Ecological Engineering 122 (2018) 69–75

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Short communication

Field evaluation of precipitation interception potential of green façades

A. Tiwary[a,*], K. Godsmark[b], J. Smethurst[c]

[a] Faculty of Engineering and the Environment, Northumbria University, Newcastle upon Tyne, UK
[b] Wood Plc, Canary Wharf, London, E14 5LQ, UK
[c] Faculty of Engineering and Physical Sciences, University of Southampton, SO17 1BJ, UK

ARTICLE INFO

Keywords:
Green façade
Stormwater interception
Sustainable drainage
Vertical greening

ABSTRACT

This paper evaluates the potential of living green façades in intercepting precipitation and delaying 'canopy through-flow' (i.e. total precipitation minus canopy interception). Precipitation interception and delayed through-flow (i.e. discharge) from two visually distinct mixed-species green façade configurations – one, fully-foliated and the other twiggy (respectively as proxies for well-managed and degenerated stands) – were monitored using rain gauges located at their base. The precipitation interception levels for the fully-foliated and the twiggy stands respectively ranged between 54 and 94% and 10–55% of the total precipitation. Regression of the experimental data showed interception volumes were proportional to the ambient precipitation up to a maximum tested event size of 35 mm. The fully-foliated façade gave a delay of at least 30 min from the start of precipitation events to the first measured through-flow, compared to about 15 min for the twiggy façade. This highlights the potential for well-foliated and maintained façades to contribute to reducing peak flows within urban drainage infrastructure, and the importance of façade maintenance in ensuring good interception and delay properties.

1. Introduction

Conventional urban drainage systems are often overwhelmed during adverse hydrological events, as they mainly rely on collection in a singular or a networks of sewer systems (Kew et al., 2014; Nickel et al., 2014). In recent years, the combined use of vertical greening structures and green roofs has been increasingly adopted as "bioclimatic" design to complement (or partially replace) urban grey drainage infrastructure systems (Nickel et al., 2014; Pérez-Urrestarazu et al., 2015). As almost 80% of the existing housing stock in Europe is still expected to be in use in 2050 (Sandberg et al., 2016), building surfaces could be effectively utilised for implementing green infrastructure (GI) stormwater management solutions (Francis and Lorimer, 2011; Kew et al., 2014). Specifically, urban fabric provide a plethora of vertical surfaces such as embankment walls, corridors next to rail and road tracks, building walls, bridges, fences etc.; an early UK estimate from 1980s suggested that approximately one-tenth of urban land surface is made up of vertical walls (Darlington, 1981). This has grown further through regeneration and construction of high-rise buildings in most cities over the last two decades.

Considerable focus has been placed on the role of green roofs in stormwater management in recent past (Köhler, 2008; Li and Babcock, 2014; Stovin et al., 2015; Vergroesen et al., 2010), alongside additional low impact options, including trees, porous pavements, swales, rain gardens and rainwater harvesting (Nickel et al., 2014). However, so far green façade performance has been evaluated as a combined category along with greenroofs (Sinnett et al., 2016). Unlike flat green roofs, which occupy a large horizontal plan area and where flow from precipitation is predominately horizontal (and thus quite slow), green façades occupy a much smaller plan area and flow is mainly vertical (and likely more rapid), which limits their role in direct runoff reduction and delay. Nevertheless, green façades can be effectively combined with greenroofs as part of augmented designs for stormwater management, mainly enhancing rain interception, evapotranspiration, retention within the soil and peak delay etc. (Tiwary et al., 2016).

To date there is little empirical evidence on the potential role of vertical greening systems of different density in building-scale stormwater management under real-world conditions. Previous studies have focused on specific issues: for example, assessing the ability of vertical greening solutions to moderate urban hydrological regimes (Loh, 2008) or simulated retention of roof runoff using a cistern to irrigate the greenwalls (Kew et al., 2014). There is also ambiguity in the extent to which implemented schemes can be deemed sustainable, mainly in terms of the installation of the 'living materials' and the regular maintenance, nutrient and water requirements that are necessary for optimal performance over its lifetime (Perini et al., 2011). Further, the

* Corresponding author.
E-mail address: abhishek.tiwary@northumbria.ac.uk (A. Tiwary).

https://doi.org/10.1016/j.ecoleng.2018.07.026
Received 22 June 2018; Received in revised form 20 July 2018; Accepted 23 July 2018

majority of these studies have a planning focus, supported largely through modelling, and there is still a lack of adequate experimental evidence (Mell, 2016). This work represents the first step trying to experimentally quantify the stormwater management mechanisms of green façades of varying composition under real-world conditions. The paper specifically evaluates the potential of green façades in intercepting precipitation and delaying the vertical discharge from the base of the plant canopy. The monitored and modelled precipitation interception patterns of two visually distinct 'real green façade' configurations are reported – one densely foliated and the other degenerated and twiggy. The implications of the precipitation interception and delay are then discussed in terms of role of green façade systems in building-scale stormwater management.

