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Use of Alternative Water Sources Based on the Multi-Dweling Urban Building 2030

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Abstract
Fresh water is a very high quality resource, and as such represents only 2.5% of the total quantity of all water in the world. Because of growing world population, increase of human lives comfort and the economic growth we have observed continuous increase of water consumption for past years. Due to these facts, we experience accelerating interest in alternative sources of obtaining potable water. One of the ways of saving this scarce resource is using rainwater.
The dynamic development of the construction and implementation of new technologies in the European Union caused certain legal problems in Poland as it comes to putting certain buildings into use and the usage of rainwater. Lack of coherent legislation blocks the introduction of innovative solutions that enable the recycling of natural resources, to which drinking water is classified. Today's construction industry focused on minimizing energy and materials forgets about the possibility of the integration of available solutions when it comes to designing water management system. Key features of the system include the supply of drinking water required for cooking, drinking, washing, personal hygiene, and its re-use, reducing the burden on sewage and drainage network. Traditional systems based on the consumption of fresh water limit the design options and do not consider the usage of rainwater. The paper describes the legal arrangements concerning the recycling of rainwater existing in Poland as a member of the European Union based on example of the new Urban Building in Warsaw.

Keywords – rainwater, non-potable water, water harvesting system, HSR, Poland, regulations

1. Introduction

The phenomenon of rain is a part of natural water cycle in the Earth environment. It is necessary to sustain life and at the same time optimises the recycling of natural resources. Excessive industrialization causes climate change disrupting natural processes, resulting in drought or very intense rainfall. Municipal sewer network during torrential rains are not able to collect such a large amount of water, which is why more and more often we hear about floods or flooded areas. This is particularly true in urban agglomerations, as they significantly reduced the ratio of green areas compared to number of buildings. One of the major problems to be solved is capturing and storing excess rain to use it in the building or its surroundings or slowly release it to the urban network during periods of drought.

In recent years, we can see increased interest in innovative technologies for the recovery of rainwater, particularly in new office buildings, but also residential flats, which is described later in this article based on a building realised in Poland as an example. At the same time, we can observe opening up to new technological solutions, especially due to the investors' needs in the field of environmental rating methods of newly constructed buildings using the available tools such as Leadership in Energy and Environmental Design (LEED), The Building Research Establishment Environmental Assessment Methodology (BREEAM), The Hong Kong Building Environmental Assessment Scheme (HK-BEAM). Conducting such an assessment makes the water systems including alternative technologies for the recovery of rainwater designed inside buildings meet the increased requirements for efficient use of drinking water along with utilization of its alternative sources, when possible. Another factor contributing to the implementation of good practices is introducing of restrictions by local authorities on the direct rainwater management on the property, which enforce measures for the efficient use of natural resources.

The problem of rainwater management is included in the idea of sustainable development, especially in relation to the 7th basic requirements of the "Sustainable use of natural resources" – Regulation of the European Parliament and European Council (EU) No 305/2011 [15] laying down harmonized conditions for the marketing of construction products.

Re-use of rainwater in buildings and their surroundings brings savings in fees for the use of drinking water with high quality parameters, and a positive impact on the respect of available natural resources.

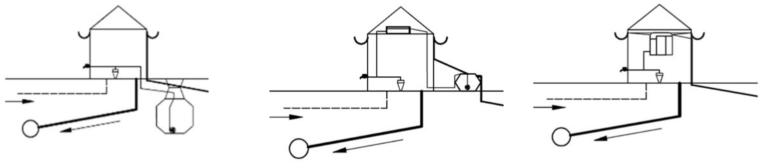
Only legal- and investment-friendly environment as well as change of users' consciousness will let re-using rainwater where no high quality water is required.

