fact sheet

Eawag
Swiss Federal Institute of Aquatic Science and Technology

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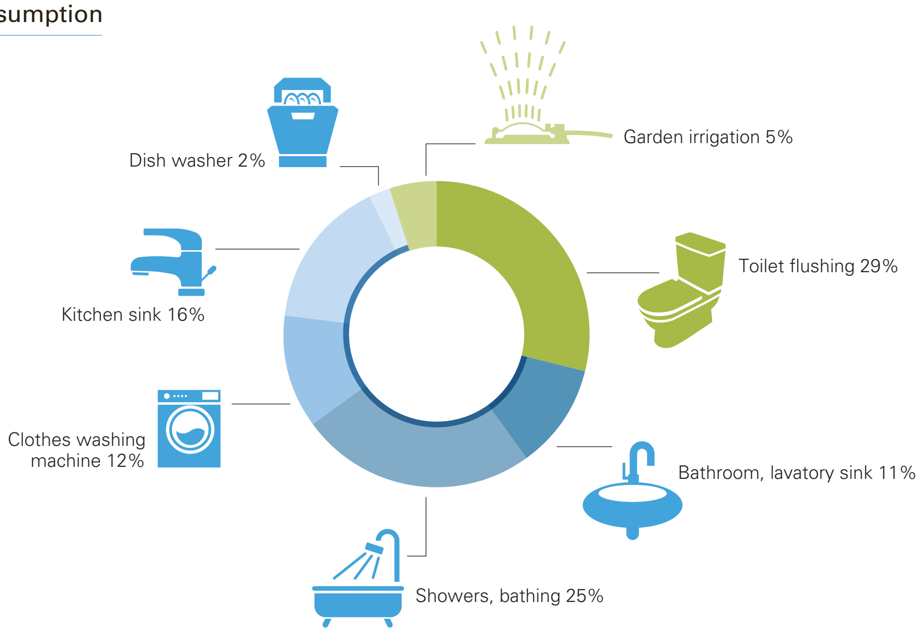
Greywater

Greywater is relatively clean wastewater – from showers, baths, bathroom and kitchen sinks, washing machines or dishwashers – which (unlike blackwater) has not been in direct contact with faeces. It accounts for almost 70% of all wastewater produced by Swiss households. After appropriate treatment, greywater can be safely reused for toilet flushing or irrigation. With advanced treatment processes, the quality and thus the potential for reuse of greywater can be further increased.

Breakdown of household water consumption

142

In Swiss households, per capita water consumption is around 142 litres per day. The chart shows what proportions of wastewater arise from the various sources: in total, 66% is classified as greywater (blue shades). [5]



eawag aquatic research

Most commercially available greywater treatment systems provide water for toilet flushing and garden irrigation. Eawag researchers are investigating and testing simple and reliable treatment technologies designed to produce water that can be safely used in washing machines and for showering or handwashing.

Basic treatment typically involves particle removal and biological treatment (e.g. with moving bed biofilm reactors, membrane bioreactors or constructed wetlands) [1]. Following basic treatment without further purification, wastewater may only be reused if human contact can be excluded.
The aim of **advanced treatment** is to make recycled greywater available for a wider range of applications – e.g. for washing machines. For this purpose, colour, odour and biodegradable organic carbon need to be largely eliminated. In addition, if recycled water will come into direct or indirect contact with humans, treatment must also ensure microbiological water quality. Advanced treatment may involve a combination of particle separation, biological treatment, membrane filtration, adsorption and disinfection (e.g. with ultraviolet light or chlorine) [1]. Greywater treatment and reuse as process water can be applied at various scales – directly at source (e.g. in a handwashing station) or for a whole building, with greywater being treated in the basement and subsequently used in washing machines or for toilet flushing or garden irrigation.

Opportunities

Whether greywater reuse is appropriate or not will depend on local conditions:

- **Alleviation of water scarcity:** Use of recycled greywater reduces demand for freshwater, which is of course particularly advantageous in areas where freshwater availability is limited or in conditions of water scarcity. With regard to the situation in Switzerland, water consumption could be reduced by a third if recycled greywater was used for toilet flushing and garden irrigation. If greywater, after advanced treatment, was also reused for applications such as showering or laundry, drinking water consumption could be reduced by up to two thirds. The potential for reuse increases in line with greywater quality. To this end, various technologies are being tested at the Empa-Eawag NEST research building.

- **Reliable water source** for irrigation of green infrastructure or for evaporative cooling: Green infrastructure, such as green roofs or walls and additional trees, can help to prevent urban heat islands, thus improving environmental quality outdoors and reducing energy consumption. Recycled greywater is a reliable water source, available throughout the year, for this purpose.

- **Water availability** in the absence of water supply/wastewater disposal infrastructure: In some cases, while freshwater may be generally available, infrastructure for water distribution and wastewater disposal may be lacking. Examples of water being provided "off grid" include handwashing stations in informal settlements or refugee camps (e.g. the Water Wall, part of Eawag's Autarky toilet), or washroom sinks in trains or aeroplanes. In the case of railway toilets, recycling reduces the effort and costs associated with the storage of fresh- and wastewater, and with tank filling and emptying.

