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Research Article

Effect of Vegetative Cover on Urban Heat Island Effect

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Abstract: With rapid industrialization and the rise of concrete forests, the effects of climate change have now posed a major challenge to the scientific community. The absorbance of radiation on the surface has incremented over the years with urbanization. The replacement of vegetation by layers of asphalt and concrete has led to changes in the characteristics of the surface like the thermal capacity, heat capacity and albedo. The consequences of which have developed a phenomenon now popularly known as the Urban Heat Island Effect (UHI). In a developing country like India, where the urban growth is in its dormant phase, it is possible to strategize for a climate-sensitive infrastructure. An observational study on the same was carried out in Kharagpur region of West Bengal. The studies revealed that vegetation in the form of grass cover over buildings reduced interior temperatures by 7.68˚C on an average as compared to structures exposed to direct sunlight at <95% relative humidity conditions. This paper therefore provides a possible and sustainable strategy to tackle UHI and to overtake adverse climate changes by a significant factor.
Keywords: Climate change, Environment, Heat island, Sustainability, Urbanization, Vegetation.

INTRODUCTION

For decades, numerous climatologists have discussed and quoted the increasing trends in the levels of CO_2 and CFCs in the atmosphere which essentially leads to global warming. The increase in temperature is now caused not only by the greenhouse gases but also by the contribution of increased heat absorption on the earth's surface due to uprooting of vegetation and poor environmental quality by pollution. We now face a challenge of sustaining our environment. Requirement of urban area expansion has become unavoidable with growth in population. Trend in urban population in India has seen a rise from 78.94 m in 1961 to 377.1 m in 2011 with % urban population as 17.97% to 31.16% respectively [1]. The mentioned figures of population are important because urbanization and the extent of Urban Heat Island Effect (UHI) have a positive correlation based on spatio-temporal data [2]. Therefore, it is extremely significant to carry out more studies on climatic effects in our country. The nature of climate in the sub-tropical regions has received minimal attention in the past [3]. Our climate over the years have reduced human comfort and increased mortality rate. The thermal stress generated possesses adverse effect on human health and thus some action needs to be taken to reduce or terminate it altogether. With global warming forecast to continue into the foreseeable future, heat waves are very likely to increase in both frequency and intensity [4].

The roof top of a building is a very effective place for growing some form of vegetation or in other words-to create a green roof. Rooftop conditions can be challenging for plant survival and growth especially with high light intensity, winds and moisture stress [5]. Also the load created on the roof should be well adjusted so as not to cause any damage to the existing infrastructure. Green grasses are both light weight and easy to maintain in direct high intensity sunlight. In this work, focus on how grasses can contribute in creating a favorable living condition and to improve the scientific understanding of the effect of vegetation on UHI has been studied.

MATERIALS AND METHODS

Experimental setup

Field measurements were carried out on a model covering 1 x 1 m^2 at a height of 0.7 m above ground. The model (Fig. 1) consisted of standard concrete slab similar to the one used for construction of a roof and a layer of 0.6 μm thick polyethylene was used as a top cover.

Fig. 1: Experimental setup: RCC slabs with and without grass covering (left); polyethylene layer and green net as walls for insulation (right)

The sides were properly insulated with heavy rugs and polythene sheet. The slab made from Reinforced Concrete Cement (R.C.C.) was divided into two areas of equal dimensions. One-half of the slab was exposed to direct sunlight and the other was covered with grass (*Cynodon dactylon)* on 0.05 m depth of soil placed over the top polythene layer. The experiment was set to compare the temperature of these sets. The objective was to study how effectively the vegetated area kept the temperature of the slab and therefore the interior temperature in check.

Temperature measurements

The experiments were carried out in Kharagpur region (22.3302˚N, 87.3237˚E) of Paschim Mednipur, West Bengal, India. All parameters were measured and recorded at 30 min intervals over 6 h day time (10:30 A.M. to 4:30 P.M.) for a 5 month period (February to June). Days with zero precipitation and relative humidity < 95% were chosen. The measurements were carried out at the interior as well as exterior environments of the study model created as shown in Fig. 2. For all surface temperature measurements, a type T (copper-constantan) Thermocouple with a sensitivity of 43 µV/°C was used. The ambient temperature was recorded with the help of a standard mercury thermometer. The slab devoid of vegetation was taken as control and the one without control (slab without vegetation) and treated (slab with vegetation). The experiment was continued with three sets of replications and the mean data was calculated.

