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Gabriel MARKOVIČ[1]
Zuzana VRANAYOVÁ[2]

THE POSSIBILITIES FOR IMPLEMENTING RAINWATER MANAGEMENT MEASURES IN TUKE CAMPUS

All of the buildings in TUKE campus are connected on water main as only one source of water. There is no building with alternative source of water for non-potable uses so that potable water is used for drinking purposes as well as all others activities (flushing toilets, cleaning..). Drainage solutions of the TUKE campus are in traditional way too. The buildings situated in TUKE campus have a classical drainage system for rainwater runoff consist from traditional direct channelling of surface water through networks of pipes to sewer system except two buildings - PK6 and PK5 which have a drainage system for rainwater runoff designed through the infiltration facilities – infiltration shafts. This paper describe a big potential savings of potable water by the use of rainwater in TUKE campus as well as the big potential for "green" drainage solution – infiltration in TUKE campus.

Keywords: drainage, infiltration, rainwater harvesting, savings

1. Introduction

As the process of growing population and the consequent urban growth is unavoidable in urban regions, resulting in non-riverine flooding due to impermeable surface, low infiltration and high runoff [1], RWH will be a significant water source [2].

By introduction of Rainwater management system it provides a lot of benefits for urban areas:

- reduced volume of paved surfaces runoff discharged to the sewer system,
- improved resilience of the existing water supply system to drought and independent source of water,
- reduced drinking water treatment costs,
- reduces costs for water supply and discharge costs,
- in generally – better life condition and educational factor [5,6].

[1] Corresponding author: Gabriel Markovič, Institute of Architectural Engineering, Faculty of Civil Engineering, Technical University of Košice, Vysokoškolská 4, 042 00 Košice, e-mail: gabriel.markovic@tuke.sk

[2] Zuzana Vranayová, Institute of Architectural Engineering, Faculty of Civil Engineering, Technical University of Košice, Vysokoškolská 4, 042 00 Košice, e-mail: zuzana.vranayova@tuke.sk

In the case of school-type buildings potential of water savings replaced by rainwater is significantly higher what result from absent of purposes as a showering, bathing, laundry, etc. The most volume of potable water of school buildings in TUKE campus is consumed for flushing toilets which is precisely the most suitable purpose for use of rainwater [3,4].

2. Rainfall conditions and rainwater harvesting potential

2.1. Basic information

For the determination of theoretical volume of rainwater we need also data of rainfall intensity. The resource that provides us information about the rainfall intensity is rain gauge and is located on the roof of University Library.
Rain gauge is joined with its own concrete foundation using a steel rod. Flat roof helped us fixing the rain gauge into horizontal position which is the first condition for receiving correct data. We use recording heated rain gauge for all year round measuring. There are known unheated rain gauges as well used for limited part of year when the temperatures aren't so low. Heated rain gauge is used for measuring liquid precipitation (rain) and solid precipitation (snow) as well. Rain gauge is made of stainless material. Rain gauge's round catchment area is 200 cm^2 and its function is based on tipping bucket mechanism. Tipping bucket is located inside the rain gauge body right under the funnel outlet. Rain or snow fall down the funnel outlet into the divided bucket. The bucket does not move until it is filled with calibrated 0.2 mm amount of water, then it tips and second half of bucket can be filled with rain water. When the bucket tips it empties the liquid from the half of the bucket into a drainage hole. Tipping bucket is made of plastic with very thin layer of titanium and it is hanged on stainless steel axial holder. Tipping continues according to the length of rainfal [5,6,8].

Figure 1 represents the measured monthly rainfall totals during our research. Data are presented for the period August 2011 to December 2014.

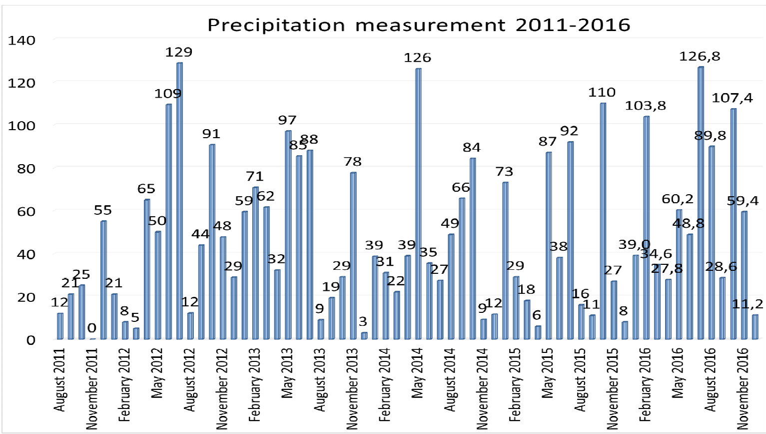

Fig. 1. Measured monthly rainfall totals during August 2011 – December 2016

Figure 2 represents view of the Technical University of Kosice campus site in Kosice-city. Blue rectangles indicate school buildings for all faculties of Technical University of Kosice.

