Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 15	No. 2	pp. 715-718	2016

Original Research Paper

The Potential of Green-Blue Roof to Manage Storm Water in Urban Areas

Muhammad Shafique*, Reeho Kim*(**)† and Daehee Lee*
*Construction Environmental Engineering, University of Science and Technology, 283, Goyangdae-ro, Ilsanseo-gu, Goyang-si, Geonggi-do, South Korea
**Environmental & Plant Engineering Research, Korea Institute of Civil Engineering and Building Technology, 283, Goyangdae-ro, Ilsanseo-gu, Goyang-si, Geonggi-do, South Korea
†Corresponding author: Reeho Kim

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 29-01-2016
Accepted: 24-02-2016

Key Words:
Green-blue roof
Peak flow
Stormwater runoff reduction
Urban area

ABSTRACT

Green (vegetated) blue roof is the best low impact development (LID) practice to improve the environment and to manage the stormwater rainfall runoff in cities. A green-blue roof was constructed at the Chungwoon middle school, Seoul and monitored to analyse its performance in reducing the stormwater runoff and peak runoff delay. Green roof is helpful in reducing the storm water runoff, because it can change the impervious area of the roof into the pervious area. Stormwater runoff from the control roof and green-blue roof has been monitored. From the results, it was found that the rainwater outflow from green-blue roof is much less than the control roof, which is helpful for the stormwater management in urban areas. Results also showed that the green-blue roof also helps to reduce the surface temperature of the roofs.

INTRODUCTION

The global population is increasing every year and the percentage of urban population is also concentrating worldwide (UNDP 2008). Urban areas are expanding in terms of space and density. The impermeable surfaces are increased due to the effect of the urbanization. This, as a result, has numerous consequences on the city infrastructure and surrounding environment. Regarding stormwater management, the infiltration decreases and surface runoff increases and also the stress on existing stormwater infrastructure increases. As a result, flooding from the sewer may become more frequent in the urban areas. In addition, the studies indicate that in certain areas, global warming may cause increased frequency of extreme precipitation events, which will also lead to increased flooding in the urban areas (Arnell & Nigel 1999, Bates et al. 2008).

As the LID practice, green roof used for the stormwater management and aesthetic appeal, these roofs (vegetated) are now gaining increased attention and used in different countries such as Germany, USA, UK, Japan and Singapore (Mentens et al. 2006, Berndtsson et al. 2008). Green roofs have several advantages in the urban areas, with the most important ones being their capability to retain and detain large amount of rainfall runoff (Villarreal et al. 2005), reduce urban heat islands (Wong et al. 2003), reduce the energy consumption of a building by cooling roofs (Del Barrio & Elena 1998), and create habitats for certain plants and animals, that also improve urban biodiversity and finally, their aesthetic appeal also improves (Emilsson et al. 2007). Despite of some constraints, such as, special design, high construction and maintenance costs,, green roofs have received increased attention due to their more beneficial impacts. Green blue roofs are very effective LID practice for stormwater management and they can play an important role in the modern urban drainage systems LID facilities, because of their ability to retain, slow down and reduce runoff volume. High evapo-transpiration from a green roof can also help to reduce the annual runoff from the urban areas (Liesecke & Hans-Joachim 1998, Knoll 2000, Bengtsson et al. 2005). Green roof has a temporary storage which holds enough water, reduces peak flow and also increase the time of concentration. A reduction in the peak flow of the green blue roof runoff helps to avoid the urban flooding and combined sewers overflows can also be considerably reduced.

Green roofs are the best sustainable stromwater management practices for the water retention and the peak runoff flow reduction in the urban areas (Moran et al. 2003). Berndtsson et al. revealed that, from the green roof runoff concentrations of heavy metals are generally in lower percentage than concentrations of heavy metals in urban runoff from hard surface (Berndtsson et al. 2009). However, the present study was started with an objective that how green roofs play an important role in storm water management during the storm events in the urban areas. For this purpose, we

installed a green-blue roof at Chungwoon middle school, Seoul. Rainfall events were studied to evaluate the reduction in the rainfall runoff and peak runoff delay by using the green-blue roof.

