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RAINWATER IN INDIVIDUAL HOUSEHOLDS

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Abstract: The management of rainwater, especially during heavy rains, is important because this water does not require treatment in a municipal wastewater treatment plant and has completely different loads than municipal wastewater. Heavy rainfall, which has become more frequent in recent years due to climate change, often leads to flooding in cities.

We propose to present aspects related to the management of rainwater, to present solutions for the drainage of this water from individual plots, possibilities of using it for various domestic purposes or its infiltration into the soil to enrich the groundwater reserve. The proposed solutions do not require large investments, they are simple and ecological.

Keywords: rainwater, retention basin, individual households

1 INTRODUCTION

Atmospheric precipitation falls on the ground surface in liquid form (rain) or in solid form (snow, sleet, hail). Liquid precipitation is important in the drainage calculation. It leads to the formation of flows much higher than those generated by snowmelt. Depending on their intensity and duration, rainfall is classified as weak to moderate rain and heavy rain to showers Weak rainfall has a long duration but low intensity, and a shower has a high intensity and a short duration. These showers are used when determining the discharges necessary for the dimensioning of sewers. In recent years we observed that due to climate change, we have long dry periods followed by heavy rainfalls. The phenomena become extreme even when the average annual rainfall has not changed significantly.

Intense urbanization has also changed the nature of the surfaces in the territory of a locality. The appearance of extensive impermeable or partially permeable surfaces (such as roads, alleys, car parks, roofs, etc.) has led to an increase in the average runoff coefficient. This means that we are moving further and further away from natural drainage conditions. In other words, large volumes of water are discharged into the public sewerage network because rainwater does not naturally penetrate the soil. Since rainwater washes various surfaces (roads, car parks, roofs and other surfaces on which dust and pollutants settle), it cannot be considered as a conventionally clean water. In separate sewerage (where rainwater is discharged separately from wastewater), rainwater must be treated before being returned to the natural cycle. In unified sewerage, where rainwater is discharged together with wastewater, the entire volume of water is treated in the municipal sewage treatment plant. However, this requires large-capacity sewage treatment plants. Of course, transport and treatment costs also increase. However, the major disadvantage of the unified sewage system is that it combines two bodies of water of different nature that require different treatment, [1], [2].

2 FOR WHAT PURPOSES CAN WE USE RAINWATER IN OUR HOUSEHOLD

Using rainwater in our household does not necessarily bring significant financial savings. The problem is rather in protecting drinking water resources by using rainwater for uses where drinking water quality is not necessarily required, [3], [4].

Possibilities of using rainwater

Irrigating your own garden and/or maintaining green spaces on your personal plot or public domain. This is the most justified and at the same time simplest use of rainwater collected on your own plot. If we limit ourselves to this use, the investment is extremely low. It consists of a collection tank and a water distribution system. Water distribution can be done by free flow or by pumping. If high pressure is required, a pump is necessary. If the collection tank is located above the ground the flow can be free. The only obstacle to this solution is that in winter the water consumption for agriculture is low, even zero. In this situation the precipitation must drain into the public sewer, and the collection tank must be prepared for the cold period. If the tank is above ground, it must be emptied, as there is a danger of it being destroyed by ice. Underground tanks will not be emptied, but they must be provided with an overflow from the construction, so that the surplus water drains into the public sewer network. A simple installation is shown in figure 1.a [3] and 1.b.



Figure 1.a Plastic tank placed above a gutter covered with a grate.

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FIgure 1.b Plastic tanks connected with siphon pipes.

Washing machine. This possibility exists and is exploited in many European countries, where tanks are sold for capturing and clarifying water, image 2. Rainwater has the advantage of being water with a very low hardness, ideal for washing (less detergent consumption). The low water hardness also extends the life of washing machines. The obstacle is that rainwater contains impurities of organic and mineral nature. These come from the collection surfaces but also from atmospheric dust.

Toilet and other household maintenance. For flushing the toilet and other household maintenance, drinking water quality is also not needed. Periodic sanitation of sanitary objects should not be neglected due to the impurities that are deposited. Rainwater does not contain chlorine (like drinking water), which leads to the rapid formation of germs. After a long storage the water becomes cloudy and generates an unpleasant smell (due to biological activity).

