Assessing Thermal Effectiveness of Attached Green Terraces in Urban Areas of Pune City

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Abstract:- With increasing global warming it is essential to find out solutions for reducing the overall load on non-renewable energy productions. This paper discussed in detail how we can reduce thermal (heat) effect by terrace plantation. It is Observed that we can reduced up to 1.9°C with planting one layer of shrubs or pot plantation. We can increase this cooing with more number of such plantations. The Plot plantation gave the flexibility in design on attached terrace and it does not require any additional waterproofing. We can save structural load with the pot plantation. The passive techniques like green roofs used to reduce the inside room temperature. The primary data collected from 3 different parts of Pune city viz. Warje, Pimple Gurav and Talegaon Dabhade in the peak hours of the day (12.00 noon to 4.00 pm). The size of the terrce gardens are near about same 6.6 sq m. and the orientation is south to south west of the terraces. Flowering plants like Tabernaemontana divaricata, Hibiscus rosa-sinensi, Tulsi (Holy Basil)are some of the common plants founded in the attached terraces. The Attached terraces can also be considered for kitchen gardening.

Keywords:- Thermal, attached Terrace, Green roof, Urban, Orientation

1. INTRODUCTION

Since the start of the human development, the only thing remain constant is change. Humans keep on developing on all fronts including political, social, science, economics etc. Human life style also keeps on changing along with these. We have adopted inventions and technologies to suit our lifestyle. We started from nature and kept challenging the nature for our developments. We have been using nature and natural resources for our benefits, extensively.

Every action has equal and opposite reaction and we are facing all the side effects of our so-called developments. Global warming is one of the side-effects we are facing in our life. Especially in urban areas, the problem of increase in heat is becoming profoundly serious. The only way to tackle this problem is we should get back to the nature. What we have taken from the nature we should give it back. To develop the urban areas, we have chosen deforestation. Now it's time to plant more trees in the urban pockets. This paper is aiming to check the thermal effectiveness of balconies and terraces in urban areas. For this purpose, I have randomly selected balconies or terraces with plantation and without plantation which at which has similar physical context.

1.1 Background, Need and Significance

Recently the entire world experienced the problem like coal crises. Some parts of the world went in black outs for couple of weeks to a month due to no electricity productions. Today the coal accounts for 70% energy generations in India[i}. This is a high time to take a serious note of this and find out passive techniques to reduce the power demand from non-renewable energy production. This paper discussed how we can reduce the temperature by planning trees on the attached terraces, which leads to reduce the inside room temperature caused due to conduction from sun rays.

1.2 Aim and Objectives

1.2.1. Aim

To check the thermal effectiveness with and without plantation in attached Terraces in urban context.

1.2.2. Objectives

To identify attached terraces in an urban area with and without plantation in similar physical context.

To measure the temperatures ofselected attached terraces during the peak hoursof the day.

1.3 Scope and Limitations

This research paper is part of the academic study of SPPU[ii], Pune University so, there is a time constrain for this study. Normally in Pune (Maharashtra) the peak temperature months are April and May, of the year. This study is carried out during the Month of October - November as a part of winter semester.

The scope of Data collection is limited to seven days of the week at three different apartments in the same locality of the Pune so that all the other aspects of the locality would remain same.

The attached Terraces / balconies chosen are from fifth floor to ninth floor of ten story buildings.

The building envelope receives direct radiation from the sun in following manner

North Side - receives only little direct radiation only in summer mornings and evenings

East and west facades - receives high radiations in summer and winters

South Facades - Highly exposed in winter

Horizontal Surfaces receives highest intensity of radiations all the time

Only horizontal surfaces are considered.

Literature Review

Assessment of Terrace Gardens as Modifiers of Building Microclimate [iii] - Authors are Chitra Chidambaram, Surabhi S. Nath, Pranjali Varshney Sakshi Kumar. They have studied roof top terrace gardens of residential buildings. They found that in summer the temperature difference was 5-10 °C and in winter it is 2-3°C as a result. They carried this study over a span of fifteen months. They selected fifteen square meter terraces for their study. Survey data on home gardeners and urban Gardening practice in Pune, India[iv]

This article provides quantitative data from a questionnaire survey on gardening practice among home gardeners in Pune, information includes growing decisions and food production, fertilization, treatment of pests or irrigation as well as the cultural and recreational use of the garden. This survey also covered socio demographic background information on the respondents and their gardening motivations. The data were used for a research.Article to build indicators for economic, environmental and socio cultural sustainability dimensions of urban agriculture and analyze gardeners' characteristics that lead to increased sustainability outcomes entitled “Home Gardening Practice in Pune (India), the Role of Communities, Urban Environment and the Contribution to Urban Sustainability” K value = Thermal conductivity, n: the time rate of steady state heat flow through a unit area of a homogeneous material induced by a unit temperature gradient in a direction perpendicular to that unit area.

