park, Buddha Nagar – 21074.28 sq.m.
2)Ganesh Park, Vaishali Nagar – 10635.32 sq.m.
3)Ram Nagar Park, Ram Nagar – 13747.25 sq.m.
4)NIT Park, Old Bagadganj – 20161.00 sq.m.

All the Eight open spaces are located in the majorly residential areas and laid in East-West direction. By this survey, it will find out that is there any difference of Thermal Comfort in Developed and Undeveloped Open Spaces in terms of ambient air temperature and humidity during Summer and Winter. To understand and researching these issues field survey has been carried out with the help of Digital 4 in 1 Anemometer (Lutron - L8000A), used to recording the ambient air temperature and humidity of the open spaces. For data collection, 9 points (spots) have been taken (in almost equal distances) on an imaginary line along the centre (East-West direction) of the parks, for measure the air temperature and humidity and two points almost on the central vertical imaginary line (along North-South direction).

Development control regulations

Table 4. Analysis of Development Control Regulations (DCR)

Name	Brief scope with respect to Open Space	Authority	Positive Aspects	Negative Aspects	Suggestions/ Remark
Development Control Regulation, DCR.	13.6.5 (b) DCR States that : structures used for the purpose of pavilion or gymnasia or club house of vipasana and yoga center and other structures for the purpose of sports and receation activity like all indoor sports may be permited. DCR-section 13.6.5 e) Such structure shall not be used for any other purpose, except for recreational activity, for which a security deposit as decided by the Chairman will have to be paid to the NIT. DCR-section 13.6.5 g) Garbage dumping area within plots. DCR-section 13.6.5 h) Parking either temporary or permanent shall not be permitted.	NIT & MNC	Regulation have been given to overcome encroachments.	Rules and Regulations framed for good reasons, instances of violation of development Control rules are observed. As a result, the development of parks, open space and playfields experiences in Incongruous usage.	In the said regulation there is need to add specific section for public safety and security. Reframe section (13.6.5 g) (because the relevant section having ambiguity in sentence, the place is not clear weather the garbage is dump on plots open land or it is to be dump in specific land fields or garbage can.

LAND ACQUISITION ACT

Table 5. Analysis of Land Acquisition Act

Name	Brief scope with respect to Open Space	Authority	Positive Aspects	Negative Aspects	Suggestions/ Remark
Land Acquisition, 1894, modified MRTP 1966	Acquiring land for public purpose and amenities from private owners. Market value to be paid as compensation for compulsory acquisition.	L. A. Officer	Instrument to acquire land for public purposes Purchase notice under s/c 49, & 127 By owner to local authority to acquire within stipulated time period.	If the land is Encroached, the re-housing responsibility is on ULB. High cost of acquisition and low priority for acquisition for open spaces. Prolonged litigation if compensation amount is challenged.	Only 10% acquired so far during the entire tenure of plan. Reluctance on part of NMC to acquire land.

Transfer of development rights

Table 6. Analysis of Transfer of Development Rights

Name	Brief scope with respect to Open Space	Authority	Positive Aspects	Negative Aspects	Suggestions/ Remark
Transfer of Developmental Rights TDR	Handing over the vacant land under reservation to NMC free of cost. In return the owner gets to transfer the buildable potential (FSI) in the same ward or in the northern direction through a Development Right Certificate (DRC)	…..	NMC gets the land for public purpose free of cost.	Owner has to make the offer. Handing over land, free of encumbrance is a precondition. This excludes many spaces which NMC could have taken over	NMC should get the power to initiate and operate TDR for open space reservation This act could be used to convince the owner to surrender the vacant land under open space reservation.

