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EFFECT OF THE GREEN WALL ON INDOOR AIR QUALITY

Ar. Ms. Prajwal Jayawant Patil
Assistant Professor
Department of Architecture,
Bharati Vidyapeeth College of Architecture, Navi Mumbai, India

ABSTRACT: A Green wall is defined as vertical vegetation grown on a separate structural system in an organized manner, attached to a framework. In urban areas due to sealed buildings and changes in the composition of building materials, heat is trapped in the indoor space which causes uncomfortable conditions for occupants. To reduce the adverse effect of heat traps, the green wall is considered an innovation to improve IAQ. The study aimed to check the effect of the green wall on indoor air quality (IAQ) in a controlled space in the warm & humid climate of Thane, India. The experiment was conducted by taking 48-hours of readings in the summer of May 2017. Primary data collection included two parameters; dry bulb temperature (DBT) and relative humidity (RH). Secondary data collection was obtained from the national building code of India (NBC) – 2016 and the American society of heating, refrigerating, and air-conditioning engineers (ASHRAE) 62.1–2004. Results witnessed that with the green wall the DBT is reduced by 3ºC and RH is increased by 4% as compared to without it.

***Index Terms* - Green wall, Indoor Air Quality (IAQ), Controlled space, Pothos-Indoor plants.**

I. INTRODUCTION

In today's scenario, most of us spend maximum time in closed indoor spaces. ISHRAE holds the view that most common IAQ problems are caused by inadequate ventilation [1]. Indoor plants help to regulate microclimate and improve IAQ. A Green wall is considered a unique solution where the horizontal plantation is not possible.

The Indian Meteorological Department (IMD) mentioned that Thane is located at an elevation of 24 meters above mean sea level. It has a maximum 36ºC DBT in April and May while minimum of 19ºC in January and February. RH ranges from 50 to 70%. Annual rainfall is about 2300mm..

The experimental setup was designed in a controlled space of a residential building in Thane, Maharashtra. The building is oriented in a North-South direction. The size of the room was 84 sq. ft. with a volume of 252 Cu. ft. The window to wall ratio (WWR) in the South direction is 7% and in the East direction is 3%. Windows having horizontal shading devices with effective SHGC of glass is 0.32. Passive design strategies used are North-South orientation of the building, horizontal shading devices, heat reflective china mosaic tiles on the terrace, and appropriate SHGC of glass.

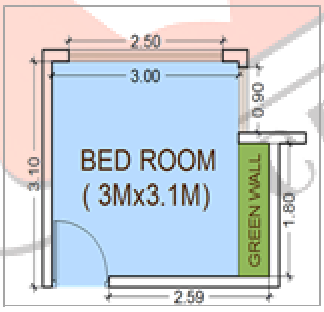

Figure-1.plan of experimental setup 2.planter box

Figure-3 schematic view of experimental setup of Green wall with a pothos plant

II. GREEN WALL

The Green wall-Planter Box system is selected for the experiment. It is defined as a substrate (soil and minerals) packed directly into an empty container. The containers are connected and anchored to a structurally secure metal framework. Individual growing containers can be removed for maintenance.

For the preparation of The Green wall, metal wire mesh of size 6feet X 7feet was installed in a controlled space. Sixty-five planter boxes were hanged to the metal wire mesh. The Green wall was having an area of 30 sq. ft. with a volume of 45 Cu. ft. Figure-3 shows the schematic view of the experimental setup of The Green wall with the Pothos plant used for the experimental setup.

III. INDOOR PLANTS

A significant study conducted by NASA and Associated Landscape Contractors of America (ALCA) in the 1980s showed that indoor plants can help to purify indoor air by photosynthesis & phytoremediation. As suggested by NASA to improve IAQ, the Epipremnum aureus (Golden Pothos) plant was selected for the experiment.

The Golden Pothos plant is from the family Araceae. Some of these plants are semi-shaded or fully-shaded which can be efficient in low natural light as well as in artificial light. It is composed of mat glossy, light green colour leaves which are heart-shaped and taper to a sharp point. It is a fast-growing plant and requires less maintenance. It is resistant to insect infection [2].

IV. INDOOR AIR QUALITY STANDARDS

IAQ is defined as conditioned air in a habitable space that is comfortable for human activities. It is affected by various thermal parameters such as temperature and humidity.

4.1 Dry bulb temperature (DBT)

The ASHRAE-55 2010 standard states that thermal comfort is defined as a condition of mind which expresses satisfaction with the thermal environment. It is also termed an absence of discomfort. It depends upon various environmental factors such as air temperature, humidity, air movement, and radiation. It is the theory that suggests a human body's connection to the outdoor and control over the immediate environment allow them to adopt a wider temperature range of 22°C to 28°C which is generally termed as comfortable [3].