U-value = is the rate of transfer of heat through a structure

1. Methods and Methodology

Identify attached terraces / Balconies which has similar physical context (Orientation, Area, depth, plantation, material)

Measure the temperature of the selected attached terraces at three different parts during the Peak temperature hours of the day. Collect the data for seven continues days. Prepare comparative analysis / graphs / from the collected data Write down observations and inferences at the end come to a conclusions.

2. Data Collection and Analysis

For the study purpose the samples are located from three different areas in Pune. Pimple Gurav, Tlegaon andWarje. Total six samples are selected two in each location to collect the data.

T1 and T2 are from Pimple Gurav. T3 and T4 are from Talegaon Dabhade T5 and T6 are from Warje

All the terraces are from eight floor of nine floor residential building. Orientation - South to South West. Data collected on 14 Nov 2021 to 20 Nov 2021. Time chosen for the data recording is 12.00 noon, 2.00 pm and 4.00 pm. The average Terrace Areas are approximately 2.4m x 2.75m. Number of plants on each terrace are 10. Average diameter of the pot is 18”. All the terraces have Antiskid ceramic tiles.For Recording the temperature the instrument used is Compact infrared thermometer with duel laser targeting (Metravi_MT-4). All temperatures are in Degree Calicoes (°C)Three locations on the terrace have been chosen like L1(left), L2(middle) and L3(right).

Pimple Gurav (PG) - T1 : Terrace 1, T2 : Terrace 2,
Talegaon (TAL) - T3 : Terrace T3, T4 : Terrace T4,
Warje (WJ) - T5 : Terrace T5, T6 : Terrace T6

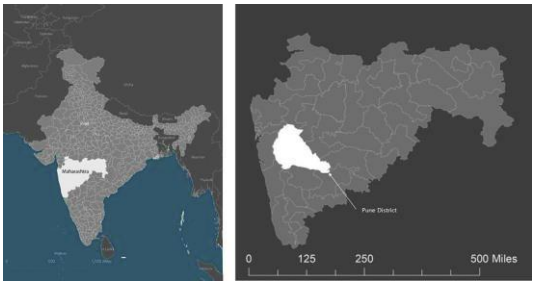


Table 1: Pimple Gurav (PG), Terrace with No Plants

PG	12.00 PM			2.00 PM			4.00 PM		
T1	L1 (°C)	L2(°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)
S	29.8	29	28.9	31	30.9	30.2	30.9	30.2	29.8
M	29.8	29	28.9	31	30.9	30.2	30.9	30.2	29.8
T	28.7	28.1	27.8	31	30.7	30.3	30.8	30.3	29.5
W	27.5	27.3	27	28	27.9	27.7	27.8	27.3	27
T	28.2	28	27.9	31.9	31.3	30.2	28.5	28.1	27.8
F	28.9	28.1	27.7	29.9	29.7	28.8	31	30.9	30.2
S	28.8	28.7	28.5	28.8	28.7	28.4	29.8	29.5	28.8
AVG	**28.81**	**28.31**	**28.1**	**30.23**	**30.01**	**29.4**	**29.96**	**29.5**	**28.99**
AVG	**28.41**			**29.88**			**29.48**		

Table 2: Pimple Gurav (PG), Terrace with Plants

PG	12.00 PM			2.00 PM			4.00 PM		
T2	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)
S	28.5	27.9	27	29	30	29.2	28.1	29.2	28.7
M	28.4	28	27	29	29.2	29.1	28.5	28	28.1
T	27.2	27	26.1	29.1	29.1	29.1	28.4	28.2	26.1
W	26.6	26	25.9	26.9	26.2	26.2	26.1	26.2	26.5
T	27.7	26.8	26.1	29.5	30	28.9	27.2	26.9	29.1
F	27.5	26.9	26.2	28.2	27.4	27.3	28.7	28.2	29.9
S	27.4	27.2	27.5	27.9	26.8	27.5	28.5	28.2	27.8
AVG	**27.61**	**27.11**	**26.54**	**28.51**	**28.39**	**28.19**	**27.93**	**27.84**	**28.03**
AVG	**27.09**			**28.36**			**27.93**		