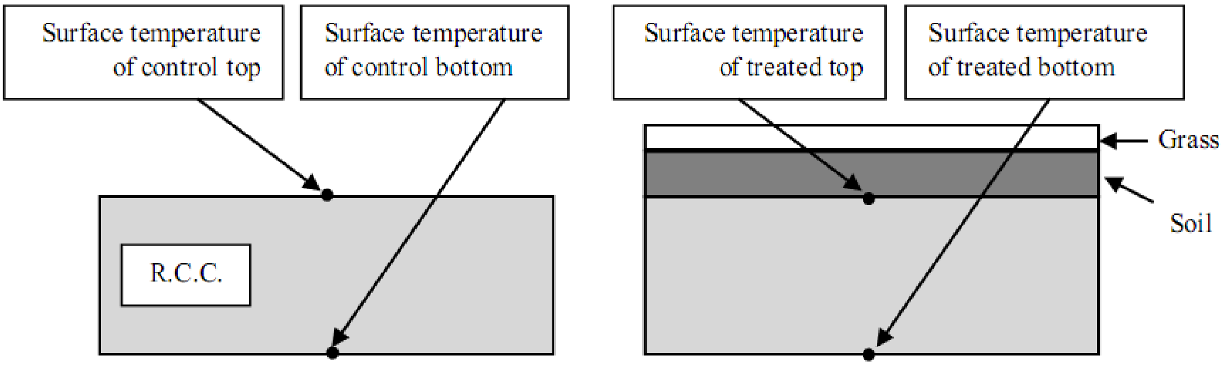

Fig. 2: Schematic showing the points of temperature measurement of the model

Maintenance of vegetative cover

Irrigation was provided 2-4 times during the entire period of study in minimal quantities of 1 L distributed uniformly over the area. This amount was 20-40% of the required water quantity calculated as per soil volume (0.02 m^3), the length, breadth and height for which were 1 m, 0.4 m and 0.05 respectively. The soil type in the current study is sandy loam and the void ratio was taken as 0.5. The base of the soil cover was kept on a polythene sheet to avoid water-slab interactions.

RESULTS AND DISCUSSION

The temperature readings averaged over 3 sets of replications for the entire duration showed that there is a significant temperature difference between the control and treated interior environmental temperatures. The maximum difference was recorded as 9.2˚C. Table 1 represents the month-wise temperature record (best 5 values) for interior conditions of control and treated slabs.

Table 1: Month wise mean temperatures of control and treated slabs

Month	Ambient temperature (˚C)	Control Top (˚C)	Interior temperature (˚C)	
			Control	Treated
February	30.5	40.2	37.2	31.7
March	33.3	44.7	40.2	34.1
April	35.2	47.7	41.0	32.1
May	35.9	51.1	43.3	34.1
June	38.5	51.3	44.6	35.9

The graph for the average month wise temperature difference (treated and control) versus day time over a mean 85% relative humidity was plotted and represented as Fig. 3. A bar graph depicting the month-wise minimum temperature difference observed for the same has also been shown in Fig. 4.

There was a significant reduction in temperature (measured during effective sunshine hours) due to application of grass on rooftop RCC. The purpose of using vegetation was to create a healthy appearance on the rooftop of buildings as well as act as a barrier to direct sunlight on concrete surface thus affecting UHI effects.