The Bureau of Indian Standard (BIS) 2016 defines Thermal comfort as the condition of a thermal environment under which a person can maintain a body heat balance at normal body temperature and without perceptible sweating [5]. The National Building Code (NBC) 2016 recommends a thermal comfort range of DBT, between 17°C to 32°C for residences and offices [4].

4.2 Relative Humidity (RH)

RH is defined as the amount of moisture present in the air. RH is the ratio of the density of the water vapour present in the air, to the saturation pressure of water vapour at the same temperature and the same total pressure. The standard by ASHRAE-62.1 2004 states that in occupied space, RH should be limited to 65% or less for warm and humid climates [6].

V. THERMAL COMFORT MONITORING INSTRUMENT

.The automatic instrument is used for measuring thermal comfort parameters. It is a monitoring technology and analytical framework based on globally recognized ASHRAE standards.

Figure-4 thermal comfort monitoring instrument

Table 1: The range of instrument sensors

THERMAL COMFORT		
Parameter	Details	Sensor Range
Temperature	Air Temperature (Dry Bulb)	-10°c –50°c
Humidity	Relative Humidity	0-100% Rh

VI. PHOTOSYNTHESIS IN PLANTS

Photosynthesis is the process in which light energy is converted to chemical energy in the form of sugar. In the presence of sunlight, glucose molecules are formed from water and carbon dioxide, and as a by-product, oxygen and water are released.

In chemical terms, photosynthesis is a light-energized oxidation-reduction process. In the photosynthesis of plants, the energy of sunlight is used for the oxidation of water (H_2O), producing oxygen (O_2), hydrogen ions (H+), and electrons.

VII. RESEARCH METHODOLOGY

The study was conducted by experimental method. Two parameters (DBT and RH) were selected to check the effect on IAQ. The instrument was calibrated and tested to generate accurate readings. The instrument was installed in a controlled space. The study adopted the observation and instrumentation method. The readings were taken for forty-eight hours in the peak summer of May 2017.

Planter box type of the Green wall was selected to perform in an experiment. For the preparation of the Green wall, metal wire mesh of size 6ft X 7ft was installed at the experimental setup. Sixty-five planter boxes were hanged to a wire mesh. The green wall was having an area of 30 sq.ft. with a volume of 45 Cu. ft.

Epipremnum aureus (Golden Pothos) plant was selected for the experiment. Before commencement of an experimental setup, the watering of plants was done at the interval of twenty-four hours. Before starting the experiment two hours interval period was allowed to eliminate fluctuation in the readings.

The readings obtained from the instrument were compared with NBC 2016 and ASHRAE-62.1 2004 standards to check the effectiveness of the Green wall.

The following two cases were considered:

Case A - Without a Green wall
Case B - Green wall with Pothos plant

Figure-5 process of experimental setup
Case (A) – without the green wall

Figure-5 process of experimental setup
Case (B) - green wall with pothos a plant

Figure-6 The monitoring instrument

Figure-7 The pothos planter boxes

VIII. RESULTS AND DISCUSSIONS

The observations below are of volume ratio of 1:16 of the Green wall to a controlled space.
Plants undergo the Photosynthesis process, producing oxygen and water. As a result, DBT is reduced by increasing the RH of the Controlled space.

7.1 DRY BULB TEMPERATURE

DBT was measured to check the effect of the Green Wall in a controlled space. DBT of a controlled space was 35°C without the Green Wall. It was observed that DBT was reduced by 2°C with the Green wall as compared to without it as shown in figure-8.
The Green wall witnessed a reduction in DBT up to 32°C which was found to be within the thermal comfort standard range from the National building code (NBC) 2016 for naturally ventilated space.

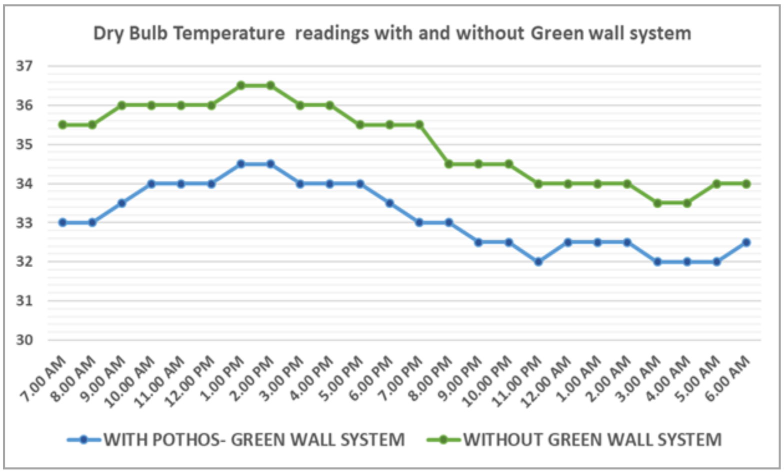

Figure-8 DBT readings with and without Green wall

DBT was analyzed by comparing maximum, average, and minimum values. Without the Green wall, the maximum DBT of a controlled space was 37°C. It was observed that with the Green wall, maximum DBT was reduced by 3°C as shown in figure-9.

