

Grey water as a part of in-building water cycle

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Abstract

The main aim of the article is to introduce *grey water* as a part of closed in-building water cycle vision consisting of rainwater, grey water, well water and potable water sources. Grey water refers to the reuse of water drained from baths, showers, washing machines, and sinks (household wastewater excluding toilet wastes) for irrigation and other water conservation applications. The costs of water infrastructure have risen dramatically. These and other aspects lead us to use alternative water sources. Progressive management of reused water in Slovakia is relatively new topic. The objective is to dispose of the water as close as possible to its origin, to what is necessary to adopt a comprehensive legislative framework and on the basis of experiments in laboratory and real-world design methodology to derive applicable management systems. Massive use of reused water for non-potable purposes in buildings also promotes the conservation of natural resources, water, and thus the overall sustainability in water management. Potable water consumption of the Slovak households isn't above average at all but we use it in inappropriate ways. Questionnaire on Grey Water, as one of data collection methods helps us to gather the essential information. This issue requires a multidisciplinary approach and establishment of criteria to meet future urban water visions.

Keywords

Grey water; in-building water cycle; questionnaire; sustainability; management

1 Introduction

Now it is the time to take our futures seriously and start providing solutions today for tomorrow's world. We live in a time with possibilities we have never had before. The new notion or significant specification of the term "BLUE to GREEN" in the modern

information age is the expression of the sustainable development of a society and beyond. By adopting 2 basic principles we can increase the benefits of coming changes and our future:

1. **The care of the Earth** – this ethics reminds to care for all things, living and non-living, including soil, water, and air....to the entire ecosystem.
2. **Care of people** – directs us to strive to meet our basic needs for air, water, food, shelter, education..etc., to sustain a basic quality of life that improves our environment, to not destroy the environment that supports us all [1].

We need to change the thinking of the society which will be in balance with nature and magnitude of the problems arising from the advent of climate variability, environmental risks, increasing urbanization and energy saving. Problems with torrential rains and drought only confirm the need for evolving new technologies, approaches and solutions as a proposal for blue alternatives for the transition to a sustainable society. Water is essential for all dimensions of life. During the last decades extreme meteorological and hydrological phenomena became more frequent and more destructive.

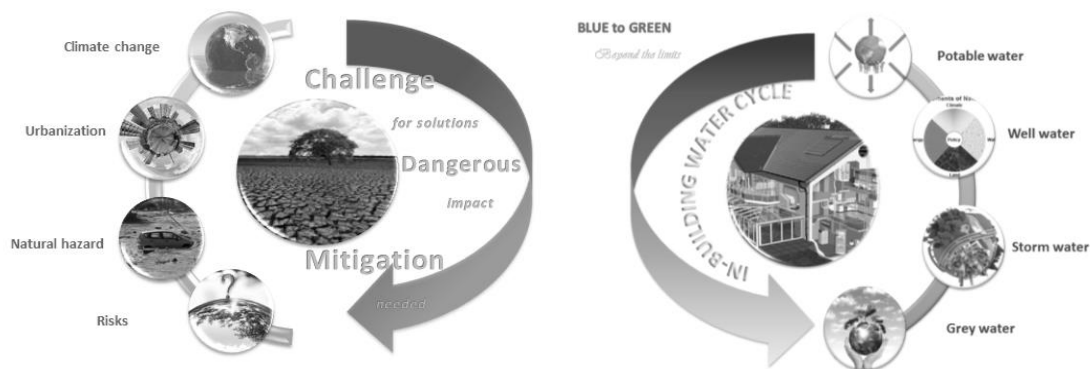


Figure 1 – Water challenge and vision

Changes in climate will have significant impact on local and regional hydrological regimes, which will in turn affect ecological, social and economic systems. Some reports [2,3,4] suggest that warmer temperatures will most likely intensify the hydrological cycle, leading to an increase in the precipitation intensity and number of storm events. However, climate change that produces an increase in the intensity of precipitation will increase the magnitude of the design discharge and that would most likely result in adverse effects on existing water structures. The use of water has increased and in many places water availability is falling to risks levels. More than eighty countries, with forty percent of the world's population, are already facing water shortages. The costs of water infrastructure have risen dramatically. The quality of water in rivers and underground has deteriorated, due to pollution by waste and contaminants from cities, industry and agriculture. We need to change the way we use the water and need to look at our designs that involve water to use what we have as efficiently as possible [5].