2. Methodology

2.1. Site description

Two co-located vertical green façades, comprising mixed-species climbing evergreen Common Honeysuckle (*Lonicera Periclymenum*) and Winter Jasmine (*Jasminum Nudiflorum*) of visually distinct vegetation densities, were selected for this study – one, fully-foliated (G1) and the other, predominantly twiggy (G2). Both were about 3 m high, 0.5 m deep and 1.2 m wide, supported by wooden trellis and wire systems (Fig. 1, Planar view), but G1 was denser whereas G2 had several interruptions to its vegetation cover, mainly attributed to the difference in the levels of maintenance. Therefore, the two stands were selected for comparison as proxies for a well-managed and a degenerated stand. No obstacles in the form of guttering and window ledges were present, and thus the site was considered suitable for sampling the reduction in precipitation as a result of only interception by the canopy. The green façades were located on the south facing brick wall of a detached residential property in southern part of UK; the choice of this site ensured a secure location whereby equipment could be left unattended during long unperturbed sampling. Surrounding infrastructure was limited to a garage, positioned approximately 50–60 m south-east of the façades.

2.2. Precipitation interception monitoring

Tipping bucket rain gauges (two Oregon Scientific gauges of the WMR series and one Campbell Scientific ARG100 gauge respectively having collecting funnel areas of approximately 78.5 cm^2 and 500 cm^2) were selected for use in this study due to their following advantages: high accuracy in low to intermediate precipitation events, reliability, and their ability to provide data in a digital format (Stovin et al., 2015; Vasvári, 2005; Vergroesen et al., 2010). The tip size was 0.202 mm of rainfall or 10 ml for the Campbell Scientific gauge, and 1 mm of rainfall or 7.85 ml for the Oregon Scientific gauge.

Canopy through-flow measurements were made for a period of 12 weeks between 18th March and 16th June 2016. The period was free of any storm events with high winds, or freezing and/or snow events that might alter the canopy through-flow behaviour. The Oregon Scientific rain gauges were located beneath the canopy of each of the green façades (Fig. 1, Elevation view), levelled via placement upon a

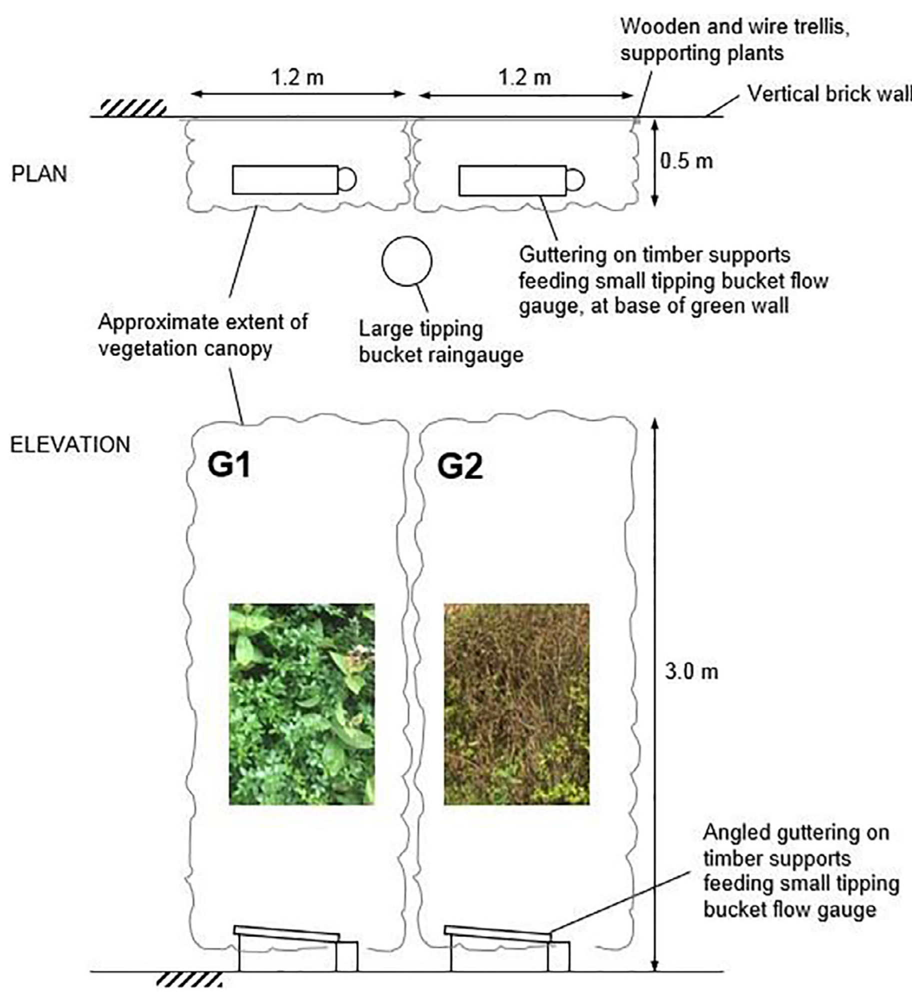

Fig. 1. Schematic showing approximate arrangements (planar views) of the two green façades - densely foliated (G1) degenerated and twiggy (G2); shown alongside the arrangement of the guttering and the tipping bucket rain gauges (elevation views).