2. Rainwater harvesting systems

Rainwater from urban areas can be discharged in a conventional sewage system (for rain or general purposes) or it can be re-used where it emerges. For this purpose, a variety of technological solutions, starting from the construction of retention reservoirs through the installation of internal water systems enabling faucets with not potable water e.g. for flushing toilets, watering green spaces, up to design so-called "green roofs" that reduce the amount of discharged rainwater into sewerage. There are different installation systems for the recovery of rainwater, from the simplest based on the structure: tank-filter-valve-pump, to more complex equipped with devices capable of maintaining the required quality and bacteriological parameters. The exemplary parameters are shown in Table 1 and Table 2. When designing the systems supplying not potable water (in this case recovered rainwater), one must bear in mind, for what purposes it will be intended, because it determines the selection of a proper system. Figure 1 below shows the most frequently occurring installation solutions for direct or indirect use of rainwater in the building or its surroundings:

- direct installation suppling the taps from the reservoir (Fig.1 a.)
- indirect installation suppling the taps using gravity (Fig.1 b.) or intermediate reservoir (Fig.1 c.)

Selection of the system supplied by rainwater is usually dictated by a calculation of water consumption for household purposes as well as the size and location of the building. Especially for larger buildings, the choice of the system should be planned at the very first stage, because it is necessary to design enough room for bulky storage tanks.



a. direct installation suppling the taps from the reservoir

b. indirect installation suppling the taps using gravity

c. indirect installation suppling the taps using intermediate reservoir

Fig.1 Exemplary solutions (based on BS 8515 standard)

The simplest installations for the rainwater recovery consist of the following components: a filter for trapping solid material (leaves, twigs, stones, etc.), a storage tank (below-ground or on-ground), a pump and a control valve. In case of using rainwater in a small space a single tank with the simplest instrumentation (watering hose, dosing pump) can be sufficient but for more complex installations such as flushing toilet supply, installations must be protected in an appropriate manner, so as to obtain adequate quality of rainwater and not to bring risk to the users' health (see Tables 1 and 2). The proposed values of bacteriological and quality parameters summarized in Tables 1 and 2 are based on the standard BS 8515 [14] for not potable water dedicated to flushing toilets, watering gardens, pressure washers and garden sprinklers. The threshold values shown in Table 1 indicate that for garden watering (using watering hoses) or flushing toilet, water containing Eserichia coli or Enterococci bacteria can be used, while the bacteria must be almost completely eliminated if rainwater is to supply pressure washers or garden sprinklers. This is because of the mist that is formed when watering using such devices which can carry much more dangerous bacteria than water drops produced by a garden hose. Similar results can be observed in relation to Legionella. This parameter might be negligible considering flushing toilets, but in the case of using pressure washer and garden sprinklers it must be taken into account.

Table 1 Acceptable values of bacteriological parameters for residential buildings

Parameter	Unit	Threshold values (depending on the usage)	
		pressure washers, garden sprinklers	gardens watering, flushing toilets
Escherichia coli	number in 100 ml	1	250
Intestinal enterococci		1	100
Coli index		10	1000
Legionella	number in 1 dm^3	100	-

Table 2 Acceptable quality values depending on the type of system

Parameter	Threshold values	Type of system
Dissolved oxygen in the retained water	> 10% saturation or >1 mg/l O_2	All applications
Suspended solids	clear water without floating particles	
Colour	colourless	
Turbidity	< 10 NTU* < 1 NTU disinfection UV * NTU – Nephelometric Turbidity Unit	
Bromate	< 2 mg/l	
pH	5 – 9	residential buildings
Chlorate	< 0.5 mg/l	garden watering
	< 0.2 mg/l	other uses

Regardless of the final assignment of the recovered rainwater, the recommendations for storage of non-potable should be followed in order to prevent the bacteria growth due to excessive stagnation caused e.g. by oversized tanks. When designing rainwater recovery installations, it is recommended to predict proper equipment to ensuring adequate water quality which will protect human health against the development of bacteria and algae, and the ingress of solid contaminants, e.g. leaves, stones, small twigs, debris, etc. To collect rainwater from the areas such as roofs or terraces a collection of different equipment is used: drains, gutters, eaves, platforms and drain lines described in standards PN-EN 12056 [11], [12], [13].

