POTENTIAL OF STORM WATER CAPACITY USING VEGETATED ROOFS IN MALAYSIA

Sabariah Musa[1] , Nor Aini Mohd Arish @ Arshad[2] , Mas Rahayu Jalil[3],Hartini Kasmin[4], Zarina Ali[5] and Mohd Shukri Mansor[6].
Lecturer[1-5],Graduated student[6],
Department of Water and Environmental Engineering, Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia , 86400 Batu Pahat, Johor, Malaysia

ABSTRACT : Storm water is among the major source of the urban flash floods problem. Roof surfaces account for a large portion of impervious surface in urban area as well pavement surfaces such as road. Establishing roof with vegetation or green roof or vegetated roof can help to mitigating storm water runoff equivalent to the control at point sources . The aim of this study was to obtain the effectiveness of the vegetated roof in reducing the quantity of storm water runoff.. Two models of flat type roof were built in a small scale, one vegetated roof (test) and one non-vegetated roof (control). Flow rate and retention capacity were investigated for both models. The results showed that the vegetated roof model retained 17 % to 48 % storm water runoff from rainfall. Overall, vegetated roof may become an alternative in urban storm water management particularly but with proper design and planning to achieve the benefit efficiently.

KEYWORDS : Green roof, Water quantity, Storm water management, Vegetated roofs.

1. INTRODUCTION

In developing countries such as Malaysia, the level of urbanization is still rising and expected to reach 83% in 2030 [13]. Cropland, grassland and forests are displaced by the impervious surfaces of streets, driveways and buildings greatly intensifying storm water runoff, diminishing groundwater recharge and enhancing stream channel and river erosion [11]. As additional impervious surfaces are created, there is an increase in storm water runoff and anthropogenic pollutants that are responsible for urban aquatic environmental problems [12]. Quantity and quality control at source in urban is one of main approach in stormwater management [14]. A stormwater management program consists of structural and non structural stormwater controls [12].

In urban, space is limited and full with the buildings. Vegetated or green roofs used engineered growing media, area drought-tolerant plants, and specialized roofing materials that can be installed on existing or new structures [12]. This roof not only become a mitigation strategy of stromwater runoff but it also give other various benefit [9]. However, many consider storm water runoff mitigation to be the primary benefit of green roofs due to the prevalence of impervious surfaces in urban and commercial areas and failing storm water management infrastructure [7]. An estimated 14% of all flat roofs are green in Germany, a nation widely considered the leader in green roof research, technology, and usage [4]. Hence, focus of this study is to use green roof suitably for storm water management in Malaysia.

Green roof is a living vegetated ecosystem of lightweight soil and self-sustaining vegetation. It is biologically ‘alive’ and as such provides a protective cover on the building by using the natural elements of sun, wind, and rain to sustain itself [8]. Green roof consist of several layer that have its own specified functions. Green roof main components include protection layer, drainage layer, filtration layer, substrate or growth media layer and vegetation layer [5]. Selection of vegetation or plant materials can range from mosses, lichens and ferns, to sedums and other succulents, to grasses, herbs and ground covers [8]. Green roof have recently been recognized as potentially useful for local management of storm water [6]. One of the significant benefits of green roofs is reducing the volume of runoff thereby possibly reducing pollutant loadings. Studies have shown that green roofs can absorb water and release it slowly over a period of time as opposed to a conventional roof where storm water is immediately discharged [9]. This reduction in quantity of runoff from a green roof leads to improved storm water runoff and surface water quality.

In urban areas, rooftops comprise a large percentage of total impervious surfaces and provide unique opportunities for storm water management. Model vegetated rooftops or green roofs have been used for decades in Malaysia to mitigate storm water runoff. In this study, we monitored storm water runoff from vegetated roof model to determine the effectiveness on storm water management in term of quantity aspects.

Heavy rainfall within short time in Klang valley area more often occur flash floods in numerous development cities like Kuala Lumpur and Shah Alam. Besides the problem, the other related problem in urban water management was the short supply of water, pollution on rivers and environment damage along rivers [14].

There have been suggestion from various parties to study rainwater harvesting as a method to mitigate flash flood. High volume of rainfall during rainy season may cause flood. Correspondingly, high rainfall intensity in short time period may cause flash flood. Thus, a suitable and effective approach to control rainwater quantity should be studied in addition to its quality for reuse purpose.

The objective of this study was to determine the efficiency of vegetated roof model on reducing storm water quantity in Malaysia . This study consisted of: (i) Designing a flat type of vegetated roof model in small scale for stormwater management at University Tun Husseion Onn Malaysia (UTHM) campus, (ii) using vegetation from type of grass that suitable with the Malaysia climate, and (iii) testing the flow rate and retention capacity.

2. **METHODS**

2.1 Roof Model

A vegetated model and a non-vegetated model (control) were built. Model effective size was 1 x 0.75 meters. Surface area was 0.75 m^2 and the slope was 6% for both models. Non-vegetated model depth was 50 mm and vegetated model 200 mm depth was including ±80 mm of vegetated layer design.