Of the total water consumed in the household, studies have shown the following proportions of household consumption, [6], [7], Table 1

Table 1 Proportions of household water consumption

Personal hygiene	36 %	Drinking water only	47 %
Drinking and cooking	5 %	Drinking water only	
Dishwashing	6 %	Drinking water only	
Toilet	33 %	Could be rainwater	53 %
Washing machine	13 %	Could be rainwater	
Other	7 %	Could be rainwater	

Personal hygiene 36 % Drinking water only 47 %
Drinking and cooking 5 % Drinking water only
Dishwashing 6 % Drinking water only
Toilet 33 % Could be rainwater 53 %
Washing machine 13 % Could be rainwater
Other 7 % Could be rainwater

It can be concluded that half of the amount of water used in a household can be water of lower quality than drinking water.

Figure 2 shows the composition of a complex installation for capturing rainwater for its use. The tank can be made modular, with the possibility of expansion. Tank and pipes are made of recyclable plastic materials. The installation includes [3]:

- storage tank;
- connection on the collection surface (roof of house, garage, annexes);
- filter and overflow equipped with a siphon, (with connection to the public sewer or to a water infiltration system in the ground);
- sampling system with a pump to ensure pressure in the household installation.

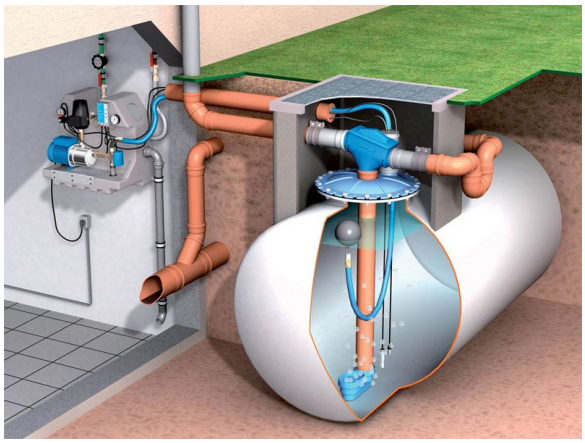


Figure 2. Complex rainwater collection system with pump to ensure pressure in the domestic installation and connection to the public sewer.

Where and how is rainwater collected. When it comes to using rainwater, it must be collected from clean surfaces. In the domestic environment, these surfaces are roofs. If possible, roofs facing north will be chosen, because moss does not settle on these surfaces.

3 FACTORS THAT INFLUENCE THE QUALITY OF COLLECTED WATER

The main factors that influence the quality of collected rainwater are, [4]:

- the surfaces from which it is collected, “clean” surfaces are recommended;
- the possibility of the system to separate solid particles from the water, (by filtration and sedimentation);
- protection of the tank against the penetration of light, (light leading to the formation of algae);
- protection of the tank against gases from the public sewerage, (protection achieved by an appropriate siphon);
- protection of the tank against the penetration of insects or rodents;

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- the method of sampling water from the tank, (the deposits on the bottom of the tank must not be disturbed);

- periodic inspection and maintenance of the installation, evacuation of deposits from the bottom of the tank.

On the other hand, it is not recommended to collect rainwater from, [4]:

- roofs whose coverings contain asbestos cement;
- grassy roofs;
- bituminous roofs;
- metal roofs, (Zn, Cu);
- roofs heavily loaded with dust, (industry, car traffic);
- road surfaces.

Manufacturers offer a very wide range of such installations, from the simplest ones, image 1.a and 1.b, consisting of tanks located near the drainpipes, to complex installations, like the one in figure 2. We consider that it is a wrong recommendation to establish the volume of the tank according to the number of tenants (beneficiary). The – theoretical – reserve of water from precipitation that can be collected actually depends on the size of the collection area and the precipitation regime in the area. A calculation model for a retention basin is presented in the next chapter.

4 REDUCING DIRECT RUNOFF OF RAINWATER FROM YOUR OWN PLOT

Direct runoff of rainwater from a plot can be achieved by retaining the volume of water, (even the entire volume), and using the water in the household, (as shown in the previous chapter), or infiltrating it into the soil. The problem arises of determining the volume of a retention basin for a calculated rainfall according to the regulations in force.

A plot with a total area of St= 600m2 is considered (the usual area for a house lot in newly built areas, bordering cities). A division of this area, depending on the runoff coefficients "Φ", would be:

S_{grass}	350 m^2	$\Phi_{grass} = 0.05$
S_{roof}	150 m^2	$\Phi_{roof} = 0.95$
S_{alley} (made of tiles with joints filled with sand)	100 m^2	$\Phi_{alley} = 0.6$
S_{total}	600 m^2	$\Phi_{average} = 0.36$

The average runoff coefficient is the weighted average of the individual runoff coefficients on the component surfaces, [1], [2].

$$\Phi_m = \frac{\sum_{i=1}^{n} S_i \cdot \Phi_i}{\sum_{i=1}^{n} S_i} \qquad (4.1)$$

and duration of the theoretical design rainfall

$$t_p = t_{cs} + \frac{L}{60 \cdot v_i} \qquad (4.2)$$

where:

t_{cs} represents the superficial concentration time in minutes;

L is the length of the canal section for the evacuation of water from the respective lot, in meters;

v_i is the water flow speed in the canal, in m/s.

