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Thermal performance of different planting substrates and irrigation frequencies in extensive tropical rooftop greeneries

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A B S T R A C T

The need for the better use of scarce planetary resources has never been more evident than it is today. However, this need is poorly reflected in human housing. In recent years, there has been a growing realization of the importance of constructing human shelters that better conserve energy and water through appropriate insulation and architectural designs. Among the important advancements in these areas is the use of rooftop greeneries for both energy and water conservation. This paper performs an investigation into this topic within the specific climatic context of tropical regions. Long-term experimental results are provided from a four-floor building in Kaohsiung in the southern part of Taiwan. The study involves a fully monitored extensive rooftop greenery and examines four different plant substrates, three different irrigation regimes, and different types of drought-enduring plants to find the most efficient combination of all three in providing maximum heat insulation and water usage efficiency. The attenuation of solar radiation through the vegetation layer is evaluated, as well as the thermal insulation performance of the rooftop greenery structure. Among the substrates, burned sludge has the best thermal reduction percentage of heat amplitude under the roof slab surface (up to 84.4%). Irrigation twice a week has the best thermal reduction percentage of heat amplitude (91.6%). Among the plant types, *Sansevieria trifasciata* cv. Laurentii Compacta and *Rhoeo spathaceo* cv. Compacta are found to be suitable for extensive rooftop greeneries because they have the best coverage ratio and are most drought enduring.

1. Introduction

The earth's scarce resources are being depleted at an ever-increasing rate. In addition, carbon emissions from the burning of fossil fuels exacerbate global warming. Until recently, little has been accomplished to improve the energy efficiency of buildings in major urban centers. This is especially true in tropical and subtropical locales where intense solar radiation leads to an increase in the thermal load of buildings and to the more frequent use of air conditioning systems. In most cases, building rooftops, which directly experience most of the sun's radiation, are poorly insulated, leading to the direct transfer of heat into buildings.

Roof gardens are built for both their aesthetic and functional values. Aside from providing temperature control, architectural enhancement, hydrological benefits, and food, they can also serve as habitats for wildlife. Roof gardens present a number of advantages. They can cool the rooms below them, especially during hot days. During winter, they provide insulation against cold temperature. In addition, roof gardens prevent the occurrence of flash floods. Carter and Jackson [1] demonstrate watershed areas where green roofs significantly reduce the total impervious area and provide additional stormwater storage. They recommend the "use of vegetative roofs as an abstractive stormwater best management practice in urban watersheds." Friedman [2] suggests that green roofs can control stormwater, replace green spaces lost to construction, improve air quality, extend the life of roof surfaces, and significantly reduce solar heat gain. Coffman [3] confirms that vegetated roof systems can improve the sustainability of a city, but these are reliant on many non-renewable resources for their construction and upkeep. The shallow-substrate ecoroof is the

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