2.2 Vegetated Roof Model Layer

The vegetated roof model layer used in the present study consisted of vegetation layer (pearl grass) with soil growth media, filtration layer (geotextile), drainage layer (Atlantis modular 30 mm) and protection layer (geotextile) which is shown in figure 2.2.

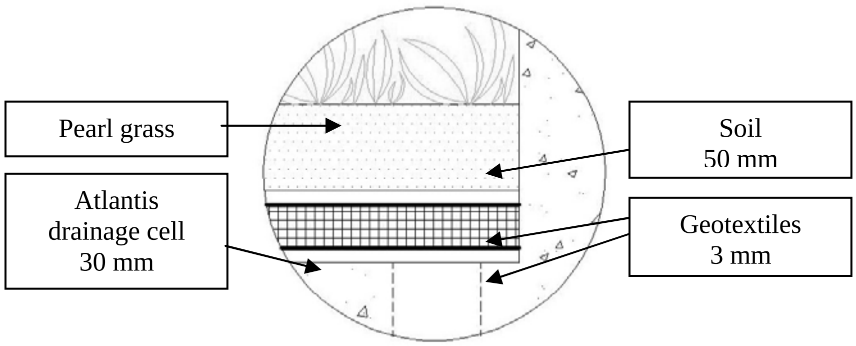

Figure 2.2: Vegetated model layer

2.3 Site Testing

Flow rate and retention capacity tests were conducted during and after rainfall event for both models. Total storm water runoff was being taken also for both models in specified time interval depend on the availability to get storm water retention capacity. Flow rate and total storm water runoff retention was performed manually on site without any particular electronic automatic device. Three samples were taken on different day.

3. RESULTS AND DISCUSSIONS

Based on Figure 3.1, it shows that flow rate of vegetated model is lower than non-vegetated model for all samples. The difference in percentage between vegetated and non-vegetated model were 20% to 39% respectively. Flow rate value has a related study linear with rainfall intensity. Figure 3.2 shows that non-vegetated model generate more storm water runoff than vegetated model for all samples.

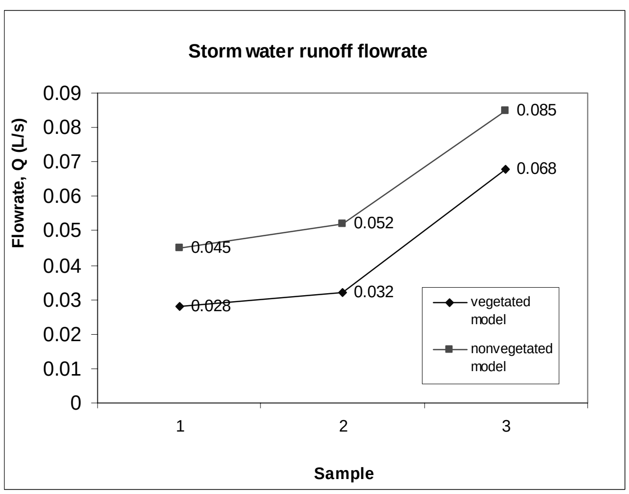

Figure 3.1: Storm water runoff flow rate.

.

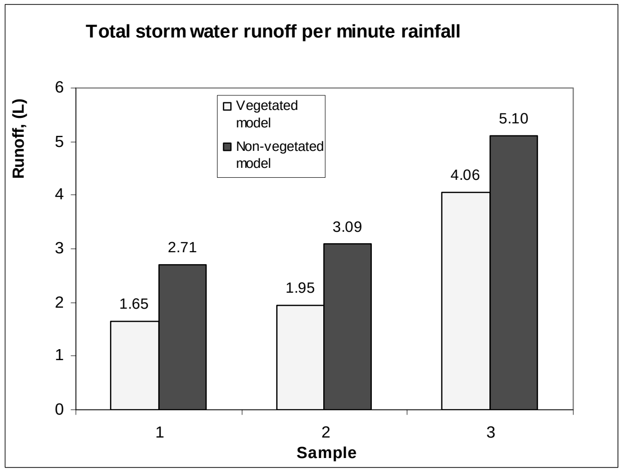

Figure 3.2 : Total storm water runoff retention capacity

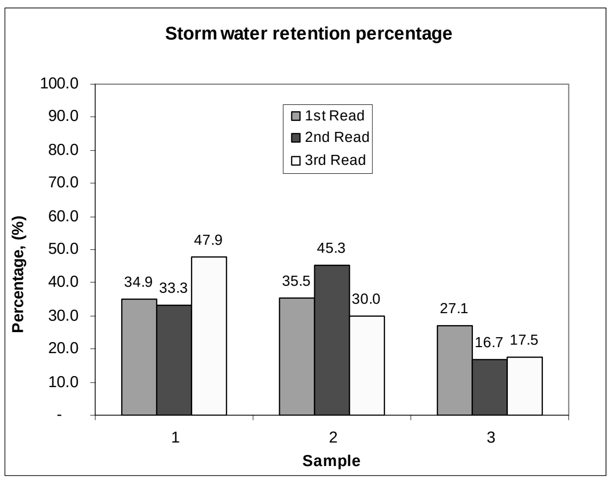

Figure 3.3 : Storm water retention percentage

Figure 3.3 shows the percentage of storm water retention for vegetated model in 3 different rainfall intensity. Each day the data was collected for 3 times. The highest retention percentage was sample 1, 47.9% with rainfall intensity 9 mm. The lowest retention percentage was sample 3, 16.7% with rainfall intensity 42 mm. This result showed that when the higher the rainfall intensity the lower the retention capacity capability for the vegetated model. Storm water retention capacity for vegetated roof from various studies is shown in Table 3.1.