Storage of rainwater should be done using products that are specially designed for this purpose and their technical properties have been confirmed by the appropriate tests before marketing. The tests cover among others, the waterproofness integrity, strength and durability. An important element of the rainwater recovery are devices enabling current monitoring and control. In the complex installations the control systems allow continuous monitoring of water consumption, operation of the pumps and level sensors, as well as detecting possible failures.

Another important element of the entire system are pumps, which should be suitable for the particular type of application and even designed for this purpose, taking into account the temperature conditions under which they will operate and their depth of immersion. Available technological systems allow the pumps to be mounted inside or outside the tanks (their choice is up to the designer). Nevertheless, it is recommended to use the submersible, centrifugal pumps. During the process of selection of the appropriate pump, one needs to pay attention to its power consumption and noise levels.

3. Description of rainwater recovery system in The Multi-dweling Urban Building 2030 – example

In recent years, in large Polish urban areas, it is more and more difficult to obtain permission to join the municipal sewage, rainwater or general systems without rainwater harvesting solutions used in the building or its surroundings. The situation is caused by several factors, for example – a small diameter of storm sewer and congestion of the network during torrential rainfall, which are becoming more common throughout the country. As a result, the existing networks are not able to quickly collect excess water fed from the affected area.

A description below is based on the existing residential building completed in Warsaw (Poland) in the dense urban area. The building has a different height from four to six residential floors (including 70 flats and apartments), the ground floor for technical and maintenance rooms and two levels of underground garages with technical rooms. There are also small architecture objects, greenery and paved surfaces (pavements, patios) around the building. During the construction phase the geotechnical studies were performed, which revealed water level approx. 5.3 – 5.7 m below ground. The main characteristics of the building is: 3007.00 m^2 of land area, 666.89 m^2 of roads, squares and sidewalks, 805.99 m^2 of greenery including 622.36 m^2 of natural land, 183.63 m^2 of garage surface, which gives a rain harvesting active area ratio of 26.80%.

The facility was funded under the programme aimed to create a project "Multi-dwelling Urban Building 2030". Its construction has been carried out by company Mostostal Warszawa and research units: Building Research Institute and Civil Engineering Dept. of Silesian University of Technology. Research activities were focused on new construction, material and system solutions allowing erecting energy-efficient, environmental friendly and user-friendly multi-dwelling buildings. The project represents a holistic approach to the improvement of technical and functional performance of buildings enclosing cooperation of civil construction, acoustics, architecture, installation, renewable energy and building physics scientists.

For the described building it was assumed that the local reuse of rainwater will relieve the sewer network during the rains, protect groundwater from the harmful effects of pollution and will provide the non-potable water for flushing toilets or watering the greens. For this purpose, a separate rainwater recovery system equipped with an emergency potable water connection (in case of failure or lack of rainfall) has been designed together with the appropriate tank for storing rainwater installed in the garage area. Anticipating the possibility of temporary shortages of rainfall, the storage tank with the additional urban water supply has been designed. For the safety purposes, the protection against contamination of the water supply system using an air gap has been introduced as well. Moreover, the storage tank has been equipped with an overflow protection.

Due to the existing environment conditions it was assumed that rainwater would be collected only from roofs and terraces meaning only surfaces finished with materials that have no negative impact on the quality of the precipitation (fixed fraction pebbles, decking, sheet). Rainwater running off the paved surfaces has been excluded due to the possibility of excessive load of harmful substances.

Installation of rainwater drainage system in the described building is supported by internal downspouts, and it was equipped with roof drains with heating system protecting against freezing in winter. Internal pipes supplying non-potable water (recovered rainwater) are made of tubes with different colour to distinguish the installations from drinking water.

The calculations performed for the needs of the rainwater recovery system have taken into account the following parameters: lift height of the hydrophore system – 53 m, outflow pressure, pressure losses (total, local, on the water meter, etc.), presence of the anticontamination valve, unexpected resistance, and water column.

