Greywater and Rainwater Management in Buildings

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Keywords: Management, greywater, rainwater, wastewater, treatment, MBR, quality.

The concept of reusing wastewater and rainwater in buildings has recently become more important. There are countries where the use of greywater in some buildings has already been made mandatory (e.g. in Japan for toilet flushing). Such measures are gradually being introduced in the EU, where water recycling projects exist for office buildings and hotels. The Czech Republic lacks experience and resources for the design of such recycling systems. The article is based on TAČR project No. TA01020311, titled “The use of grey and rain water in buildings”, and summarizes basic information about the quality of greywater, and methods of treating it and recovering its heat.

Introduction

The reduced quality and yield of surface and ground water caused by droughts and changing climatic conditions has given rise to the concept of reusing waste and rainwater directly at its source, i.e. in buildings. This concept is based on the use of alternative water resources, which do not always need to adhere to the same strict parameters as drinking water. There are countries where the use of greywater in some buildings has been already made mandatory (e.g. in Japan for WC flushing). These trends are also gaining a foothold in the EU and such systems are becoming a necessity in southern Europe and in the Middle East, where many areas are beginning to suffer from a lack of drinking water: recycling systems are cheaper than sea water treatment. They are also appearing in projects aimed at office buildings and hotels in Central Europe. In the Czech Republic, the experience and resource materials needed for the design of such systems are currently lacking.

Project Introduction

This article presents issues dealt with in TAČR project No. TA01020311, titled "The Use of Grey and Rain Water in Buildings." This project is being implemented by Brno University of Technology and by ASIO spol. s.r.o. under the ALFA program of the Technology Agency of the Czech Republic. The project objectives are as follows [1]:

- to prepare MBR technology for the treatment and subsequent use of grey and rain water to be rolled out in the market in practical applications;
- to evaluate the optimal scale of water recycling in specific types of building and determine the extent of sanitation facilities required (recommended technical equipment) for various usage types;
- to determine the technical conditions for the use of greywater;
- to verify the functionality of a prototype.

The Issue of Greywater and Rainwater

The use of greywater in buildings is not a new concept, but a means for environmental water management. A greywater system collects greywater even before it flows into a sewer, septic tank or wastewater treatment plant. Greywater, i.e. water from showers, washing machines and washbasins, is not usually extremely polluted. It requires basic purification processes, such as degreasing, filtration, sedimentation, sanitation and disinfection. Water thus treated may be used as service water for toilet flushing and the irrigation of gardens or green areas. Greywater from households accounts for up to 35% of total water consumption. Relatively clean greywater is produced in large volumes in buildings such as hotels, schools, restaurants, hostels and other public facilities.
Rainwater may also be used, and can be collected from impervious surfaces, particularly roofs. The treatment of rain water consists of basic purification processes such as sedimentation, filtration and sanitation. Rainwater usually contains fewer pollutants than greywater. However, the rainwater system is strongly dependent on rainfall, climatic conditions and the storage tank size. For the above reasons, rainwater and greywater should be used in a combined system.

Greywater and Rainwater Quality

Since the quality of greywater is not addressed by any standards in this country, one needs to look at sources existing abroad in this field. According to DIN 4045, greywater is municipal water without any feces and urine. It may therefore be classified into 4 categories, namely unseparated greywater, greywater from kitchens and dishwashers, greywater from washing machines and greywater from washbasins, baths and showers [2].
The greywater pH values range between 7 and 8 for municipal water, 9.3 and 10 for greywater with a portion of water from washing machines, and 5 and 8.6 for greywater from bathrooms and kitchens.
The temperature of greywater from washing machines varies between 28 and 32°C, and that from baths, showers and washbasins between 18 and 38°C, as warm water is used for sanitary purposes.

Floating substances may be noticed in greywater from kitchens and dishwashers. Table 1 shows COD, BOD_5, suspended solids and pH values, the ratio of which is usually 4:1. This indicates a relatively high proportion of quite poorly degradable organic substances.

Table 1. BOD_5 and COD values in greywater [2]

Source of greywater	Washing machines	Baths, showers, washbasins	Kitchens, dishwashers	Unseparated greywater
BOD_5 [mg/l]	50-700	20-210	650-780	40-200
COD [mg/l]	300-400	60-800	20-1600	500-700
SS	70-300	5-140	130-1250	80-800
pH	9,2-10	5-8,6	6,3-7,6	6,1-8,4

One may say that water from showers and washing of clothes is the least polluted. Water from kitchens, due to its higher content of residue, is more contaminated. Based on these findings, greywater may be divided into water suitable for recycling and that conditionally usable for recycling. Water from washbasins, baths and showers is suitable and thus usable, while water from kitchen sinks and dishwashers is conditionally usable. Through the treatment of greywater suitable for recycling one may obtain sanitary service water with a quality close to that of drinking water. Such water is called white water and finds its application for toilet flushing, irrigation or the washing of clothes. This is a step towards reducing the consumption of drinking water used for such purposes.

Within the TAČR project, samples of greywater are being taken from some localities and subjected to chemical and microbiological analyses, as shown in Tables 2 and 3.

