BUDOWNICTWO
CZASOPISMO TECHNICZNE
TECHNICAL TRANSACTIONS
CIVIL ENGINEERING
WYDAWNICTWO POLITECHNIKI KRAKOWSKIEJ
2-B/2012
ZESZYT 3
ROK 109
ISSUE 3
YEAR 109

ZUZANA VRANAYOVÁ, DANIELA OČIPOVÁ,
ZUZANA KARELOVÁ*

WATER MANAGEMENT PROBLEMS IN MODERN CITIES

PROBLEMY GOSPODARKI WODNEJ W MIASTACH NOWOCZESNYCH

Abstract

Water is one of the most valuable natural resources on Earth; therefore "the water topic" should be one of the most important themes of discussion for us. Water management consists of hundreds of subtopics. Only one of the water management subtopics is shortly described in this paper: stormwater management (SWM). Stormwater causes major problems in the cities where more and more impervious surfaces contribute to more extensive and faster runoff which may lead to the overloading of the sewerage systems and consequently create urban flooding as well. This article briefly describes how urbanization has changed urban runoff and what sustainability means in the context of SWM as well as presents our research carried out in this respect at the Faculty of Civil Engineering.

Keywords: water management, rainwater, stormwater management (SWM), sustainability

Streszczenie

Woda to jedno z najcenniejszych bogactw naturalnych na Ziemi, dlatego też „temat wodny" winien stanowić jeden z najistotniejszych wątków naszej dyskusji. Gospodarka wodna składa się z setek podtematów. W niniejszym artykule pokrótce opisano zaledwie jeden z nich, a mianowicie zarządzanie wodą opadową (storm water management – SWM). Woda opadowa przysparza najwięcej kłopotów miastom, w których wzrastająca ilość powierzchni nieprzepuszczalnych przyczynia się do rozleglejszego i szybszego odpływu, co może prowadzić do przeładowania systemów kanalizacyjnych, a w konsekwencji do zalewania terenów miejskich. Wyjaśniono, w jaki sposób urbanizacja zmieniła strukturę odpływów i co oznacza rozwój zrównoważony w kontekście SWM, a także przedstawiamy autorskie badania prowadzone w tym zakresie na Wydziale Inżynierii Wodno-Lądowej.

Keywords: gospodarka wodna, woda deszczowa, zarządzanie wodą opadową (stormwater management – SWM), rozwój zrównoważony

* Doc. PhD. Eng. Zuzana Vranayová, PhD. Eng. Daniela Očipová, Eng. Zuzana Karelová, Department of Building Services, Faculty of Civil Engineering, Technical University in Košice.

1. Introduction

Water management comprises a wide range of problems, especially in modern, quickly growing cities. We would like to discuss the problems, principles and solutions of stormwater management (SWM) in urban areas in detail. What does stormwater management really mean?

According to Marsalek and Chocat, stormwater management is a process employing various non-structural and structural measures to control stormwater runoff with respect to its quantity and quality. [1] There are several definitions of stormwater management regarding different approaches.

Most drainage systems in Slovakia are combined similarly to the UK, France and Germany where about 70% of the total drainage system length is interconnected. [2] Nowadays, we know that this kind of a system is economically and environmentally inefficient and in many cases causes the overloading of sewerage systems and treatment plants as more frequent floods prove it. It is essential that we introduce new sustainable approaches in the urban drainage systems under our conditions as well.

Next figures show how the development of urban areas has changed infiltration and evapotranspiration processes and how runoff has increased up to 55% due to impervious surfaces. Stormwater runoff can cause significant damages in urban areas, especially during cloudbursts. [3]

We must face urban floods in areas where they used to be less common. This fact should make us think more about alternative ways of stormwater disposal.