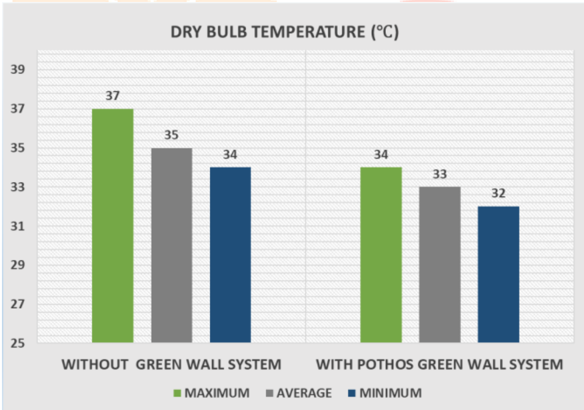

Figure-9 DBT maximum, average and minimum values

7.2 HUMIDITY (RH)

RH was measured to check the effect of the Green Wall in a controlled space. Without the Green Wall RH of a controlled space was 60%. It was observed that RH increased by 4% with the Green wall as compared to without it as shown in figure-10.
The Green wall witnessed an increase in RH up to 64% which was found to be within the standard limit given by ASHRAE 62.1 2004 in occupied spaces for warm and humid climates.

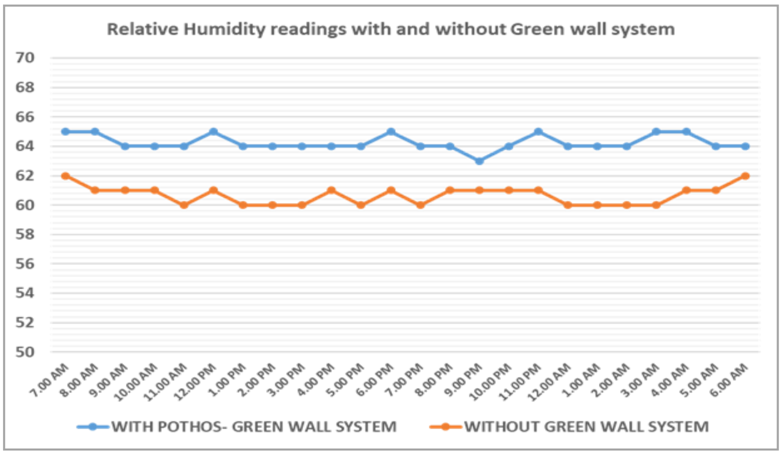

Figure-10 RH readings with and without green wall

RH was analyzed by comparing maximum and average and minimum values. Without the Green wall maximum RH of a controlled space was 61%. It was observed that with Green wall, maximum RH was increased by 5% as shown in figure-11.

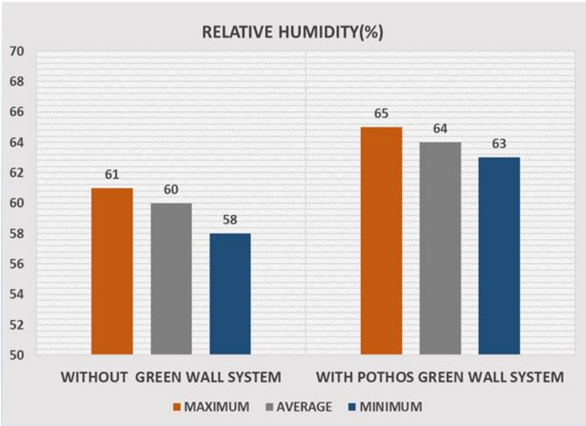

Figure-11 RH maximum, average and minimum value

IX. CONCLUSION

The Green wall showed a reduction in DBT up to 32°C which was found to be within the thermal comfort standard range from NBC 2016. As a result, The Green wall with the Pothos plant was effective in improving the DBT of controlled space in a warm and humid climate.

The Green wall witnessed an increase in RH up to 64% which was found to be within the standard limit given by ASHRAE 62.1 2004 for warm and humid climates.

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