CAN GREEN ROOFS PURIFY STORMWATER RUNOFF? - THE ESTABLISHMENT OF EXPERIMENTAL GREEN ROOFS

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Abstract: This article introduces the establishment of the experimental green roofs and of green roof research on Mendel University in Brno. The experimental green roofs were established in August 2015 and it is based on current issues of rainwater management and the quality of storm water launched into recipients or sewage system. There is a valid legislation addressing the management of rainwater in environment – decree no. 268/2009, Coll., and decree no. 269/2009, Coll. Four experimental plots were created and placed in Mendel University Campus. It was hypothesized that different types of experimental plots will result in different amount of retained water and in different quality of water runoff. Water quality will be monitored and evaluated by Government Regulation no. 23/2011, Coll., using spectrophotometric method, then analysed in laboratory of the Department of Applied and Landscape Ecology, Mendel University in Brno.

Key Words: experiment, green roof, water quality, water retention, storm water runoff

INTRODUCTION

Rainwater management is currently much discussed topic in the Czech Republic. People constructing their houses regularly meet with the requirement of the building authority for disposal of rain water from the site of construction. Since 2009, valid legislation addresses the management of rainwater in environment. In particular, the decree implementing the Building Act no. 268/2009 Collections, as amended, and Decree of the Ministry for Regional Development no. 269/2009 Coll.

Decree no. 268/2009 Coll., §6, section (4) states: "Buildings of which flow off the surface water resulting from the impact of atmospheric precipitation (hereinafter referred to as "rain water"), must ensure their removal, unless rainwater is retained for future use. The pollution of these waters by harmful substances or their excessive amounts are handled by appropriate technical remedies. Removal of rain water is provided by infiltration preferably. If it is not possible, it is ensured their removal into surface water; unless it can be drained separately, it is removed by the uniform sewers."

So far, it is usual that the construction joined the storm sewer system that rainwater runoff drained into streams. However, more and more cities solves the problem of the storm sewer capacity. Therefore, given the huge amount of unused roof area (Dunnett, Kingsbury 2004), green roofs may be one possible alternative way of dealing with rainwater runoff. Moreover, the creation of more green areas is also an answer to the recent calls for a more ecological and greener urbanization (White 2002). However, the impact of green roofs on the storm water quality remains a topic of concert to city planners (Vijayaraghavan et al. 2012). Current studies point out that green roofs may be a sink for some pollutants (Vijayaraghavan, Joshi 2014, Gregoire, Clausen 2011)

Green roofs basically consist of a vegetation layer, a substrate layer (where water is retained and in which the vegetation is anchored) and a drainage layer (to evacuate excess water) (Mentens et al. 2003). In the terminology of design and architectural solutions for flat roofs have long since enshrined the concept of "green roof" like a roof covered with vegetation.

Green Roofing is divided into three different types, depending on use, construction factors and the method used to carry out the work. These play a critical part in determining both the plant types which are selected and how the vegetation will look. Green roofs can be: (a) intensive, (b) simple intensive or (c) extensive. Each of these types covers a variety of forms of cultivation, with seamless transition and site-specific differentiation (Losken et al. 2008).

Small capacity of substrate (up to 150 mm of depth) in extensive green roofs offers conditions for perennials, alpine plants and xerophilous plants (such as *Sedum* sp.) that can withstand extreme conditions of heat, drought and frost. Due to the fact, this type of green roofs is suitable for sloping roofs (up to 45°) (Mentens et al. 2006). On the other hand, intensive green roof is implemented in structures having a resistance of up to 1000 kg $\cdot$ m^{-2}, so it is possible to use soil to a thickness of 1–1.3 metres, which is suitable for forming and using garden flowers, shrubs and low trees. Intensive green roofs are more demanding in terms of maintenance (Losken et al. 2008).

The main advantages of green roofs include decongesting the sewer system and slowing rainwater runoff, or production of oxygen and carbon dioxide saturation as well as absorption of pollutants from the air, and, ultimately, helping to increase biodiversity in urban environments. As a disadvantage could be considered structural complexity (especially the emphasis on the waterproofing layer) and the need for statically reinforced load-bearing structure of the building.

The experiment described below deals with current issues of rainwater management and the quality of storm water launched into recipients or sewage system. The size of built-up areas in the landscape is constantly growing, thus increasing the quantity of rainwater drained into sewage networks already designed which capacity is not enough. Therefore, it is necessary to look for alternatives in the storm water runoff management. Due to their structural arrangement, green roofs provide a suitable way of solving this issue, especially in industrial areas and technical parks in which flat-roofed buildings dominate.