Fig.2 The multi-dweling Urban Building in Warsaw/Poland (photo by M. Lipska)

Fig.3 Rainwater harvesting sysyem (storage, filters) in the multi-dweling Urban Building in Warsaw/Poland (photo by M. Lipska)

4. Regulations in Poland

Poland does not have consistent regulations on the re-use of rain water in buildings, while countries such as Germany, Great Britain and Canada have developed their own guidelines and standards to be applied.

By the end of 2015, Poland has not introduced legislation on issues such as water recovery and rainwater use inside buildings and their surroundings as it can be found e.g. in the British standard BS 8515 [14]. However, the good news is that in 2016, the work has been undertaken in the Polish Committee for Standardization [21] on the introduction of standards covering the above mentioned issues.

So far, unsettled legal status in Poland continuously has been raising concerns of future users about the introduction of rainwater (other than drinking water) for indoor use. In the current situation we have only the laws related to drinking water and as such are not directly applicable to rainwater.

The Polish provisions stipulate that drinking water is needed for cooking, preparation of meals, food production and maintaining personal hygiene – hence, it should be free of pathogens, parasites, chemicals, be colourless, odourless, transparent, with possibly constant temperature and meet the requirements of the Regulation of the Minister of Health of March 29th 2007 on the quality of water intended for human consumption.

The Polish standard PN-EN 12056 [11] defines the concept of drinking and non-potable water used for domestic purposes in residential or non-residential buildings as:

- non-potable water – water used for flushing toilets, washing machines, watering the garden, maintenance of common areas;
- potable water – water used to supply: sinks, faucets, bathtubs, bidets, urinals, showers, dishwashers.

The Regulation of the Minister of Environment on conditions to be met when introducing sewage into the water and soil and on substances particularly harmful to the aquatic environment [18] identifies when rainwater does not affect the deterioration of the environment and the situations in which they become sewage. It was assumed that rainwater and snowmelt from the roof areas should not be considered as sewage, which allows you to enter them directly into water or earth without pre-treatment. This provision thus enables the acquisition of precipitation directly from the roofs and then its re-use (as in the building described in section 3), however the same regulation [18] does not apply to the required degree of wastewater treatment before its entering the building and the effectiveness of the products used for the treatment.

Polish regulations [16] do not refer to the use of non-potable water in sanitary installations and the required level of security protection system either, but at the same time it allows using rainwater collected in storage tanks, provided a separate installation, detached from the drinking water system is made. Further on, no requirements regarding the quality of rainwater used in the above case have been specified and the Regulation of Ministry of Health [17] refers only to drinking water and as such – does not apply to rainwater used for supplying flushing toilets or garden sprinklers.

The lack of consistent standards and rules in Poland on the re-use of rainwater in buildings slows down the implementation of proven systems to use inside buildings without risk to the health of future users, but in recent years thanks to existing regulations in other EU countries that can be applied in Poland, we find that this is no longer a blocking agent.

5. Conclusions

The popularization of technological solutions used for the efficient use of rainwater and the removal of legal barriers for alternative sources of water in city buildings and their surroundings significantly affect the protection of valuable natural resources including drinking water.

Contributing factors are: the need for environmental assessment of buildings, local authorities who block direct discharge of rainwater into the municipal sewage system, increase of users' awareness for efficient use of water as well as economic development in new production areas. With regard to the last factor, we note that Polish companies bring innovative technological solutions for the recovery of rainwater to the market every year.

Financing of international and domestic projects enables the realization of sustainable construction for the protection of scarce and precious natural resources, through forced and thoughtful use of the environment in a way not to cause its degradation leading to irreversible changes, because the construction and operation of buildings are the cause of 42% of final energy consumption in the EU, 35% of emissions of greenhouse gases into the atmosphere, as well as a significant consumption of water. In many cases we managed to carry out projects that without additional financial support could not have been implemented, because they go beyond the current regulations – an example of which is the realization of the water system for recycling rainwater in apartment building in urban areas [22].

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