SR & TP ACT, 1966

Table 7. Analysis of SR & TP Act, 1966

Name	Brief scope with respect to Open Space	Authority	Positive Aspects	Negative Aspects	Suggestions/ Remark
Section 52, 53.54 of MR & TP Act, 1966	The unauthorized constructions (like encroachments) are present in the park/open space according to section 52 penalty for unauthorized development, power to require removal of unauthorized development under section 53, power to stop unauthorized development under section 54.	NIT & NMC	Power to stop unauthorized development. Within the Parks and open space.	No Concern of authorities towards existing encroachments in open space and playfields.	If local authority is not liable to his duty, authority shall be punishable with fine.

SRA Schemes

Table 8. Analysis of SRA Schemes

Name	Brief scope with respect to Open Space	Authority	Positive Aspects	Negative Aspects	Suggestions/ Remark
SRA Schemes	Pertains to Slum settlement occupying the land reserved under open space reservations.	SRA NMC	On redevelopment of Slum settlement, 33% of the encroached area or 500 sq. m (whichever is More) is to be left as open space. This area is in addition to the existing vacant land if any	There is no mechanism to take over such land by NMC's Garden Department unless it is handed over by SRA.	Mechanism to convert the open space into a usable RG should be formulated. No concessions to be given in marginal open spaces.

Case Study

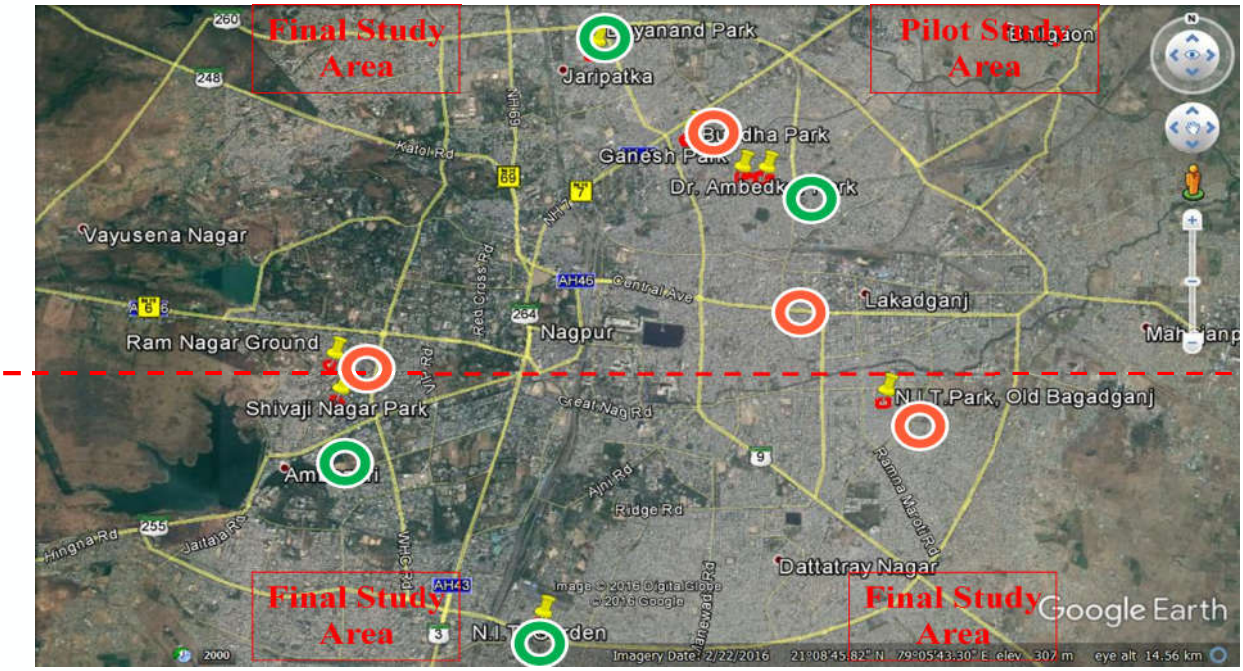

Figure 1. Identification of study areas

Also, four points on the outer side of the parks on each direction to measure the impact of open spaces on surrounding areas in terms of air temperature and humidity. (Ref. Fig.3,4,5 & 6 for Developed and Fig. 7,8,9 & 10 for Un-developed open spaces). All the data (3 sets of total 15 points) each set for morning (8.00 A.M.), afternoon (2.00 P.M.) and evening (8.00 P.M.) respectively of all open spaces have been taken on those points above 1 mt. ground level with Digital 4 in 1 Anemometer (Lutron – L8000A). The data was being taken in the months of April, May and June for Summer.

