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A Review of Thermal, Acoustical and Daylight Performance of Greenery Systems in the Realm of Green Building

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Greenery systems (for instance, green wall, green roof, etc.) for buildings remained much unexplored in the realm of green building concept, especially in the densely built-up areas of inner cities. Greenery systems concentrate on one key aspect of the greening process: the use of plants on and around buildings. It goes without saying that this can only be part of any overall greening strategy. There are many benefits of greenery systems for buildings, for instance, energy savings, biodiversity support, absorbing pollutants, storm-water control, noise mitigation, and improving the local climate. However, despite these benefits relatively little research has been made on this valuable opportunity.

This research paper concentrates greenery systems and its effect on thermal, acoustical and daylight performance in an indoor and built environment. The paper concludes that the greenery systems have significant potential as a tool to make building design a green building.

***Keywords*:** Green Building, Heating-Cooling, Acoustics and Daylight Performance, Vertical greenery systems

1. Introduction

Greenery system can be developed along various spaces of the building, that is; courtyards, terraces, balconies and so on. There are different types and typologies of greenery systems (refer Figure 1) for building; therefore, available data in this regards is scattered and spare. A systematic literature review is implemented to gather knowledge about the greenery systems and its contribution to the sustainable designing of the building specifically for heating, cooling, acoustics and daylight performance.

As noted by Chen Wang greenery systems has evolved from gardening, aesthetic design, or artistic expression, providing fashion function for the built environment (1). Advantages and disadvantages of green walls depend on many factors, for instance, installation methods, layout plans (location), types, etc. Some studies have also shown that the greenery systems in workspaces, industry, and interaction with plants may change human attitudes, behaviours; improve productivity and the overall well-being (2) (3).

Researchers used various methods in the evaluation of the effectiveness of the green walls. These methods include qualitative (questionnaire survey of the occupants) and quantitative approaches. Greenery systems evaluations include both indoor as well as outdoor built environments.

Research on green walls in an indoor built environment revealed aesthetic as a top benefit whereas fewer benefits towards noise reduction as an effective function of it. On the contrary, research on green walls on the outdoor surfaces revealed significant benefits of both aesthetics and noise reduction (4). The greenery system could improve air quality by filtering contaminants from different pollutants in both indoor and outdoor built environments.

Type	Plants for the greenery system	Growing media for the greenery system	Construction type required for the greenery system	Example of the greenery system
Wall-climbing greenery system	Climbing plants	Soil on the ground or in planted box	Minimal supporting structure is needed	
Hanging-down greenery system	Plants with long hanging-down stem	Soil in planted box on every story	Planted boxes and supporting structure should be built at according storey	
Module greenery system	Short plants	Lightweight panel of growing media (such as compressed peat moss)	Supporting structure for hanging or placing modules should be built on facades	

Figure 1: Outdoor Greenery Systems Type and Methods

2. Thermal Performance of the Greenery Systems in the Built Environment

Varieties of heating and cooling systems are explored in the green building design to satisfy the thermal comfort requirements of building occupants. The interaction of the heating system with the fabric of the building is critical to the comfort achieved and the energy efficient operation of the system. Evapotranspiration from the vegetation used in such a greenery system lowers the temperature around the planting environment. Assessments of the thermal performance of an indoor green wall have been observed by several researchers. Thermal performance in an indoor and built environment refers to how well a structure responds to changes in the atmospheric temperature during the daily and seasonal cycles.

Greenery systems influence several environmental parameters and thus also influence the thermal comfort of the occupants. Assessments of the greenery system's thermal performance and its influential responses on environmental factors such as air temperature, relative humidity, air speed, and radiant temperature have been observed by several researchers (5).

Rafael Fernandez-Canero in his research on the cooling potential of the green wall using different substrates (namely, Geotextile, Epiweb, Xaxim, and coconut fiber) in a warm climate monitored several parameters such as temperature, humidity, plant growth or water consumption (5). The research concluded with a significant cooling effect of the green wall with an average reduction of 4°C over the room temperature though maximum decrements of 6°C in warmer conditions. Alongside, higher air humidity levels have been experienced near the green wall, increasing the overall humidity in the observed built environment. Thus, in this research, greenery systems have been proven to be very useful and interesting for warm indoor environments due to

the cooling effect observed in addition to their bio-filtration capacity and the aesthetic component. Similarly, several studies suggested that through evapotranspiration indoor and built environment can control humidity and air cooling is possible.

Greenery systems have been proven very useful for warm, arid and composite climatic regions since the air is protected from radiation and the greenhouse effect.

