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Modifying the Outdoor Temperature around Single-Family Residences: The influence of landscaping

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Abstract

This paper investigates the effect of vegetation in modifying outdoor temperature around a single-family house in a hot and humid tropical climate. The climatic parameters, house location, and physical characteristics of landscape design are measured and surveyed. The focus of this study is on the potential impact of trees and different types of foliage on the thermal environment of the houses. The main findings are that heavily landscape around single-family houses can potentially slow heat build-up by shading, evapotranspiration, and wind channelling by as much as 4°C.

Keywords: Single-family house; thermal performance; landscape design; evapotranspiration

1. Introduction

In tropical climates, vegetation has significant effects to influence the microclimate. Vegetation cover can influence urban microclimates directly by shading surfaces and channeling wind, and indirectly by evapotranspiration of water (Hashem Akbari, Davis, Dorsano, Huang, & Winnet, 1992; DOE, 1993). The vegetative areas are capable to provide positive impacts on regulating high temperature in urban area (Buyadi, Mohamad, & Misni, 2013). Trees, grass and shrubs will reduce air temperatures near the house and provide evaporative cooling. The type and species of trees used is very important. They should be selected according to the amount of shade they provide as well as their aesthetic appearance. Shrubs and other low growing foliage provide shading during the morning and late afternoon when the sun is low in

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the sky. Shrubs planted close to the house will shade walls and windows. Vines provide a very fast growing source of shade for a building, and they require little space for growth. Shading is the most cost-effective way to reduce solar heat gain. Akbari et al.'s (1986) study in Los Angeles stated that planting trees can save as much as 34% of residential cooling demand on a hot summer day.

In hot and humid tropical climates, wind is an asset which can provide natural ventilation and convective cooling of hot exterior building surfaces. Olgyay (1963) suggests that wind is particularly important for comfort when temperatures are above 29°C and relative humidity above 50%. In these cases, cooling needs are high and landscaping around the buildings should be directed to channelling cooling breezes, and to minimize humidity closest to the house. McPherson, Herrington and Heisler (1988) suggest that in hot and humid climates, high-branching and wide canopy trees and low ground covers should be used to promote shade and encourage wind.

The evapotranspiration process can reduce surrounding air temperatures. Heisler has stated that trees are effective for cooling because they absorb 70–85% of the heat from solar radiation by transpiration (cited in Hashem Akbari et al., 1992). Since leaves are generally dark and coarse and thus reflect very little light, they make ideal solar radiation absorbers and controllers. The leaves have the highest light absorption: about 50% of the total solar energy (Taiz & Zeiger, 2006). DOE (1995) reported that planting three trees per house could reduce heat build-up and the city heat island effect by shading, and evapotranspiration. It would reduce surrounding air temperatures by up to 5°C (DOE, 1995; Foster, 1994). Similarly, groundcover such as grasses or turf also have a cooling effect from evapotranspiration. The temperature above a groundcover can be 10–15°F cooler than above a heat absorbent material (Morgan et al., 2000). Taha (1997) reported that the factors that affect temperature reduction are evaporative cooling and shading of the ground. Careful landscape planning can potentially reduce the amount of sunlight heating building surfaces and can prevent reflected solar radiation from entering the home.

2. Methodology

Research methods in this study were divided into three parts: houses with a surrounding landscape selection, observation, and field measurement for weather data and landscape elements.

2.1. House selection

The aim of houses selection was to identify and choose a similar of building construction, and site location but different in orientation and the amount of landscape structure and design. The particular site studied is in Precinct 14 Putrajaya, Federal Territory Putrajaya, Malaysia. The elevation is of the order of 80m (2°N Latitude, 101°E longitude). Putrajaya is located in the equatorial doldrums area has a hot and humid climate. Putrajaya is the administrative capital was developed as a 'garden city'. The approach of tropical architecture for single-family residence in this area is to conserve as best as possible the natural environment, and allows the building to blend with the existing site characteristics, making its physical presence felt (PJH, 2001). In this context, landscape architecture and design play an important role to provide an exterior and interior space cool and comfortable.

The area of development consists of 27 houses was located in well planned community area which represent around 5% from the residential zone in Precinct 14. This low density development site was surrounded by a wide green open space sited on very gentle slopes and has been planted with grass lawn and rare of immature tropical garden trees. The age of houses is in about three years. The two houses were chosen because of similar criteria; under 5 years' development, medium size of the house, used standard of construction, but different in their landscape treatments and orientation.