Climate change is frequently discussed and we cannot leave it out of consideration when we talk about stormwater management. Observed climate warming is consistently associated with changes in hydrological cycles and systems, such as: changing precipitation patterns, intensity and extremes; the widespread melting of snow and ice; increasing atmospheric water vapour; increasing evaporation; changes in soil moisture and runoff. [5]

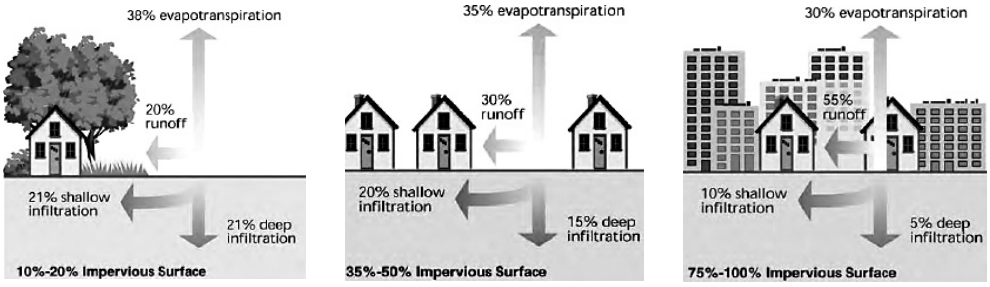

Fig. 1. Relationship between impervious cover and surface runoff [4]

Rys. 1. Związek między pokryciem nieprzepuszczalnym a odpływem powierzchniowym [4]

2. SWM and sustainability

There is a number of case studies from all around the world promoting sustainability in stormwater management and water management in general. Sustainable SWM or sustainable drainage systems bear different names in different countries but their target is the same:

sustainability. Common terms are used, for instance BMPs – best management practices, LID – low impact development, or SUDS – sustainable urban drainage systems.

According to ASCE/UNESCO (1998), sustainable water systems are 'those systems designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity'. [2]

Sustainable SWM goes hand in hand with water saving which considers water recycling and alternative water usage.

Table 1

Comparison of conventional and sustainable drainage system from [7]

	Conventional system	Sustainable system
Cost to construct	*May be equivalent but potential of multifunctional use of BMPs may reduce overall cost*	
Cost to operate and maintain	Established	*Unclear for some systems: further work required*
Onsite flood control	Yes	Yes
Downstream erosion and flood control	No	Yes
Potential for water reuse	No	Yes
Potential for groundwater recharge	No	Yes
Potential for pollutant removal	Low	High
Public amenity benefits	No	Yes
Educational benefits	No	Yes
Performance lifetime	Established	*Not established for some systems: further work required*
Land take	Not significant	*Dependent on type of system: varies between significant and substantial*
Design criteria	Established	*Not established for some systems: further work required*

According to [6] we can summarize the contemporary SWM theory in ten basic principles. Here are just some of them: "Managing stormwater as a resource, Managing stormwater as close to the source as possible, Sustaining the hydrologic balance of surface and ground water, Slowing runoff down, and not speeding it up, Preventing potential water quality and quantity problems" [6].

As it is stated in the basic principles, contemporary SWM techniques should dispose stormwater as close to the source as possible. Infiltration techniques have been known for many years and we can say that these are the natural techniques we are trying to promote as sustainable nowadays. We simulate natural processes and improve them to promote sustainability in SWM across urban areas. There are several infiltration techniques, e.g. infiltration on vegetated surfaces (lawns, swales, trenches or ditches), permeable paving, infiltration shafts, extensive and intensive green roofs or bio-retention, which help us to manage runoff as close to the source as possible. These techniques are used more and more frequently in urban areas, city centres and residential zones making them more attractive. What is most important, they support sustainability.

There are more artificial techniques based on accumulating rainwater and stormwater, thus facilitating water saving. Rainwater and stormwater is usually collected and stored in an underground tank and reused for various non-potable purposes. There are numerous examples of rainwater harvesting on a smaller scale for individual houses all around the world but also larger-scale projects using rainwater and stormwater harvesting, such as industrial, commercial, municipal or residential areas. It is very important to use corresponding water quality for different purposes in the field of water saving which is one of the general problems of water management.

It is essential to combine suitable SWM measures to manage stormwater runoff in the modern cities and develop sustainable modern cities. Sustainability is not only a worldwide trend but also a necessity. There are a lot of examples of sustainable SWM in the modern cities worldwide, and it is our intention to adopt some of these sustainable ideas in our conditions as well.

3. SWM and current research at the Faculty of Civil Engineering in Košice

Under the auspices of two projects "Increasing of the rainwater management efficiency for the purpose of energy demand minimization" and "Energy balance research on rainwater management in the cities of the future", we are running our research at the Faculty of Civil Engineering in Košice. Our experimental buildings and devices are located close to one another at the university campus.