2 Design for water – assessment, demand and consumption

Water is the only commodity on Earth for which there is no economic substitute. Design for water means that the fresh water – blue water does not have to be the first choice for

a water source [5]. One of the reasons is the fact that drinking water resources will be disappearing and the need for drinking water will be growing with growing population. People use a lot of water for drinking, cooking, washing, and irrigating landscapes, but even more for producing food, materials products, and manufactured items such as clothes and to run buildings [5].

Average consumption of potable water in Slovakia
145 l / person per day

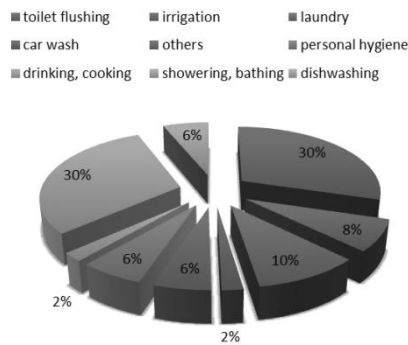


Figure 2 – Average daily water consumption

Figure 2 shows the average daily water consumption of a household - 145 l/person per day in Slovakia. It shows that about 60% of drinking water may be replaced by alternative water source (rainwater, well water, grey water). This fact gives credit to reuse of potable water in closed in-building water cycle and better percentage weight in building environmental assessment. Water management field in the environmental assessment system (BEAS) used in Slovakia has a percentage weight of 8.88% [6,7]. The percentage weights for water management fields in other countries are described in Table1. We can sum up that water field has significant role in the environmental assessment compared to other fields in Slovakia.

Table 1 Environmental assessment systems [6]

[%]	Country	Optimize Site Potential	Optimize Energy Use	Protect and Conserve Water	Use Environmentally Preferable Products	Enhance IEQ	Optimize Operational & Maintenance Practices	Other
CASBEE	Japan	15	20	2	13	20	15	15
BREEAM	UK	18	19	6	12.5	25	-	19.5
SBTool	28 countries	12.5	20.8	-	-	16.7	16.6	33.4
Green Globes	Canada	11.5	36	8.5	10	20	-	12.5
LEED	USA	27	36.5	10.4	6.3	15.6	-	4.2
HK-BEAM	Hong Kong	13.2	41.3	6.3	12.3	25.9	-	2.6
NABERS	Australia	16.7	16.7	6.7	13.3	6.7	-	40
SABA	Jordan	10.8	23.1	27.7	10.3	11.8	-	16.3
BEAS	Slovakia	14.7	21.5	8.8	21	23.6	5	5.4

Buildings that have attained a specific green building level of LEED Certification or any of certification mentioned in the table 1 are meeting the future sustainable challenge, which means we can reduce our water footprint.

3 Grey water in building water cycle

The water from municipal water supply system goes through the highest level of testing and it is the fastest, easiest and most reliable source of water that we have. Of course, there are many times when this source of water is unavailable (water supply failure, damage, technical problems, disasters...) These reasons are why the best sources of water for most household uses do not come only from your tap, but from rainwater, well water and *used* water known as **grey water** [9]. On-site collection and use of grey water is an alternative to public mains or private potable water supply for a variety of non-potable water uses in the home, workplace and garden [10].

There are many types of water as defined by Kinkade-Levarios [5]:

1. *Atmospheric water* – rain and fog
2. *Blue water* – water from lakes, rivers
3. *Green water* – soil moisture
4. *Stormwater* – rainwater that has hit the ground
5. *Grey water* (light, dark) – waste water from laundry, bathtub, shower, basin
6. *Alternate water* – water that has been used previously
7. *Black water* – water from toilets and kitchen sinks
8. *Reclaim water* – water that has gone through a sewer treatment process and has been filtered and processed for reuse in various ways.

Grey water refers to water sourced from kitchen (depending on national regulation), laundry and bathroom drains, but not from toilets. Grey water may contain urine and faeces from nappy washing and showering, as well as kitchen scraps, soil, hair, detergents, cleaning products, personal-care products, sunscreens, fats and oils [11]. Domestic wastewater (excluding fecal matter and urine) from bathrooms, basins, showers is called **light grey water - LGW**. Contaminated or difficult –to-handle grey water, such as solids-laden kitchen sink water or from laundry is called **dark grey water**.

