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Research Paper

Effects of vertical greenery on mean radiant temperature in the tropical urban environment

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HIGHLIGHTS

- Mean radiant temperature (t_{mrt}) in front of 2 green walls was measured, showing reduction of t_{mrt} for up to 1 m.
- One green wall is removed midway during measurement, resulting in time lag and increase in t_{mrt} of up to 12.8 °C.
- GIS software used to generate t_{mrt} map shows the extent of t_{mrt} reduction due to green wall varies at different times of the day.

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ABSTRACT

Studies on vertical greenery generally focus on the measurement of air temperature, surface temperature and cooling load. There is a lack of information on how vertical greenery can influence outdoor thermal comfort. The objective of this study is to quantify the effects of mean radiant temperature (t_{mrt}), as the first step towards determining the thermal quality of outdoor space due to installation of vertical greenery.

The t_{mrt} of two green walls (Green Wall A and Green Wall B) was measured up to 2 m away at intervals of 0.5 m. Two datasets were obtained, one consisting of t_{mrt}, surface and air temperature collected from the two green walls and the second for just green wall A and the exposed concrete wall after Green Wall B was removed. t_{mrt} was measured using customised globe thermometers calibrated for local use. Data was analysed using a GIS, thus enabling convenient visual comparison between t_{mrt} profiles at different times. The diurnal t_{mrt} profile was altered significantly due to the installation of vertical greenery. When both green walls were present the peak t_{mrt} occurred at 15:00 h, but with more concrete exposed when one wall was removed, the peak occurred at 17:00 h and was 10.9–12.9° higher at 0.5 m away from the wall. Vertical greenery thus helped to reduce t_{mrt} both during the day and at night, to varying extents. The proposed methodology enables systematic quantification of the effects of vertical greenery on t_{mrt}.

1. Introduction

Vegetation can play an important role in the climate of cities as well as the microclimate of buildings. Besides providing a conducive environment for social activity (Gobster, 1998; Maas et al., 2009; Troy & Grove, 2008), promotion of mental health (Grahn & Stigsdotter, 2010; Korpela & Hartig, 1996; Takano, Nakamura & Watanabe, 2002), the introduction of greenery is a useful mitigation strategy in rising temperature due to climate change. For high-density urban environments, greenery can help to cool the air and provide shade. It can also lower a building's energy consumption by providing better outdoor boundary conditions.

Urban greenery can bring about benefits to the microclimate through several physical processes (Wilmers, 1991; Dimoudi & Nikolopoulou, 2003):

- Plant and tree shade can lower the solar heat gain on the building envelope;
- Shading reduces terrestrial radiation due to lower surface temperature; and
- Latent heat of cooling in the atmosphere is increased due to added moisture in the air via plant evapotranspiration.

Numerous studies have validated the cooling effect of urban greenery (Sad de Assis & Barros Frota, 1999; Ca, Asaeda, & Abu,

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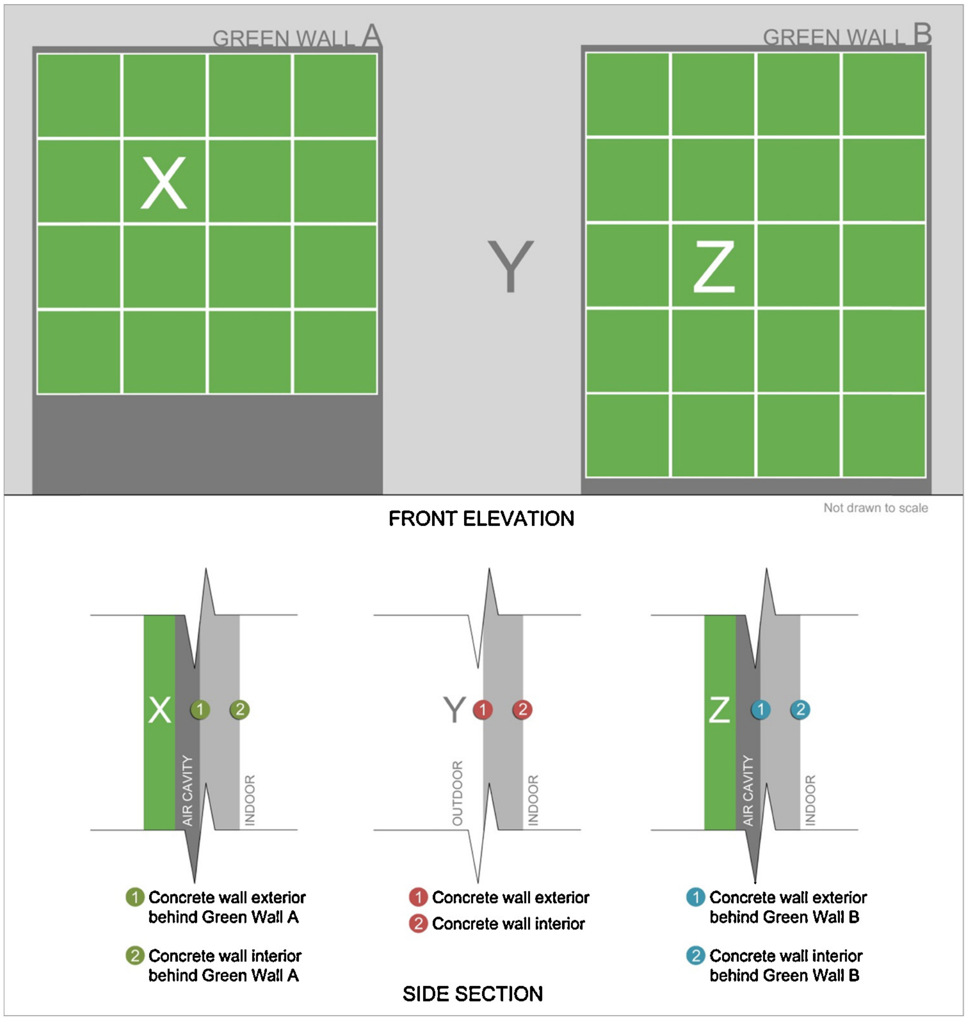

Fig. 1. Surface temperature measurement spots.

Fig. 2. Measurement setup. Globe thermometers were attached to poles with white PVC pipes housing surface and air temperature loggers.