Step – III (Analysis)

As per the Extreme temperature analysis, May is the most discomfort and hot month during summer season. Thus, analysis has been carried out for the extreme Summer month i.e. May.

Summer Analysis

For Summer Morning

As per accepted standards, the human comfort range of temperature varies from 21.5^0 C to 27.0^0 C; and Humidity ranges from 18% to 75%.

As per meteorological data the average temperature in the month of May, 2015 at 8 A.M., is 35.5^0 C and humidity is 27%.

Observations & Analysis

From Table 11 and Fig. 11, it is observed that in developed parks the temperatures are just above the comfort range but below the Meteorology recorded data and the humidity is consistently well within the comfort range, whereas, in un-developed parks the temperatures are above the comfort range and the Meteorology recorded data as well but humidity is consistently well within the comfort range. Thus it is observed that in developed parks the temperatures are just above the comfort range but below the Meteorology recorded data, whereas in undeveloped parks, the temperatures are much higher than the comfort range and above the Meteorology recorded data in the morning itself. Similarly, the humidity in developed parks is consistently well within the comfort range, while in undeveloped parks it is close to the lower limit in the morning hours. As per meteorological data the average temperature in the month of May, 2015 at 2 P.M., is 44.7^0 C and humidity is 20%.

Table 9. Percentage of Soft Surface & Hard Surface in Developed Open Spaces

Developed Parks	Area in %	
	Soft Surface	Hard Surface
Dr. Ambedkar Park, Vaishali Nagar	74.03	25.97
Dayanand Park, Jaripatka	76.3	23.62
Shivaji Park, Shivaji Nagar	77.41	22.59
NIT Park, Suyog Nagar	84.2	15.8

Figure 2: Digital 4 in 1 Anemometer (Lutron - L8000A)

Table 10: Accuracy factor of Digital 4 in 1 Anemometer (Lutron - L8000A)

Measurement	Range	Accuracy
Air velocity	80 to 5910 ft/min	≤ 20 m/s : ± 3% F.S. > 20 m/s : ± 4% F.S.
	0.4 to 30.0 m/s	
	1.4 to 108.0 km/h	
	0.9 to 67.0 mile/h	
	0.8 to 58.3 knots	
	32 to 122 °F	± 2.5 °F
	0 to 50 °C	± 1.2 °C
Humidity	10 to 95 %RH	< 70% RH : ± 4 %RH ≥ 70% RH : ± (4%rdg + 1.2 %RH)
	32 to 122 °F	± 2.5 °F
	0 to 50 °C	± 1.2 °C
Light	0 to 20,000 Lux	± 5% rdg ± 8 dgt
	0 to 2,000 Fc	
Temperature	-148 to 2372 °F	± (1% rdg + 2°F)
(Type K)	-100 to 1300 °C	± (1% rdg + 1°C)

Remark :
ft/min : feet per minute — MPH : miles per hour
m/s : meters per second — knots : nautical miles per hour
km/h : kilometers per hour — Ft-cd : feet candle