Table 3.1: Comparison of storm water retention capacity from various studies

Various studies	Carter and Rasmussen, 2003	Moran et al., 2003	VanWoert et al., 2005	Liptan and Strecker, 2003	Emilsson, 2005	Mentens et al., 2005	Present Study
Rainfall retention capacity, (%)	78	60	60	30	50	58	17 - 48

Although retention percentage of vegetated model is low for the high rainfall intensity, it was still effective to reduce the storm water runoff compare to the non-vegetated model. The lowest retention percentage was 16.7% and the highest was 47.9%. Retention percentage also depended on rainfall intensity. Main factors that affected the retention percentage were soil layer and vegetation in vegetated model. Pearl grass used in this study was only one month life period on vegetated model when this study was implemented. Thus the molecular of soil was not bonded. firmly. Therefore, soil porosity was large. As a result from that soil capability to hold the water was not at optimum level.

4. **CONCLUSION AND RECOMMENDATION**

Results showed that vegetated roof model was satisfying retained storm water during the period of study. For all rainfall events, vegetated roof model retained almost 50% of storm water. Even though the vegetated roof model did not retain much storm water, they still serve as effective tools for storm water management if proper design and planning was executed.

Disconnecting impervious surfaces from the storm water conveyance network has proven successful in protecting water quality, quantity, and habitat. Green roofs provide an alternative tool to consider when developing storm water plans that limit impervious cover and maintain the natural hydrology of a site.

There is a lot of recommendation which may consider overcoming and improving the results of vegetated roof efficiency in storm water management for further studies: grass planting should do early and give them naturally live on model before water sample is taken, collect much of data to obtain more precise and effective results and apply and use comprehensive and systematic tools in data collection to obtain the data precisely.

5. **REFERENCES**

Antrop, M., (2004),”Landscape change and the urbanization process in Europe”. Landscape and Urban Planning 67, 9–26.

Atlantis Water Management (2007),”Roof Garden and Planter Box Drainage”. Atlantis Corporation Australia.

Bengtsson, L., Grahn, L. & Olsson, J.(2005), ”Hydrological function of a thin extensreenroof in southern Sweden”. Nordic Hydrology *36*, 259-268.

[Herman, R. (2003),”Green roofs in Germany: Yesterday, Today and Tomorrow”.1st North American Green Roof Conf.: Greening Rooftops for Sustainable Communities, Chicago.29– 30 May 2003, The Cardinal Group, Toronto.

Jeroen Mentens, Dirk Raes dan Martin Hermy (2005),“Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century?” Landscape and Urban Planning 77 (2006) 217–226.

Justyna Czemiel Berndtsson, Tobias Emilsson, Lars Bengtsson (2005), “The influence of extensive vegetated roofs on runoff water quality”. Science of the Total Environment, 355 (2006) 48-63.

Liptan, T. (2003),” Planning, zoning and financial incentives for ecoroofs in Portland, Oregon”. page 113–120. *In* Proc. of 1st North American Green Roof Conf.: Greening Rooftops for Sustainable Communities, Chicago. 29–30 May 2003. The Cardinal Group, Toronto.

Liptan, T and Strecker, E (2003), Ecoroofs (Greenroofs) – A More Sustainable Infrastructure”, Bureau of Environmental Services, Portland Oregon, USA.

Moran, A., B. Hunt, and G. Jennings. (2003), “A North Carolina Field Study To Evaluate Greenroof Runoff Quality, Runoff Quantity and Plant Growth”. ASAE Paper, American Society of Agriculture Engineering, USA.

Nicholaus D. VanWoert, D. Bradley Rowe, Jeffrey A. Andresen, Clayton L. Rugh, R. Thomas Fernandez dan Lan Xiao (2005),“Green Roof Stormwater Retention: Effects of Roof Surface, Slope, and Media Depth” Journal of Environmental, Volume 34, May–June 2005.

Stone Jr., B., (2004),”Paving over paradise: how land use regulations promote residential imperviousness”, Landscape and Urban Planning 69, 101–113.

Timothy L. Carter and Todd C. Rasmussen (2005),“Use Of Green Roofs For Ultra-Urban Stream Restoration In The Georgia Piedmont (USA)” Greening Rooftops for Sustainable Communities, proceedings. May 2005, Washington D.C.

United Nations (2002),”World Urbanization Prospects: The 2001 Revision”. United Nations, New York.

Urban Stormwater Management Manual (2001), Department of Irrigation and Drainage Malaysia. Malaysia Government.