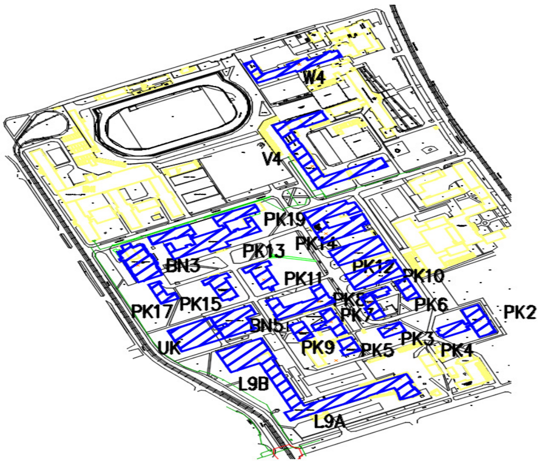

Fig. 2. TUKE campus

A planned situation of rainwater management in TUKE campus consider about replacing of traditional rainwater drainage into the sewage system by the use of rainwater in the school buildings. All of school buildings respectively the roofs of these buildings in TUKE campus (figure 3) represent a potential source of rainwater for non-potable purposes especially for flushing toilets [7].

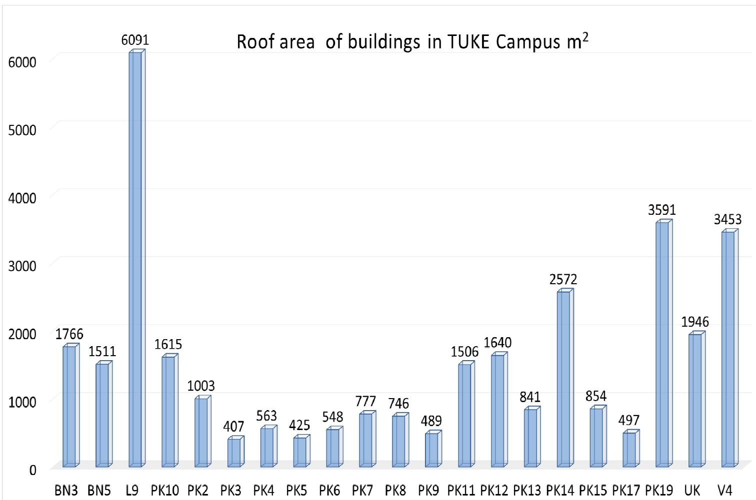

Fig. 3. Roof areas (m2) of buildings in TUKE campus as o potential source for RWH

According our measurements of monthly rainfall totals, figure 4 represent theoretical monthly volumes of collected rainwater from roof areas of buildings in TUKE campus. Data are presented for the period August 2011 to December 2016.

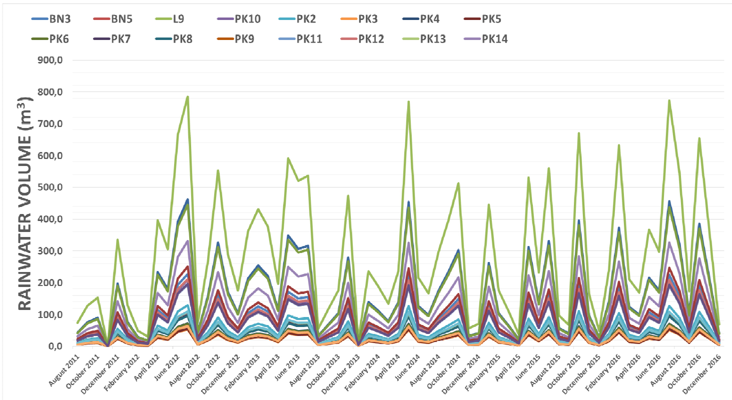

Fig. 4. Theoretical monthly volumes of collected rainwater from roof areas of buildings in TUKE campus during our research August 2011 – December 2016

2.2. Measured data

We have started our research and own measurements in scope of stormwater quantity and quality parameters at the campus of Technical University of Košice within the project relating to the management of stormwater. The objects of research represent two infiltration shafts in the campus of TU Kosice that were made before the start of our research. These infiltration shafts represent drainage solution for real school building PK6 and all of the runoff rainwater falling onto the roof flows into these underground shafts [6,10]. Data of rainwater inflow provide us information about real rainwater volumes from roof construction of PK6 building.

Table 1 summarizes the measured monthly rainfall totals with corresponding theoretical volumes of collected rainwater and comparison with real volumes of collected rainwater from our measurements. Data are presented for the period April 2012 to December 2015. (data are present from April 2012 because at that time began measuring of the flow from all roof area of the building PK6 and precipitation measurements simultaneously) (Notice: August 2012 without data due to equipment failure) [11].