Figure 3: Dr. Ambedkar Park, Vaishali Nagar

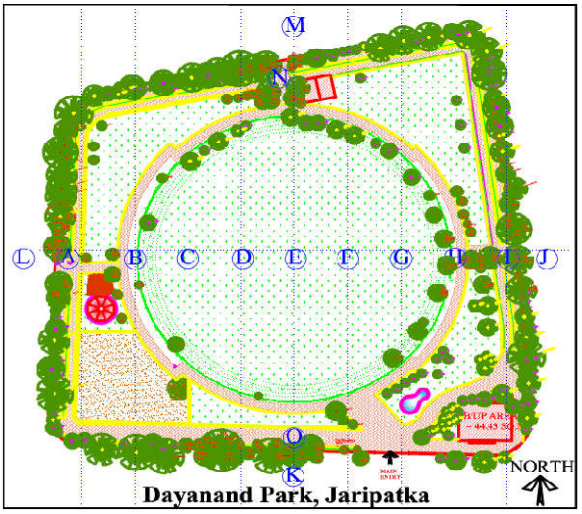

Figure 4: Dayanand Park, Jaripatka

Figure5: Shivaji Park, Shivaji Nagar

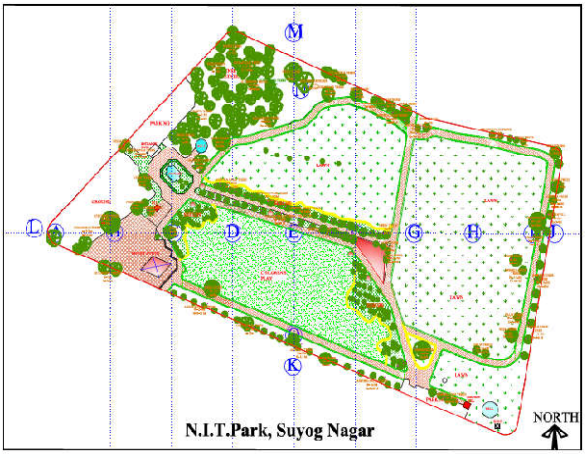

Figure 6: N.I.T. Park, Suyog Nagar

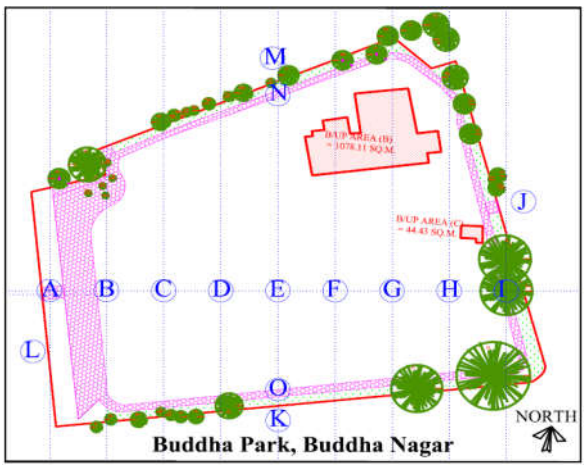

Figure 7: Buddha Park, Buddha Nagar

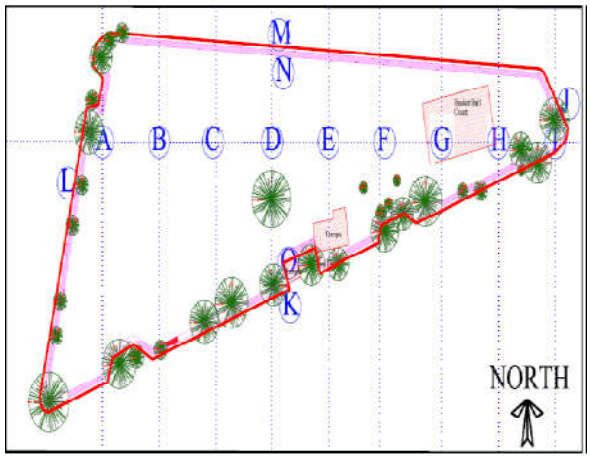

Figure 8: Ganesh Park, Vaishali Nagar

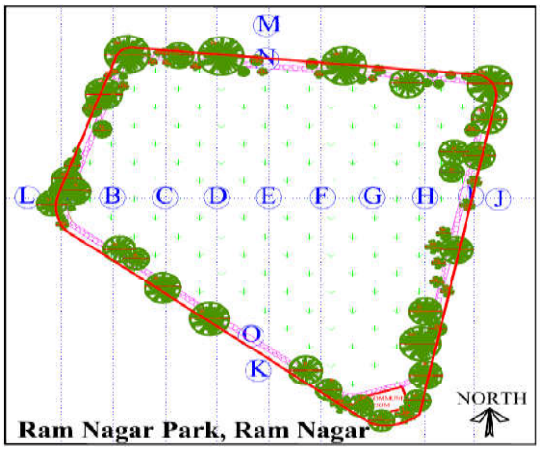

Figure 9: Ram Nagar Park, Ram Nagar

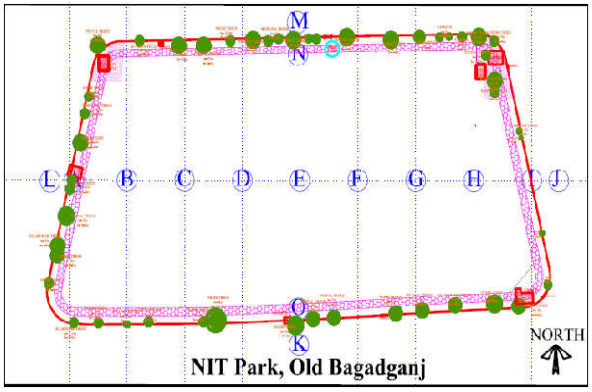

Figure 10: NIT Park, Old Bagadganj

Table 11. Data for summer morning

Study Area	Developed				Un-Developed			