Table 3: Talegaon, (TAL)Terrace with No Plants

TAL	12.00 PM			2.00 PM			4.00 PM		
T3	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)
S	29.8	29.3	28.9	30.9	30.2	30	30	29.8	29.7
M	29.7	29.3	28.8	31	30.8	30.2	31.1	30.9	30.5
T	29	28.9	28.7	31	30.8	30.2	31.1	30.7	30.4
W	27.9	27.3	27.2	29	28.8	28.5	27.9	27.3	27.2
T	28.9	28.7	28.2	30	30	29.8	28.9	28.5	28.1
F	29	28.9	28.7	29.8	29.9	29.5	29	29.5	28.8
S	28	27.9	27.5	28.2	28.5	28	27	27.4	27.1
AVG	**28.90**	**28.61**	28.29	29.99	29.86	29.46	29.29	29.16	28.83
AVG	28.60			29.77			29.09		

Table 4: Talegaon, (TAL) Terrace with Plants

TAL	12.00 PM			2.00 PM			4.00 PM		
T4	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)
S	27.4	27.8	27.1	29.1	28.8	28.7	28.9	27.4	27.7
M	27.6	27.4	27.2	29.9	29.2	28.9	29.9	28.5	28.2
T	27.2	26.9	27.1	29.9	29.1	28.9	29.5	28.4	28
W	25.1	25.8	25.3	27	26.9	26.4	26.1	26	26
T	27.1	27.5	26.9	28.9	28.8	28.2	27.2	27	26.8
F	26.9	27	27.2	27.1	27.4	27.6	27	26.9	26
S	25.5	25.1	25	26.1	26.6	26	25	25.4	25.1
AVG	**26.69**	**26.79**	26.54	28.29	28.11	27.81	27.66	27.09	26.83
AVG	26.67			28.07			27.19		

Table 5: Warje (WJ) Terrace with no Plants

WJ	12.00 PM			2.00 PM			4.00 PM		
T5	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)
S	29	28.9	28.2	31	31.2	30.8	30	30.7	30.2
M	29	28.9	28.2	31	31.2	30.8	30	30.7	30.2
T	28	27.9	27.5	31	31.4	30.8	30	30.9	29.9
W	27	27.1	26.8	28	28.9	28.5	27	28.1	27.9
T	28	27.3	26.8	30	30.9	30.1	27	28	27.9
F	28	27.3	26.4	30	30.7	30.2	28	29.1	28.7
S	28	27.5	27.1	28	29.2	28.8	27	28.3	28.1
AVG	**28.14**	**27.84**	27.29	29.86	30.50	30.00	28.43	29.40	28.99
AVG	27.76			30.12			28.94		

Table 6: Warje (WJ) Terrace with Plants

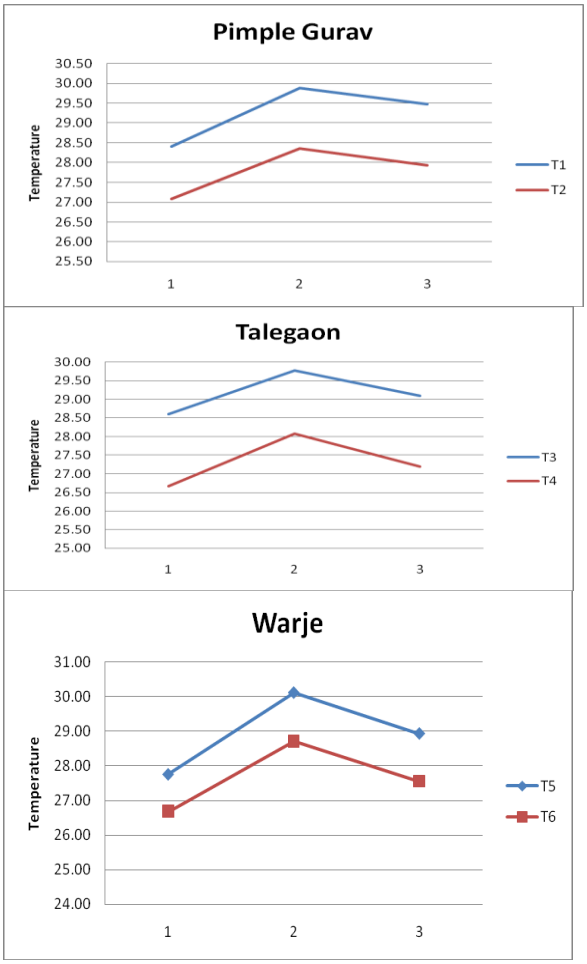
WJ	12.00 PM			2.00 PM			4.00 PM		
T5	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)	L1 (°C)	L2 (°C)	L3 (°C)
S	28.5	27.9	27.4	29.9	30.1	29.8	29.1	29.4	29
M	28.5	27.9	27.4	29.9	30.1	29.8	29.1	29.4	29
T	26.9	26.9	27	29.8	29.9	29	28.8	28.9	28.7
W	25.9	26	25.1	26.5	26.7	26.4	25.8	26.9	26.2
T	26.9	26.8	25.1	28.9	29.2	29	25.9	27.1	27
F	26.9	26.1	25.7	28.8	28.5	28.9	26.9	27.1	27.2
S	25.9	25.9	25.5	26.9	27.5	27.4	25.6	25.9	25.5
AVG	**27.07**	**26.79**	**26.17**	**28.67**	**28.86**	**28.61**	**27.31**	**27.81**	**27.51**
AVG	26.68			28.71			27.55		