Grey water systems depend significantly on the behavior of the people using the collection appliances, as well as the quality and volume of water collected. There are many different methods used to filter/treat collected grey water, which range in complexity and the level of treatment. About 60% of potable water can be replaced by grey water in a household as shown on the figure 4.

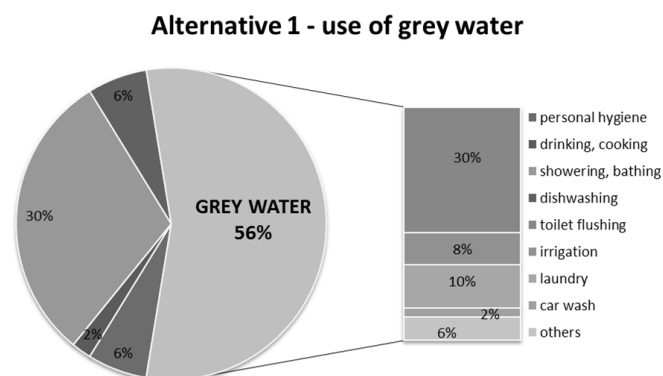


Figure 4 – Grey water possible use in % from the average daily water consumption in Slovakia

As presented also in Portuguese study by prof. Afonso [11] it is considered that reclaimed water can be used in flushing of toilets, washing clothes and watering gardens, after appropriate treatment. The quantitative characterization, and a physico-chemical and microbiological analysis of light grey water was presented in the by C. Matos and I. Bentes. Grey water use at the domestic level may well be the simplest form of water reuse and should be investigated as a means to reduce the impact of residential developments on water resources worldwide. [13]. Reuse of grey water can also reduce the load on septic tanks and drain fields. In US they the Green Plumbing and Mechanical Code Supplement, IAPMO in chapter 5 deeply describes the construction, alteration, and repair of grey water systems.

3.2 Grey water systems

Grey water systems vary significantly in their complexity and size, and can be grouped according to the type of filtration or treatment they use, as follows as described in British standard BS 8525-1:2010 [10]:

1. Direct reuse systems (no treatment)
2. Short retention systems
3. Basic physical/chemical systems
4. Biological systems
5. Bio-mechanical systems - these systems, the most advanced for domestic grey water reuse, combine biological and physical treatment, e.g. removing organic matter by microbial cultures and solid material by settlement. They encourage bacterial activity by bubbling oxygen through the collected grey water
6. Hybrid systems – integrated with rainwater, or other water source.

Hybrid system represents the vision of **in-building water cycle**. Potential uses for grey water depend on the quantity and quality of water available. Each case must be assessed by individual plan to design the most efficient and *green sustainable* water system.

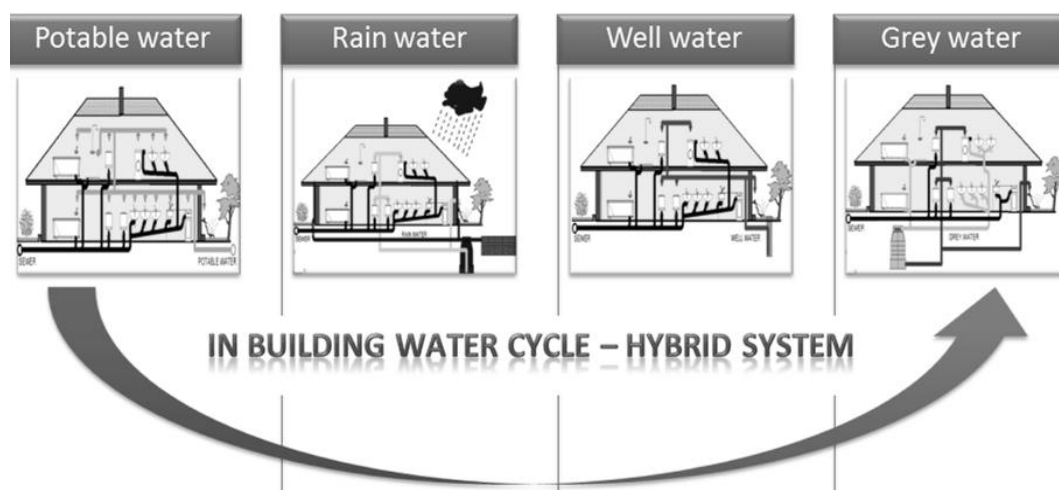


Figure 5 Hybrid system of in-building water cycle

When recycling water, it is essential to protect the health of both the public and the environment, and a risk management approach is the best way to achieve this [11]. The quality of grey water is very important and depends on the purpose for use. Each

country has own standards and guidelines with limits. We can sum up advantages and disadvantages of grey water system:

Advantages:

- recharges groundwater instead of depleting it
- uses nutrients in the grey water to support plant growth – irrigation
- reduces energy and chemical use
- lower water bills
- reduce the load on septic tanks and drain fields
- support sustainability

Disadvantage:

- if mishandled, can spread disease
- becomes smelly if stored more than 24 hours
- may damage soil from salt buildup

3.2 Questionnaire on Grey water in Slovakia

Questionnaire on Grey Water, as one of data collection methods helps us to gather the essential information. Massive use of reused water for non-potable purposes in buildings also promotes the conservation of natural resources, water, and thus the overall sustainability in water management. Potable water consumption of the Slovak households isn't above average at all but we use it in inappropriate ways. Our questionnaire was completed by the group of 100 people from different spheres of society divided to 45 male and 55 female respondents. The average age is 43 years. Important fact is that 80 % of respondents use potable water for all domestic purposes such as flushing toilets and watering the garden. We asked our respondents if they are afraid of grey water use and only 35 % of them were not, but around 60% would think about sustainable solutions if they would build a new house and would consider installing such system only if the return on investment is between to 6-10 years. Interesting result is that respondents were more afraid of grey water (65%) than the rainwater use (43%). The main reasons for water saving was the water bill reduction in 42% of respondents, 35% for sustainability and reservoirs saving only 22%. As shown on the figure 6 39% will use the grey water for toilet flushing. Our respondents see the biggest potential in installing the grey water system in administrative buildings and hotels etc... (Figure 7).

Grey water - purposes for reuse

■ laundry ■ toilet flushing ■ car wash ■ irrigation

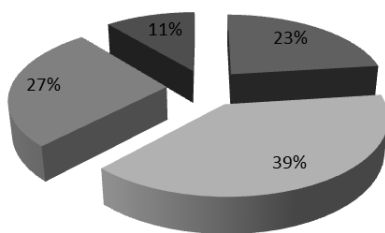


Figure 6 Grey water use

Where do you see the biggest potential for grey water reuse ?

■ family houses, flats ■ industrial buildings
■ administrative buildings ■ hotels, hospital, social houses, etc...

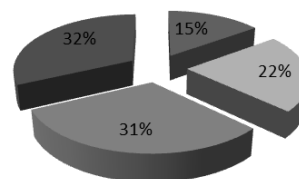


Figure 7 Building types for grey water reuse

Questionnaire shows people's willingness to use alternative water source for non-potable purposes rather than potable water. This questionnaire gives us closer look on people's attitude to alternative water sources and their water consumption habits. The result is that most of our citizens are pro water saving oriented and open to new water ideas as closed in-building water cycle. In Slovakia this area hasn't been so developed yet. It is necessary to define regulation and set standards for designing hybrid systems for example according to foreign national standards and performed experiments in Slovak conditions.

4 Conclusions

As grey water systems become more popular, there is a need for standardization to protect the public and to ensure that reliable systems are designed, installed and maintained. A modern decentralised water infrastructure can include site-collected rainwater, grey water, stormwater, and black water systems [8]. These alternative water sources may never totally replace centralised system. They do help manage and store water and treat it to various levels of quality for use in buildings and the sites upon which they stand. The designers should complete the site and building as the one system – where water is conserved, energy saved and the costs are reduced. New technologies and better understanding of the in building water cycle allow us to reduce our water footprint. The provision of safe water and sanitation has been more effective than any other intervention in reducing infectious disease and increasing public health. The public expects to have safe water and sanitation; therefore, when recycling water, it is essential to protect public health and the environment. The guidelines and risk management framework for beneficial and sustainable management of water recycling systems is missing in Slovakia. On the basis of the scientific, policy, economic and social impacts, the study pointed out challenges and recommendations to strengthen and enhance future of alternative water sources, especially grey water research in our conditions.

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5 Presentation of Author(s)

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