	Ambedkar Park	Dyanand Park	Shivaji Park	NIT Park, Suyog	Buddha Park	Ganesh Park	Ram Nagar	NIT Park Bagadganj
Recorded Morning Ambient Air Temp.	32.1	30.4	29.9	28.5	39.4	38.8	38.7	39.1
Recorded Morning Humidity	31	33	34	38	21	22	22	21

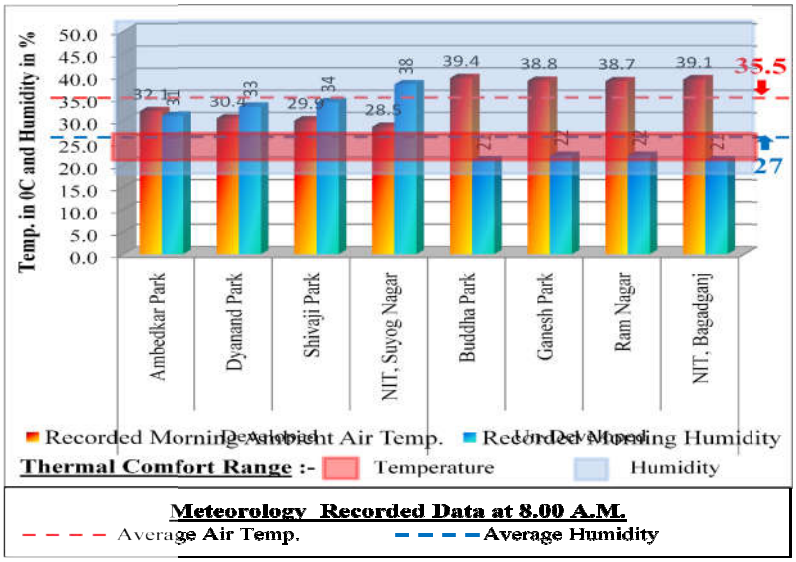

Figure 11. Graphical analysis for summer morning

Table 12. Data for summer afternoon

Study Area	Developed				Un-Developed			
	Ambedkar Park	Dyanand Park	Shivaji Park	NIT Park, Suyog	Buddha Park	Ganesh Park	Ram Nagar	NIT Park Bagadganj
Recorded Morning Ambient Air Temp.	40.4	39.2	39.0	37.4	46.6	45.7	45.4	46.1
Recorded Morning Humidity	18	18	21	23	12	14	17	13