MATERIAL AND METHODS

The experimental green roofs (Figure 1) are situated in Mendel University Campus in Brno (Zemedelska street, Brno; GPS: 49.2098817N, 16.6133425E). There are four variants of experimental plots to determine differences in water filtration:

A. extensive green roof with following layers: protective water-storage fabric (Optigreen type RMS 300), drainage nep film (Optigreen type FKD 40), filtering fabric (Optigreen type 105), extensive substrate (Optigreen type E, 100 mm of depth; composition below), vegetation cover (list of species named below)

B. extensive green roof with following layers: protective water-storage fabric (Optigreen type RMS 300), drainage nep film (Optigreen type FKD 40), filtering fabric (Optigreen type 105), extensive substrate (extensive "Czech" substrate, 100 mm of depth; composition named below), vegetation cover

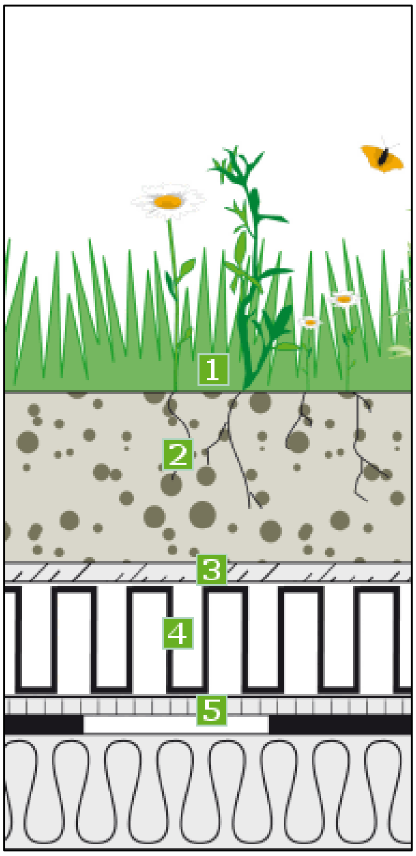
C. extensive green roof with following layers: protective water-storage fabric (Optigreen type RMS 300), hydrophilic panel (ISOVER hydrophilic vegetation panel Cultilene), extensive substrate (Optigreen type E, 50 mm of depth), vegetation cover

D. semi-intensive green roof with following layers: protective water-storage fabric (Optigreen type RMS 300), hydrophilic panel (ISOVER hydrophilic vegetation panel Cultilene), extensive substrate (Optigreen type E, 150 mm of depth), vegetation cover

Scheme of typical green roof is illustrated on Figure 2. Plots are made of wood standing on concrete permanent formworks. Slope of roofs is 5%. Hydrophilic vegetation panel is used to determine a function of water retention and filtration so there is no need to use a drainage nep film and filtring fabric in these plots (www.isover.cz). Exensive substrate Optigreen type E has pH 6.0–8.5 and consist of expanded shale, lava, pumice-stone, keramzit (expanded clay), crushed brick and green compost. Extensive "Czech" substrate has pH 6.2–6.8 and consist of crushed Liapor, crushed brick, cinder, peat and PG mix 14-16-18 (fertilizer). Vegetation consist of *Achillea millefolium*, *Allium schoenoprasum, Anthemis tinctoria, Aster amellus, Campanula rotundifolia, Centaura scabiosa, Chrysanthemum leucanthemum, Dianthus carthusianorum, Dianthus deltoids, Galium verum, Geranium robentianum, Hieracium aurantiacum, Linaria vulgaris, Organum vulgare, Petrorhagia saxifrage, Potentilla argentea, Prnella grandiflora, Prunella vulgaris, Sanguisorba minor, Saponaria ocymoides, Saponaria officinalis, Sedum album, Sedum reflexum, Silene nutans, Thymus pulegioides, Thymus serpyllum, Festuca tenuifolia, Festuca ovina vulgaris, Melica ciliate,* and *Vulpia myuros* (www.ekrost.cz).

Figure 1 Experimental plots of green roofs in Mendel University Campus, photographed on a day of establishment, vegetation is in a phase of sowing, du to this substrate layer is visible (August 2015; photo: by author).

Figure 2 Scheme of green roof layers – (1) vegetation cover, (2) substrate (3) filtration fabric (4) drainage nep film (5) protective water-storage fabric (www.optigreen.cz)



Legend: 1 – vegetation cover, 2 – substrate, 3 – filtration fabric, 4 – drainage nep film, 5 – protective water-storage fabric

After the establishment of experimental plots monitoring water retention and regular sampling of water collected for subsequent determination of selected quality indicators will begin. These are the basic parameters of water quality indicated by Government Decree no. 23/2011 Coll., as amended.

Spectrophotometric method will be carried out in the laboratory of Water Management at the Department of Applied and Landscape Ecology. Water samples will be properly adjusted (filtration and mineralization in thermoreactors) and mixed with the appropriate reagents. For subsequent determination of concentration of N and P ionts will be used a spectrophotometer type DR / 400 (Hach-Lange company) when compared to a blank. For the purposes of determining the retained water in green roofs data from meteorological stations located in the area univerzity and the Institute of Geonics of the Czech Academy of Sciences, based on Schodova Street in Brno, will be used.

RESULTS AND DISCUSSION

The experimental green roofs were established in August 2015 and results of the research will be presented in disertal thesis of the first author of this article. It was hypothesized that different types of experimental plots will result in different amount of retained water and in different quality of water runoff. We expect similar results as Vijayaraghavan, Joshi (2014) or Gregoire, Clausen (2011). Water quality will be monitored and evaluated by Government Regulation no. 23/2011, Coll. According to this results the conclusion will be formulated. This experimental plots will be also used for other monitoring, as well as for educational purposes at the Department of Applied and Landscape Ecology.

CONCLUSION

The aim of this article was to briefly apprize the scientific community of the establishment of the experimental green roofs and of green roof research on Mendel University in Brno. There is an effort to cooperate with researchers of Brno University of Technology to maximalize the knowledge of green roof composition and construction, runoff water quality of green roofs and of using hydrophilic vegetation panels in green roofs.

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