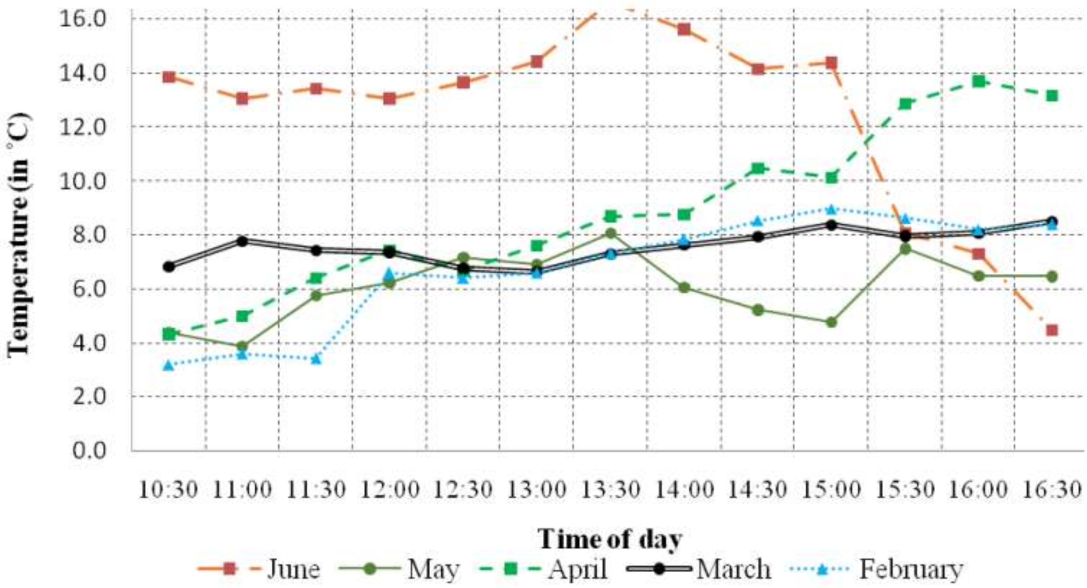

Fig. 3: Interior environment temperature variation with time for control and treated slabs

The lowest differences in temperature with the minimum being 3.2˚C were recorded at the beginning of the observations as the ambient temperature was relatively low but gradually progressed with time and month. Green roof was able to maintain comfortable temperatures within an infrastructure even when the surface temperature went as high as 55.7˚C. A dip in temperature difference was recorded in the month of June as the relative humidity approached 95% along with cloudy weather. The fluctuation in temperature difference of control base and treated base (Fig. 4) were significantly high which in this study has been considered > 2˚C which can create a huge impact in the terms of energy conservation during household cooling using air conditioners.

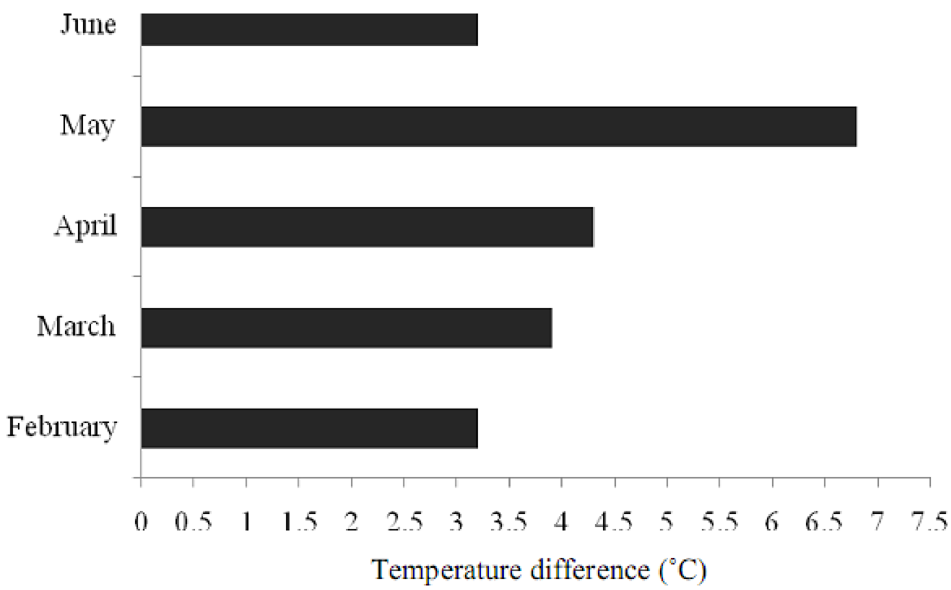

Fig. 4: Month-wise minimum temperature difference

CONCLUSION

Green roofs provide an environmental friendly method in micro managing temperatures in human habitat. It enriches our ecological environment as well as reduces energy consumption by plummeting room temperatures. The heat absorbance by the growing urban structures can hence be prevented if vegetative development is promoted on their rooftops. Also, lower use of air conditioning systems will lead to lower environmental heating thereby affecting abrupt climate change scenarios. Green roof technology needs higher attention and further research and promotion to utilize it needs to be done among the masses.

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