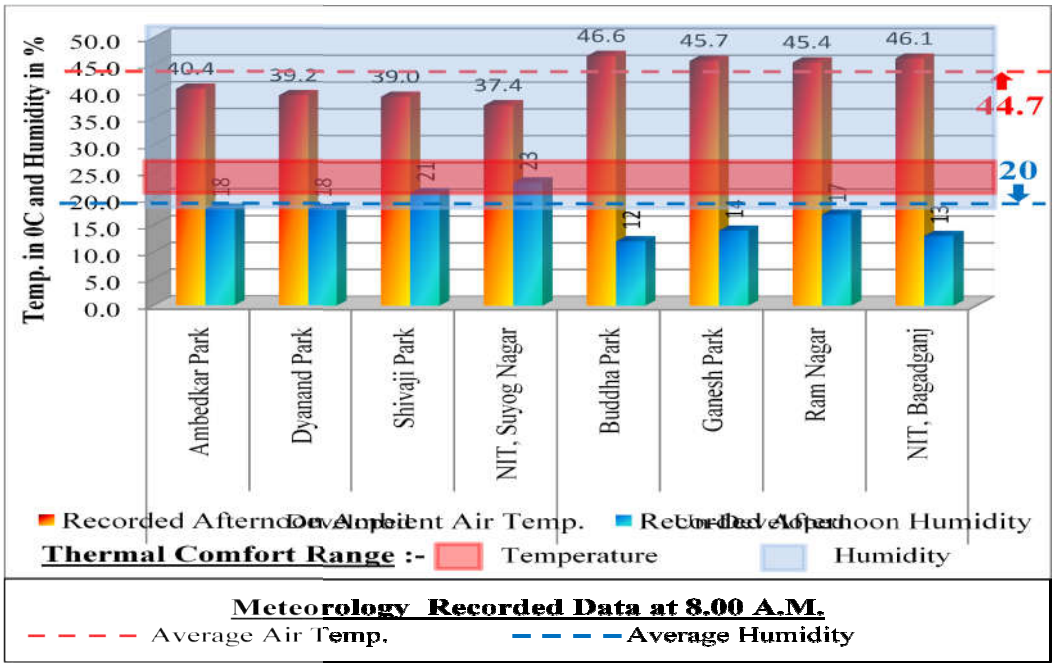

Figure 12. Graphical analysis for summer afternoon

Table 13. Data for summer evening

Study Area	Developed				Un-Developed			
	Ambedkar Park	Dyanand Park	Shivaji Park	NIT Park, Suyog	Buddha Park	Ganesh Park	Ram Nagar	NIT Park Bagadganj
Recorded Morning Ambient Air Temp.	34.0	31.6	30.1	28.2	37.9	37.3	37.1	37.5
Recorded Morning Humidity	39	42	46	49	24	26	27	25