The first and one of the most important devices is the rain gauge located on the rooftop of one of the buildings at the campus. It is very important to proceed with our own precipitation measurements and create a database useful not only for this research but also for educational purposes and future research activities. The advantage of our own rain gauge is detailed information about every single rainfall event throughout the year. The predefined measuring time step during the rainfall is set to one minute and therefore it is very accurate. The other measured parameters, besides precipitation amount, are the roof runoff, the groundwater level, the water level in the infiltration shaft and the qualitative parameters of stormwater. This gives us an overview of the basic hydrological parameters in the experimental area.

For our purpose, we study a combination of different SWM techniques to promote sustainable alternatives to stormwater disposal, for example how rainwater harvesting would affect stormwater runoff. Each of these techniques has its pros and cons so it is necessary to analyze the whole system carefully to be able to evaluate it. A risk analysis will be used to assess the system of rainwater harvesting.

The risk analysis phase focuses on the most important stressors, their exposure pathways as well as the resulting environmental and health effects. The analysis phase includes the characterisation of exposure – the manner in which a valuable resource contacts or co-occurs with a stressor, and the characterisation of effects – environmental or health response that results from exposure. The scope of the risk analysis may focus on the major stressor of concern or seek associations between a stressor and its impact [8].

4. Conclusions

Stormwater is just one of water management problems in the modern cities but using sustainable approaches in the urban drainage can contribute to the improvement of the current situation. The results of a questionnaire completed by a group of fifty people show that they support water saving mainly because of a water bills reduction. There is another reason which considers almost 40% of the respondents: natural resources saving. All of the respondents use potable water for all domestic purposes (flushing toilets included) which is highly inefficient from any given point of view. The good news is that almost all the respondents would use an alternative water source in their household if they had such an opportunity. Water management as a widespread topic needs to be discussed more and more extensively at different levels of social life, with fellow citizens and children too, because education in new water management approaches as well as stormwater management attitudes and solutions helps to implement them in real life and promote sustainability.

This paper was supported by the Slovak Research and Development Agency under Contract No. SUSPP-0007-09. VEGA 1/0450/12 Energy balance research on rainwater management in the cities of the future.

References

[1] Marsalek J., Chocat B., *International Report: Stormwater management*, Water Science and Technology Vol. 46, No. 6-7, 2002, 1-17.

[2] Butler D., Davies J.W., *Urban Drainage, 3rd Edition*, Spon Press an imprint of Taylor & Francis, 2011.

[3] Karelová Z., *Sustainable stromwater management*, Seminár doktorandov 2011 Ústavu budov a prostredia, 3. ročník, Zborník vedeckých prác, Košice 2011.

[4] FISRWG, Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group, 1998 (http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/alphabetical/water/restoration/?&cid=nrcs143_026903).

[5] Bates B.C., Kundzewicz Z.W., Wu S., Palutikof J.P. (Ed.), *Climate Change and Water, chapter 5, Analyzing regional aspects of climate change and water resources*, IPCC Secretariat, Geneva 2008, 210 (http://www.ipcc.ch/publications_and_data/publications_and_data_technical_papers.shtml).

[6] Pennsylvania Stormwater Best Management Practices Manual, Chapter 3, Stormwater Management Principles and Recommended Control Guideline, 2006 (http://www.elibrary.dep.state.pa.us/dsweb/Get/Version-48474/04_Chapter_3.pdf).

[7] Middlesex University, Report 5.1. Review of the Use of stormwater BMPs in Europe, DayWater 2003 (www.daywater.org).

[8] Zeleňáková M., *Preliminary flood risk assessment in the Hornád watershed*, In: *River Basin Management 5, Fifth International conference on River Basin Management including all aspects of Hydrology, Ecology, Environmental, Management, Flood plains and Wetlands*, Ramla Bay Resort, Malta. Southampton, Wessex Institute of Technology, 2009, 15-24.

[9] Karelová Z., *Sustainable Approaches in Stormwater Management*, Mladý vedec/Young Scientist 2011, 3rd Ph.D. Student Conference of Civil Engineering and Architecture, Košice: TU SvF, 2011.

[10] Vranayová Z., Očipová D., Karelová Z., *Rainwater management in urban areas, Design, technology, refurbishment and management of buildings*, 37th IAHS World Congress on Housing, Santander, University of Cantabria, 2010.