Considering, for lowland areas, t_{cs}= 12min, the length L= 40m, (corresponding to a lot of S= 600m2), and v_i= 0.70m/s, (corresponding to the self-cleaning speed), the resulting rain duration is equal to:

t_p= 12+ 40/(60·0.7)= 13 min. A minimum time for sizing will be considered tp= 15min.

According to [5], for the territorial area 13 and the design rainfall frequency f=1/5 (urban area with up to 100000 inhabitants) and f=1/10 (urban area with over 100000 inhabitants), the design rainfall intensities will be i= 210l/s·ha and i= 260l/s·ha.

The rainfall for the two situations:

$$Q = m \cdot i \cdot S_t \cdot \Phi_m \qquad (4.3)$$

f	m [-]	i [l/s·ha]	S [ha]	Φ_m [-]	Q [l/s]
1/5	0,8	210	$600 \cdot 10^{-4}$	0,36	3,52
1/10	0,8	260	$600 \cdot 10^{-4}$	0,36	4,49

(the reduction coefficient m was considered to be 0.8)

Multiplying this flow rate by the duration of the rain results a volume of the retention basin, V= Q·tp:

f	Q [l/s]	V [m^3]
1/5	3,52	3,17
1/10	4,49	4,04

This means a volume of 4.00m3, corresponding to a rain shower. For domestic use, the volume of water is smaller, taking into account only the "clean" surfaces for collection. The calculation presented can be easily adapted for other surfaces, different in size and nature.

The solutions for infiltrating water from precipitation into the soil and enriching the groundwater are multiple. Their presentation goes beyond the scope of this paper. A simple infiltration gutter is shown in figure 3.



Figure 3 Gutter for rainwater infiltration into the soil, made of perforated tiles.

5 ADVANTAGES AND DISADVANTAGES OF USING RAINWATER

Some advantages of using rainwater in the household:

- reducing the consumption of drinking water from the network;

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- using water with very low hardness;
- reducing the amount of water discharged into the public sewer network, this aspect is particularly important when wastewater is channelled together with rainwater;
- refreshing the groundwater by using rainwater for garden and green space maintenance;
- the installation is simple to do, and can be done by the owner (DIY);
- creating a water reserve for dry periods.

Disadvantages of using rainwater:

- rainwater is not drinking water, even if it is conventionally considered clean;
- rainwater cannot be stored for a long period due to biological impurities;
- storage tanks are large and require adequate hydraulic equipment;
- the need to pump the stored water from the tank for use;
- due to climate change that has led to the formation of high intensity but rare rainfall, the resulting storage tanks must be of large volume;
- the need to expand the water supply network inside the building, the two networks, the drinking water and the rainwater networks, serve common objects but are not allowed to interfere;
- the rains are acidic in nature (in the region analysed by the author, many rains had a pH close to 5.5);
- the use of a hydrophore is not recommended due to the biological impurities of rainwater;
- in the case of photovoltaic panels mounted on roofs (which have become increasingly common lately), which must be periodically cleaned with chemicals, these detergents will be found in the storage tank.

5. CONCLUSIONS

The solutions presented above, even if they are very simple, also contribute to avoiding urban flooding due to shower rains.

The use of rainwater in the household is justified, even if from an economic point of view there are no immediate advantages.

Public sewage cannot be dispensed with, regardless of the solution adopted. The volumes of water collected in the event of showers are large, and not all collection surfaces can be considered clean.

It is recommended to experiment with simple installations, even improvised ones, at least for garden and lawn maintenance.

Creating a water infiltration basin in the soil is also an interesting experiment that can be carried out by the owner (DIY). Such a basin can be very nicely integrated into the garden. The overflow pipe should not be omitted. It prevents flooding of the basin in the event of a rainfall exceeding the design rainfall.

The need to enrich the groundwater is a necessity at the current stage, especially due to intensive urbanization. Infiltration of rainwater from individual plots is one of the possibilities to achieve this, while reducing the amount of rainwater discharged into the public sewer network. Infiltration of rainwater into the soil is not always possible. For example, in cases of clay soils, high groundwater levels or the vicinity of old buildings without foundation waterproofing.

To reduce construction costs and make better use of available space, such an installation can be executed and operated by several neighbours.

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