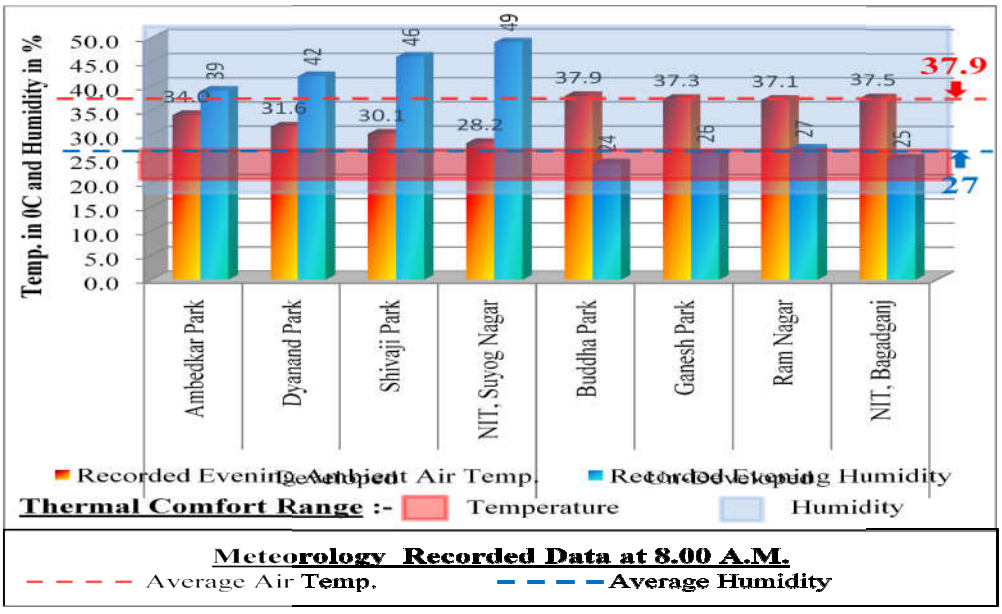

Figure 13. Graphical analysis for summer evening

Observations & Analysis

From Table 12 and Fig. 12, it is observed that in developed parks the temperatures are far above the comfort range but below the Meteorology recorded data and the humidity is consistently well within the comfort range. Similarly, in un-developed parks the temperatures are far above the comfort range and the Meteorology recorded data but humidity is consistently well within the comfort range. Thus it is observed that in developed parks the temperatures are higher than the comfort range, even though slightly moderated due to shade and moisture but for undeveloped parks the temperature is extremely high as there is no moderation. At the same time the humidity in developed parks is close to the minimum comfort range while the same is consistently below the comfort range in undeveloped parks. As per meteorological data the average temperature in the month of May, 2015 at 8 P.M., is 37.9^0 C and humidity is 27%.

Observations & Analysis

From table 13 and Fig. 13, it is observed that in developed parks the temperatures are slightly above the comfort range but below the Meteorology recorded data and the humidity is consistently well within the comfort range, whereas, in un-developed parks the temperatures are far above the comfort range and nearer to the Meteorology recorded data but humidity is consistently well within the comfort range. Thus it is observed that in developed parks the temperatures are slightly higher than the comfort range during the evening hours whereas in undeveloped parks the temperature is much higher than the comfort range till late in the evening. Conversely the humidity in developed parks is consistently more than the humidity in undeveloped parks but within the comfort range.

Conclusion

The study suggests that in developed parks the temperatures are just above the comfort range during morning hours, whereas in undeveloped parks, the temperatures are much higher than the comfort range. Similarly, the humidity in developed parks is consistently well within the comfort range, while in the undeveloped parks it is close to the lower limit. Similarly, during noon hours, in developed parks the temperatures are higher than the comfort range, even though slightly moderated due to shade and moisture, whereas in undeveloped parks the temperature is extremely high as there is no moderation. At the same time the humidity in developed parks is close to the minimum comfort range while the same is consistently below the comfort range in undeveloped parks. Similarly, in developed parks the temperatures are slightly higher than the comfort range during the evening hours whereas in undeveloped parks the temperatures are much higher than the comfort range till late in the evening. Conversely the humidity in developed parks is consistently more than the humidity in the undeveloped parks but within the comfort range. Developed Open Spaces (Parks) with vegetation have the cooling effect during the morning hours of the day and have a positive effect on human comfort, whereas in undeveloped parks with sparse vegetation have created discomfort. In case of Developed Parks, Parks with more percentage of hard surface area are found to be warmer than the other parks with comparatively less percentage of hard surface area, especially throughout the day, and have a negative effect on human comfort. There is a direct correlation is evident from the above observations and analysis that as the soft surface (vegetation) area increases the temperature decreases which creates thermal comfort.

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