3. Acoustical Performance of the Greenery Systems in the Built Environment

Greenery systems can reduce sound levels as a passive acoustic insulation system. Sound can be reflected and dispersed by vegetation elements, such as trunks, branches, twigs, and leaves. Another mechanism is 'absorption' by the green wall. This effect can be credited to mechanical vibrations of vegetation elements caused by sound waves. Thus, vegetation converts sound energy to heat. And, sound levels can be reduced by vegetation as a contribution to attenuation by thermo-viscous boundary layer results at vegetation surfaces. Figure 2 shows sound absorption coefficient of greenery systems modules with low, medium and high compactness arrangements.

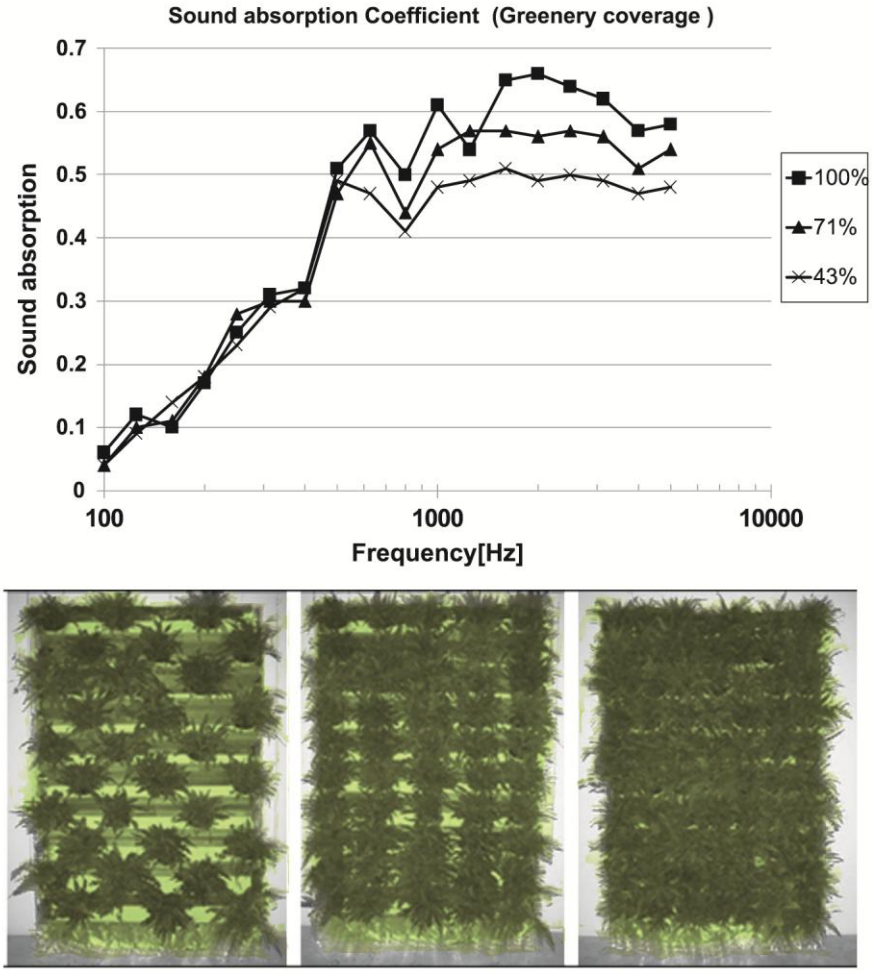

Figure 2: Sound Absorption Coefficient of Greenery Systems Modules with Low, Medium and High Compactness Arrangements.

Some research also noted noise mitigation by greenery systems by the destructive interference of sound waves due to the growth media. Accordingly, there are verities of factors that manipulate noise reduction in greenery systems, such as the depth of the growing medium, the materials used as structural components and the overall surface coverage (4).

3. Daylight performance of the Greenery Systems in the Built Environment

Greenery systems in the indoor built environment not only help screen or reduce the glare of the daylight but also improve indoor air quality. Figure 3 shows how green wall helps reduce glare and the harshness of the daylight into the interior of a building courtyard.

Figure: 3 Green Walls Reducing Glare Effect in the Interior of a Building Courtyard.

The literature review revealed that certain common indoor plants may provide a natural way of removing toxic agents. And, use of indoor greenery systems does not have compulsion on the penetration of daylight in the indoor for the vegetation growth and functioning. There are certain low-light-requiring houseplants with activated carbon filters and potential for improving the air quality of an indoor built environment.

4. Conclusion

Conclusions Greenery systems have been observed to improve occupant comfort, as well as their perception of the quality of their environment, including thermal, acoustics and daylight performance. However, there is scare data and little research done on the greenery systems, and its potential opportunities in the thermal performance, acoustical performance and daylight performance in an indoor and built environment. Further research is required on the greenery systems and its sustainable mechanism to make building design a green building. Detail research is required on plant species, type/ typologies, layout patterns, light source, number of plants, surface area and its effect on the energy performance of the building.

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