Table 7: All terraces Comparison

	12.00	2.00	4.00
T1	28.41°C	29.88°C	29.48°C
T2	27.09°C	28.36°C	27.93°C
T3	28.60°C	29.77°C	29.09°C
T4	26.6°C	28.07°C	27.19°C
T5	27.76°C	30.12°C	28.94°C
T6	26.68°C	28.71°C	27.55°C

Table 8: Difference in Temperature

T1-T2	1.32°C	1.52°C	1.55°C
T3-T4	1.93°C	1.70°C	1.90°C
T5-T6	1.08°C	1.40°C	1.39°C
AVG	**1.44°C**	**1.54°C**	**1.61°C**



Analysis - Difference in temperature ranges from 1.32°C to 1.90°C. South Side exposed (L3) temperature is higher than north side (L1) on the same terrace.

3. KEY FINDINGS

We can reduce the temperature and radiations with the plantation on terraces in an urban pocket.More the plants more will be temperature difference.

4. Conclusions and Recommendations

With more Number of plants on terrace gardens or Green roofs we can observe cooler room temperatures in side. We can save a lot in the electrical energy for cooling the room in a tropical climate like Pune. Saving the electrical energy will automatically reduce the load on electricity generation which has direct impact on reducing global warming.Passive techniques like terrace gardens, Green roofs, vertical gardens are highly

5. SCOPE FOR FURTHER RESEARCH

Microbial Organism technique is the replacement of soil on terrace gardens to reduce the structural load on slab however further research can be done on this material. Soil is a very good thermal insulating material; however it is required to check if we can have same thermal insulating properties of this microbial organism and still contributing lesser structural loads.

ECBC (Energy Conservation Building Code) is ready with the draft[v] (2017) set of rules and regulations for energy efficient buildings. For this purpose we need to calculate the U values of the material. with this research I have calculated the U value for building envelope which should be lower than 0.33 (ECBC prescribed U value) for conduction through roof. While it seems soil would be an effective insulator, it has an R-value of only 0.05 to 1.0 per inch at 20% moisture content, (inspectapedia.com) - which is much less than rigid foam insulations. inspectapedia.com[vi] is Encyclopedia of Building & Environmental Construction, Diagnosis, Maintenance & Repair. A further research can be done on which type of the soil would be effective for reducing the heat conduction. Following table shows the illustration for the same

Table 9. Conduction through roof

Conduction through roof			
		Thickness in Mt./ K value	R-value -W/m2k
1	1		**0.076**
	fo		
2	100 mm soil	0.4	**4.000**
	0.1 of 0.037	0.1	
3	75 mm brick bat	0.075	**0.188**
		0.4	
4	150 mm RRC slab	0.15	**0.104**
		1.44	
6	15 mm int. plaster	0.02	**0.043**
		0.461	
	fi		**0.123**
Total R - value			**4.534**
U value = 1/ R value	1 / 4.534	**0.221**	0.33 - ECBC value

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7. ACKNOWLEDGEMENTS

I wish to show my appreciation for all the faculties of SKNCOA, Pune. Special thanks to Prof. Dr. Avanti Bambawale, Prof. Mukta Kulkarni from SKNCOA, Pune.
I would like Thank to my wife Ms Shruti Kulkarni for helping me recording the temperatures and primary data Collections
Special Thanks for Ar. Milind Deshmukh for helping me recording the temperatures, primary data collections and guiding me for calculating the U value of the soil.

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