MATERIALS AND METHODS

Study area and green blue roof design: A green-blue roof was established in the Chungwoon middle school building. The roof systems were designed in several 0.5 × 0.5 × 0.2 m assemblies as shown in Fig. 1, with the same principle as the full-scale vegetated roofs. Green blue roofs assemblies were placed above the common roof. Overflow runoff from the green blue roof was collected through pipes. The catchment area of the green-blue roof was 285 m^2. Green blue roof consisted of the different layers, the topmost was vegetation layer composing of a growing soil medium and vegetation. Green blue roof works same as green roof, however it has one more storage layer at the bottom as shown in Fig.2, where more stormwater can retain and helps to avoid flooding. The local garden substrate was used in the present study. While selecting plants for the green roofs, it was considered that they have ability to withstand in low nutrient conditions, and in extreme weather conditions (i.e. extreme hot or cold temperature). Once planted, the vegetation kept growing naturally without using the fertilization and artificial watering. The control roof, also shown in Fig. 1, has no soil or vegetation. By applying the green-blue roof on the building, we convert the impervious area of the roof into a porous soil area that also helps to maintain the natural environment. We measured the rainfall runoff from the control roof and green-blue roof during storm event. In order to analyse the volume of the rainwater inflow/outflow, the data of the rainfall pattern with an average 90mm/hr of rainfall intensity between 22/7/2014 to 28/7/2014 were collected.

Figs. 2 and 3 indicate the structure and all the details of the green-blue roof that was installed in the Chungwoon middle school building roof, Seoul, Korea. It also indicated the moisture gauge, water level and flow meter position in the green-blue roof.

Fig. 3 also shows the mechanism on which it is works and also indicates the different layers of the green-blue roof. The water is stored in the storage layer of the roof which helps to reduce the rainwater runoff.

RESULTS AND DISCUSSION

Rainfall runoff during rain events: A field experiment was conducted with the rainfall event to evaluate the runoff flow from the green-blue roof and control roof. The storm with an average 90mm/hr rainfall intensity that occurred from 22th

Fig. 1: Green-blue roof at the Chungwoon middle school.

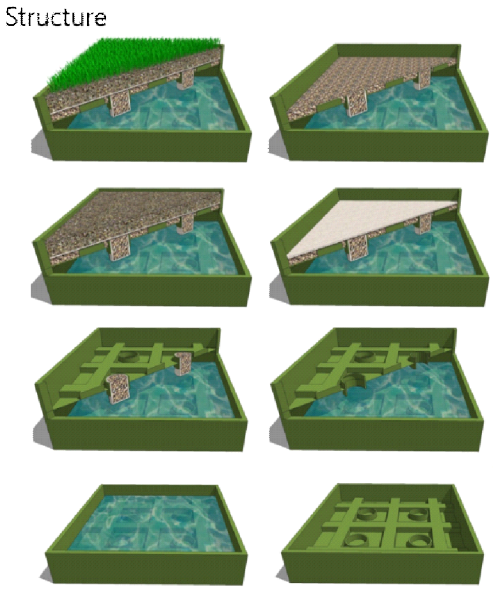

Fig. 2: The structure view of the blue-green roof.

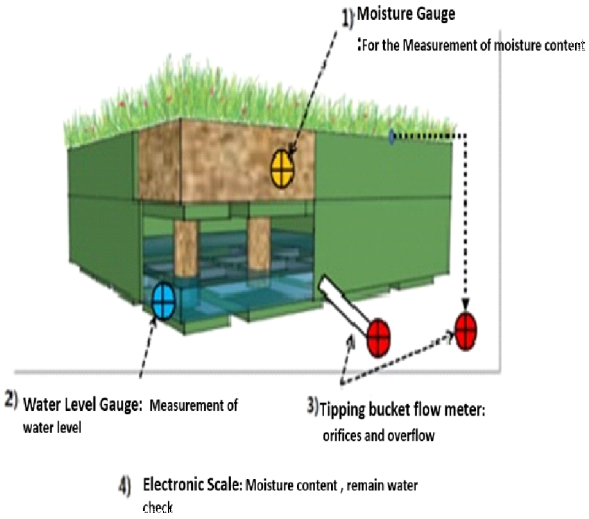

Fig. 3: Design of the green-blue roof.

