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Alterations in use of space, air quality, temperature and humidity by the presence of vertical greenery system in a building corridor

Aini Jasmin Ghazalli[a,b,*], Cris Brack[a], Xuemei Bai[a], Ismail Said[c]

[a] *Fenner School of Environment and Society, Australian National University, Australia*
[b] *Faculty of Design and Architecture, Universiti Putra Malaysia, Malaysia*
[c] *Faculty of Built Environment, Universiti Teknologi Malaysia, Malaysia*

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ABSTRACT

Urban greenery is valued not only for its aesthetic value but also for environmental services and the overall health benefits that follows. A large portion of the world population now resides in built environments, and there is growing need to provide a conducive and healthy environment for the dwellers. Vertical greenery systems (VGS) provide greenery opportunities in cities even when there is limited land space especially as recent technology enables people to grow plants outdoors as well as indoors. Indoor vertical greenery (iVGS) was installed to monitor any alteration in the temperature, humidity, particulate matter and use of space. The present study used an actual environment, included paralled corridors in the same building. The movement in both corridors were significantly ($p < 0.05$) correlated and post green wall establishment data showed the relationship changed significantly ($r^2 = 0.8748$, $P < 0.0001$, RMSE = 23.4521) with relatively more people using the corridor after the iVGS installed. Significant difference was seen in the humidity levels but not in the temperature after the installation. Particulate matter levels dropped 48.5%, 82.6%, 5.5% (PM2.5, PM10, > PM10 respectively) in the corridor with iVGS by the end of the data collection. These findings suggest larger green coverage would have a greater positive impact on the environmental conditions of an indoor environment.

1. Introduction

Environmental problems affect all living organisms on the planet. Some of the environmental problems that cities residents face are overpopulation, resource depletion, pollution, climate change, and degradation of health. The urban population is continuing to expand with more than 50% of the world's population resides in towns and cities in 2007 (WHO, 2012). The migration of people around the world to urban areas increases demands for space and is resulting in an increase of building density in cities. Despite any increase in density, the living condition in cities must be healthy, safe, conducive and nurturing to ensure sustainable development and social value. Unfortunately, cities can also be a source of health problems (Galea et al., 2005). Although the result of a healthy lifestyle is closely related to choice, the environmental living conditions of our cities are often beyond individual control and can lead to physical and mental health issues.

Health is determined by several interacting factors, including environmental conditions, lifestyle choices and access to health facilities (Brannen et al., 2009) as well as biological factors, gender and social support. For urbanites working in high-rise buildings, the building itself becomes a major determinant of their health condition because building characteristics can influence the indoor environmental conditions. The tightness of a building influences the air exchange, while the ventilation system influences air movement within the building, and the use of furniture and finishes can influence the chemical contents in the air (Ghazalli et al., 2012). Building occupants coming in and out of the building can also influence indoor environmental conditions by opening and closing of doors as well as allowing materials to be brought inside by wind or on clothing and shoes. This further influences the air quality as dust and other chemical compounds that are present outdoors can be brought into closed spaces.

Particulate pollution (solid particles such as dust or liquid droplets) has the potential for serious negative impacts on human health and life quality (Przybysz et al., 2014; Speak et al., 2012; Weber et al., 2014) and urban population may be more generally at risk from particle pollution generated by road dust and vehicle exhaust (Beckett et al., 2000; Dzierzanowski et al., 2011). The size of particulate matter determines its behaviour and toxicity with sizes less than 10 µm in diameter (PM10) found to seriously affect humans while PM2.5 (diameter 2.5 µm and less) has a disproportionately greater impact. Smaller

* Corresponding author at: Building 141, Linnaeus Way, Fenner School of Environment and Society, Australian National University, Canberra ACT 0200, Australia.
E-mail address: u5387345@anu.edu.au (A.J. Ghazalli).