Table 2. Chemical analysis of greywater

Sampling locality	Monitored indicator								
	BOD_5	COD_{Cr}	N_{total}	P_{total}	pH	SS	Surfactants	Temperature	Turbidity
	[$mg.l^{-1}$]	[$mg.l^{-1}$]	[$mg.l^{-1}$]	[$mg.l^{-1}$]	[-]	[$mg.l^{-1}$]	[$mg.l^{-1}$]	[°C]	[ZF(t)]
Detached house	420	865	9	0.5	6.77	146	12	19.8	190
Swimming pool	75	180	11.5	0.18	6.67	44	0.6	18.8	27
Indoor swimming pool	12	30	9	1	7.37	11	0.45	–	0.7

Table 3. Microbiological analysis of greywater

Sampling locality	Monitored indicator			
	Escherichia coli	Enterococci	Coliforms	Pseudomonas aeruginosa
	[cfu/100ml]	[cfu/ml]	[cfu/100ml]	[cfu/100ml]
Family house	2	10	0	0
Swimming pool	0	0	0	0
Indoor swimming pool	0	0	35	0

Water treatment, repeated recycling

Greywater is slightly polluted wastewater, as described above. Under certain conditions, it may be used again as service water. The treatment technology and the equipment configuration selected for its processing are fundamentally different depending on the amount of water to be handled, which is affected by the size of the population using the greywater treatment unit.

Greywater treatment is performed using the following technologies: coarse filtration, microfiltration, activation (biological-mechanical purification), sedimentation, and UV radiation.

Aerobic greywater treatment technology is suitable for water from showers, hand washing and the washing of clothes [3, 4].

The completion of water treatment may be carried out using UV radiation; this is an alternative greywater treatment. Purified water is stored in a tank. Greywater must be stored in such a way as to prevent the growth of microorganisms. The best placement option for a greywater tank is in the ground, as the temperature is low and there is little light, or in a basement location.

These facts are utilized via the design of an MBR treatment unit during the activation process shown in Fig. 1.

The Use of Greywater Heat

The wastewater discharge system should be optimized in terms of energy use. Wherever it is practicable and cost-effective, wastewater heat energy should be utilized. Heat off-take is accomplished using a heat exchanger. Depending on the off-take point, heat may be transferred directly to the heated substance through a heat transfer surface (which must comply with EN 1717) or to a heat conveying substance within an inserted intermediate circuit. Energy recovery must not restrict or impede the purpose of the sewerage system, i.e. wastewater discharge and treatment.

Conclusion

To date, there has not been any economic pressure exercised to use water other than that from public distribution systems or wells in the Czech Republic. The abundance of resources has, in fact, been sufficient in recent years. One may expect that water and sewage rates will continue to increase to facilitate the gradual replacement and reconstruction of largely outdated utilities. This increase will create conditions for return on investments in grey and rainwater use. For these reasons, TAČR project No. TA01020311, titled "The Use of Grey and Rain Water in Buildings", which deals comprehensively with the above-mentioned issues, has been submitted and accepted.

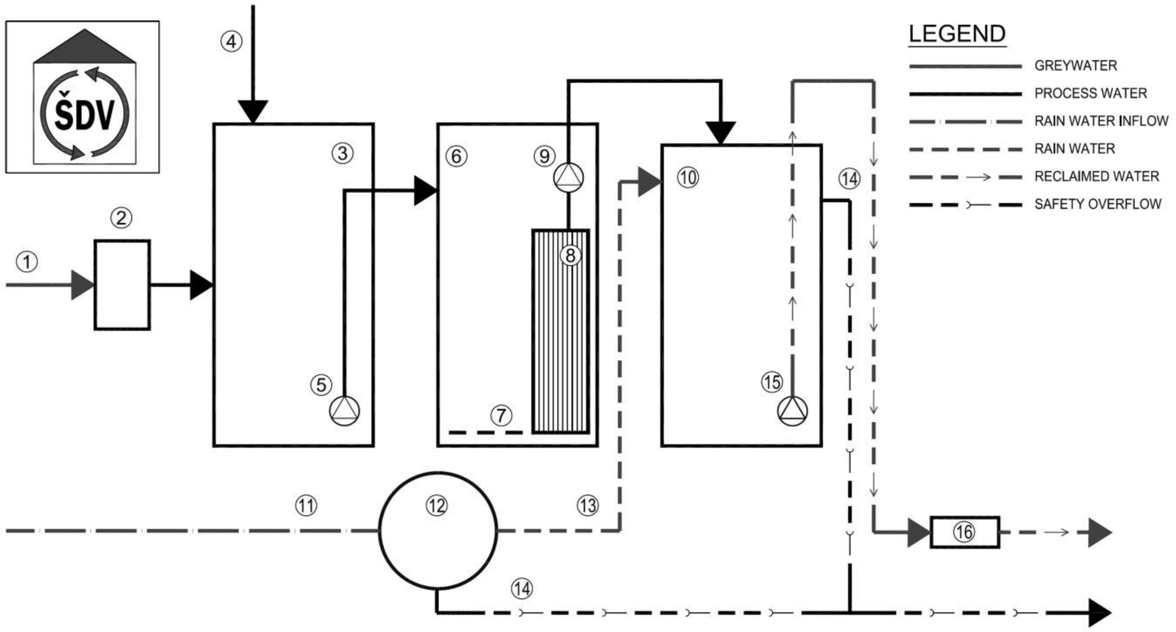

Fig. 1 Process diagram of an MBR treatment unit (legend: 1-greywater inflow, 2-mechanical pre-treatment, 3-expansion tank, 4-chemical dosing, 5-pump, displacement into biological unit, 6-biological unit, 7-activation, 8-MBR unit, 9-pump, displacement into storage tank, 10-storage tank, 11-rainwater inflow, 12-rainwater storage tank, 13-rain water draw-off into storage tank, 14-safety overflow into sewer system, 15-automatic booster station, 16-hygienic safety unit)

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Acknowledgement*: This contribution has been prepared within project No. TA01020311, titled "The use of grey and rain water in buildings", which is being implemented with the financial aid of the TA ČR.*