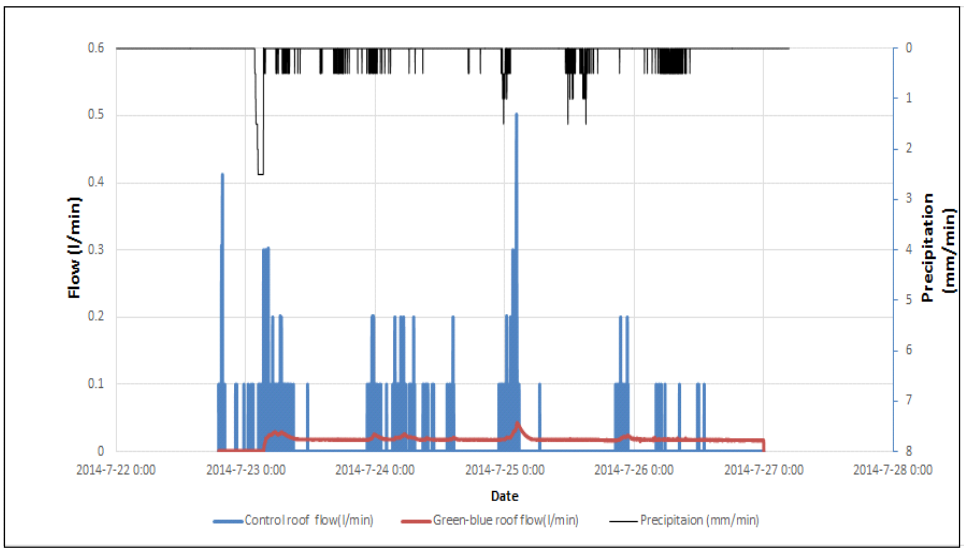

Fig. 4: Variation of the water flows from the control roof and green-blue roof during the rainfall event.

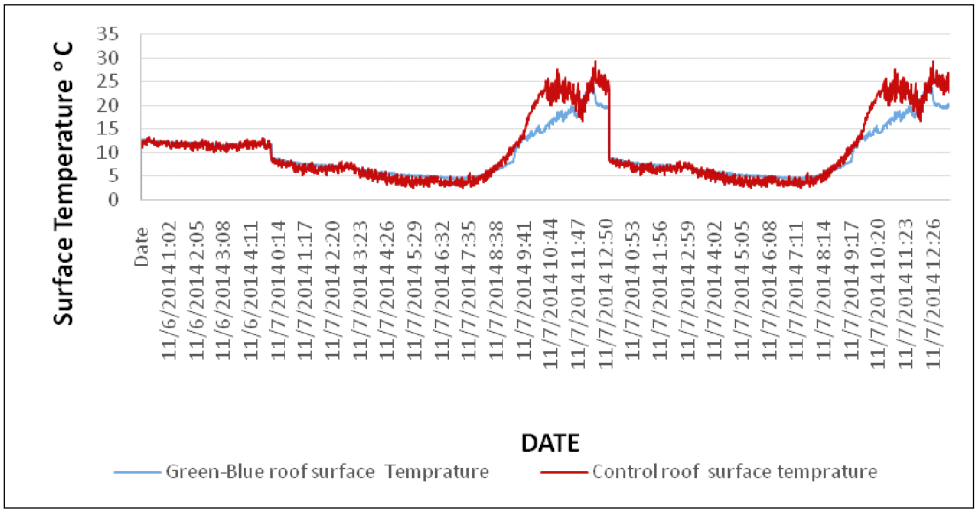

Fig. 5: Variation of the surface temperature from both the roofs.

July 2014 to 28th July 2014, was analysed on the control roof and green-blue roof. The result from Fig. 4 shows that the rainfall runoff outflow from the roof green-blue is much smaller than the control roof outflow. The peak outflow from the green-blue roof is also less than the control roof which also helps in the stormwater management in urban areas. The green-blue roof reduces the rainfall runoff, retains the rainwater and increases the time of concentration.