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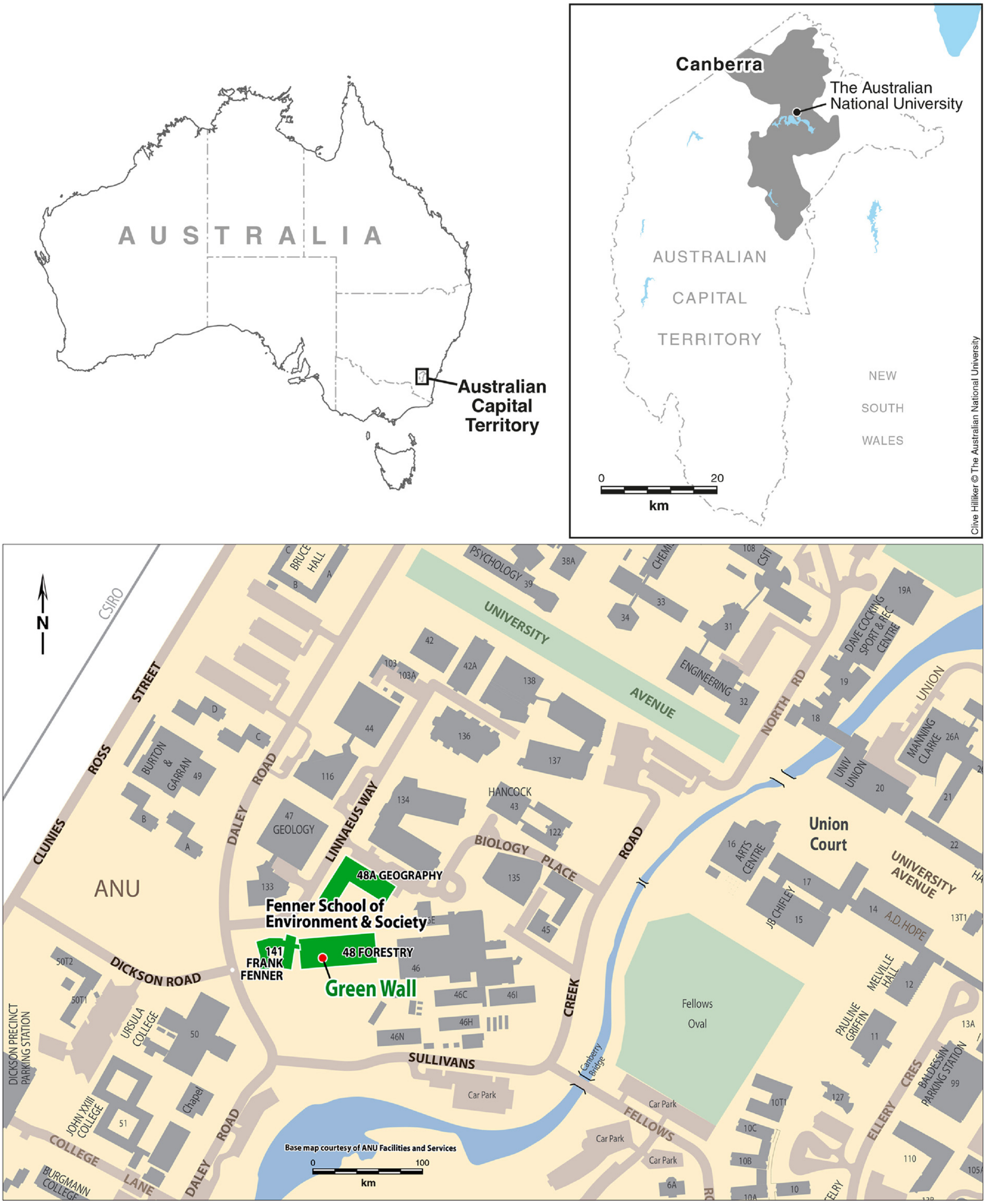

Fig. 1. Location of study building within the university compound.

particles can penetrate deep into the lungs even to alveolar regions (Dzierzanowski et al., 2011; Song et al., 2015; Speak et al., 2012; Wang et al., 2015). High pollutant concentration affects not only health but also the economy as poor health leads to increases in hospital admissions, emergency room visits and absenteeism (Currie and Bass, 2008).

The European Union sets a maximum limit of PM10 concentration to daily average of 50 $\mu g m^{-3}$ and an annual average of 40 $\mu g m^{-3}$ (Dzierzanowski et al., 2011), however a handbook on pollution abatement pointed out health problems can even occur in low particulate levels (World Bank Group, 1998). Personal exposure towards airborne pollutants such as particulate matter differs between individuals. Certain groups are more susceptible and can be affected even at low levels. Previous studies found children to be more vulnerable towards air pollution (Dzierzanowski et al., 2011) with hospitalization rates to be higher due to asthma-related attacks (Currie and Bass, 2008).

Air quality has been a concern in most major cities. Increasing green spaces in cities is one option for improving air quality because it acts as an effective particulate sink (Smith and Staskawicz, 1977). Plant surfaces provide sinks through sedimentation and diffusion (Beckett et al., 1998), while rainfall washes the particulates onto earth. The surface