Table 1. Monthly rainfall totals with corresponding theoretical volumes of collected rainwater and real amount of rainwater from roof of PK6 building (548 m^2)

Month	Rainfall (mm)	Theoretical volume from 548 m^2(m^3)	Real volume from 548 m^2(m^3)
April 2012	65	35.6	26.7
May 2012	50	27.4	18.9
June 2012	109	60.0	40.8
July 2012	129	70.6	49.6
August 2012	12	6.7	-
September 2012	44	24.0	17.9
October 2012	91	49.6	36.5
November 2012	48	26.1	16.9
December 2012	29	15.8	12.1
January 2013	59	32.6	19.9
February 2013	71	38.8	23.5
March 2013	62	33.8	22.8
April 2013	32	17.6	11.8
May 2013	97	53.2	30.6
June 2013	85	46.8	30.2
July 2013	88	48.2	36.6
August 2013	9	4.9	3.8
September 2013	19	10.5	8.9
October 2013	29	15.9	13.7
November 2013	78	42.5	38.4
December 2013	3	1.6	1.3
January 2014	39	21.2	10.9
February 2014	31	17.0	12.4
March 2014	22	12.1	8.3
April 2014	39	21.3	13.3
May 2014	126	69.2	44.9
June 2014	35	19.4	12.6
July 2014	27	15.0	13.9
August 2014	49	26.7	20.8
September 2014	66	35.9	-
October 2014	84	46.1	-
November 2014	9	5.0	4.1
December 2014	12	6.4	4.7
January 2015	73	40.0	22.9
February 2015	29	15.9	8.9
March 2015	18	9.9	4.8
April 2015	6	3.3	2.1
May 2015	87	47.7	19.9
June 2015	38	20.8	11.0
July 2015	92	50.5	23.3
August 2015	16	8.8	3.9
September 2015	11	6.0	4.1
October 2015	110	60.3	35.6
November 2015	27	14.8	7.9
December 2015	8	4.4	2.2

3. Potential for runoff infiltration

As was mentioned above we have started our research and own measurements in scope of stormwater quantity and quality parameters at the campus of Technical University of Košice within the project relating to the management of stormwater. The objects of research represent two infiltration shafts in the campus of TU Kosice that were made before the start of our research. All measured data during our research show, the total infiltration of rainwater runoff inflow into the infiltration shafts from roof of PK6 building take place at the same time of duration of rainfall events, respectively very short-time after.

This represents a high infiltration rate of this infiltration shafts. It is given by the coefficient of infiltration of soil at the bottom of shaft. If we compared size of area for infiltration of runoff with other types of infiltration facilities (for example infiltration boxes) this size is several times smaller against other types of infiltration facility. But the infiltration coefficient of surveyed infiltration shafts $k_f = 1.10^{-3}$ m/s [3] ensures safe disposal of surface runoff [6,9,10]. The maximum water level at the infiltration shaft A, measured during the research period is 2.48 m, which is cca 1/2 filling depth of infiltration shaft A and maximum water level at the infiltration shaft B, measured during the research period is 1.31 m, which is less than 1/3 filling depth of infiltration shaft B too. Maximum water levels during a research are shown in figure 5. (notice: part of roof construction was unconnected what result to lower volumes of rainwater from year 2015).

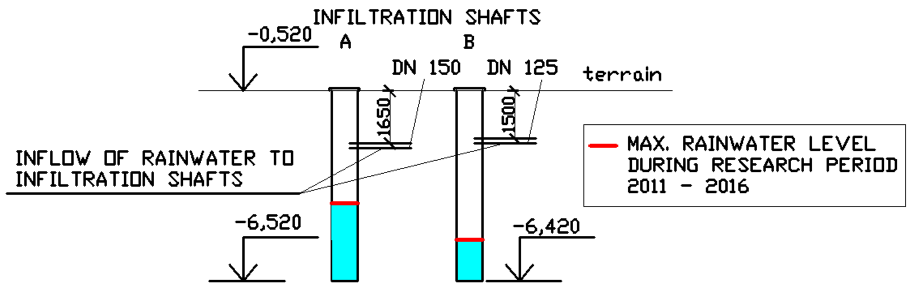

Fig. 5. Infiltration shafts and maximum water levels during the research

Application of RWH systems in TUKE campus has a big potential from environment, technical and financial point of view. Rooftop RWH potential in the TUKE campus as well as appropriate conditions for infiltration of rainwater is promising and could be applied on a larger scale for later beneficial use. Rainwater management in educational type of building has not only financial benefits but also educational and ethical benefits. Education of students leads to awareness of value of potable water and would avoid of wasting precious potable water which is used for example - for flushing toilets in our society. Further studies are recommended to quantify the economic value and environmental impact related to the application of RWH in the study area.

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