Generally, runoff continues to flow from the green-blue roof even after the rainfall stops, while the control roof stops producing runoff. This delay is due to the water entering the green-blue roof must filter through the soil, drainage layer and filter membrane and then exit the roof as runoff. Green blue roof also retained enough water during the storm events. We can also avoid flash flooding by applying the green roof in the urban areas. Green-blue roofs are the best LID practice for the stormwater management in the highly developed areas.

Blue-green roof effects on the surface temperature: Green-blue roof also helps to reduce the surface temperature in the summer season. For this purpose, we measured the surface temperature from the green-blue roof and control roof for the time period 6/11/2014 and 7/11/2014. Fig. 5 shows that the reduction in surface temperature from the green-blue roof

is more than 5°C than the control roof, which indicates that the green roof also change the microclimate of the roof, which also helps in reducing the cooling costs.

CONCLUSION

The present study investigated the rainfall runoff from the green-blue roof and control roof based on the actual rain event. Storm was observed and analysed for the green-blue roof and control roof from 22th July 2014 to 28th July 2014. Green- blue roof reduced the stormwater and also decreased the peak rate of runoff as compared to control roof. During the rain event, rainfall was first absorbed by soil and growing medium and then runoff was generated. It was found that the rainfall runoff flow from the green-blue roof is much less as compared to the control roof. The surface temperature of the green-blue roof also reduced as compared to control roof.

ACKNOWLEDGMENT

This research was supported by a grant (15 technology innovation C04) from Advanced Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of the Korean Government.

REFERENCES

Arnell, N.W. 1999. The effect of climate change on hydrological regimes in Europe: a continental perspective. Global Environmental Change, 9(1): 5-23.

Bates, B., Kundzewicz, Z.W., Wu, S. and Palutikof, J. 2008. Climate change and water: technical paper vi. Intergovernmental Panel on Climate Change (IPCC)

Bengtsson, L., Grahn, L. and Olsson, J. 2005. Hydrological function of a thin extensive green roof in southern Sweden. Nordic Hydrology, 36: 259-268.

Berndtsson, J., Bengtsson, L. and Jinno, K. 2008. First flush effect from vegetated roofs during simulated rain events. Hydrology Research, 39(3): 171-179.

Berndtsson, J.C., Bengtsson, L. and Jinno, K. 2009. Runoff water quality from intensive and extensive vegetated roofs. Ecological Engineering 35(3): 369-380.

Del Barrio, E.P. 1998. Analysis of the green roofs cooling potential in buildings. Energy and Buildings, 27(2): 179-193.

Emilsson, T., Berndtsson, J.C., Mattsson, J.E. and Rolf, K. 2007. Effect of using conventional and controlled release fertiliser on nutrient runoff from various vegetated roof systems. Ecological Engineering, 29(3): 260-271.

Knoll, S. 2000. Das Abflußverhalten von extensivenDachbegru¨ nungen e Ph.D. Dissertation, TU-Berlin.

Liesecke, H.J. 1998. Das retentionsvermögen von dachbegrünungen. Stadt und Grün, 47(1): 46-53.

Mentens, J., Raes, D. and Hermy, M. 2006. Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? Landscape and Urban Planning, 77(3): 217-226.

Moran, A.C., Hunt, B. and Jennings, G. 2004. A North Carolina field study to evaluate greenroof runoff quantity, runoff quality, and plant growth. Doctoral dissertation, North Carolina State University.

UNDP, 2008. Human Development Report 2007/2008. Demographic trends. Available at: http://hdrstats.undp.org/indicators/41.html (visited 10th June 2009).

Villarreal, E.L. and Bengtsson, L. 2005. Response of a Sedum green-roof to individual rain events. Ecological Engineering, 25(1): 1-7.

Wong, N.H., Chen, Y., Ong, C.L. and Sia, A. 2003. Investigation of thermal benefits of rooftop garden in the tropical environment. Building and Environment, 38(2): 261-270.