- **Heat recovery:** Greywater is much warmer than other household wastewater. Greywater treatment also facilitates heat recovery, since improved water quality will reduce fouling of heat exchangers.

Challenges

- **Water safety:** For any kind of water recycling, water safety must be assured. The standard to be aimed for will depend, for example, on the treatment technology selected and the operation, control and maintenance of the system, but also on the particular type of reuse.

- **Regulations** and legal framework: In Switzerland, there are no guidelines specifying water quality requirements for the reuse of greywater, although there is an Ordinance on Drinking Water and Water in Baths and Showers Accessible to the Public (TBDV) [2]. Guidelines for greywater treatment technologies, including water quality requirements for indoor (mainly toilets) and outdoor applications, are available in countries such as Germany, Australia, Singapore and the US. There is as yet no international consensus (see Box).

- **Technologies and monitoring:** To ensure stable operation, technologies need to be tested under real-life conditions; this is now possible thanks to the NEST building. Treatment systems must be monitored so that an early warning is triggered in the event of malfunction. No low-cost, robust online sensors capable of detecting inadequate water quality are currently available for deployment at the household level. For this reason, new approaches for monitoring treatment and distribution systems are being investigated at the NEST building. Complex technologies may operate effectively in a household setting if the system provides feedback for users – similar to a washing machine signalling that a filter requires cleaning. In addition, the local system needs to be integrated into a wider service and monitoring network (similar to gas central heating).

- **Management:** Greywater recycling has to be integrated into overall urban water management operations. Changes in water demand – due to water-saving equipment, altered user behaviour and greywater recycling – will affect the system as a whole. Reduced flows and increased concentrations of solid matter may lead to failures in the sewer system. Different approaches to the reduction of freshwater consumption may be in mutual competition. There is a need to develop strategies whereby systems combining centralised and decentralised processes can be optimised.

- **Costs:** In Switzerland and in most European countries, the costs of greywater treatment are still higher than the savings achievable through recycling. However, as indicated above, other motivations may apply. In addition, in some countries, water recycling in the building sector is promoted by sustainability certification systems – e.g. the Building Research Establishment Environmental Assessment Method (BREEAM) or Leadership in Energy and Environmental Design (LEED).

- **Assessment of local conditions:** For each situation, the source of the water and the type of reuse need to be assessed. There is no universally applicable standard solution. To ensure the sustainability of greywater recycling, experts must be familiar not only with the technologies available but also with local needs.

Technology development at Eawag

Water Wall: Eawag's Water Wall (http://www.autarky.ch) shows that advanced treatment permits direct reuse of microbiologically safe handwashing water [8, 4].

Water Hub at NEST: The Water Hub (http://www.eawag.ch/waterhub) at the NEST research building enables Eawag to study various questions under real-life conditions – advanced greywater treatment, heat recovery, and assessment of microbial greywater quality during on-site storage and treatment. Treated greywater is not yet being reused at NEST.

Reuse of greywater in low and middle-income countries: In water-stressed countries, greywater reuse can contribute to more sustainable water management. An Eawag report published in 2006 provided recommendations for water quality control measures, the design of primary and secondary treatment systems, and safe reuse and disposal of treated greywater [3]. The report includes case studies and presents both simple treatment systems for individual households and complex systems for whole neighbourhoods.

No international consensus

There are no international guidelines for greywater recycling. Some countries have their own national regulations, others none at all.

Switzerland: The TBDV Ordinance covers drinking water and water in baths and showers accessible to the public (TBDV) [2]. It includes limits for biological and chemical parameters. However, there are currently no guidelines for greywater recycling.

Germany: Guideline DWA-M 277 [1] defines two specific categories of reuse (C1: Toilet flushing in private households, C2: Toilet flushing, irrigation of crops and ornamental plants, and washing machines).

US: Here, guidelines and regulations vary from state to state. The various requirements for water reuse are summarised in a publication issued by the Environmental Protection Agency [9] fA recent Water Environment & Reuse Foundation report [6] proposes a risk-based framework for the development of public health guidance for decentralized non-potable water systems; this is stricter than the requirements currently applicable in many states.

FAQs

Is recycled greywater safe enough to be used for handwashing?

The quality of recycled water largely depends on the type of treatment used. In Eawag's Water Wall – a system designed for recycling of handwashing water – concentrations of organic carbon and total bacterial cell counts are lower than those found in Zurich tap water [7]. Field-testing of the Water Wall in a park in the city of Zurich showed a 99% reduction in organic carbon. Concentrations of *E. coli,* an indicator of pathogenic microorganisms, were below the limit of detection. This means that water from the Water Wall can be safely used for handwashing.

Why should greywater not be used for toilet flushing without first being treated?

Untreated greywater should not be used anywhere where human contact may occur. Without treatment, concentrations of pathogens and organic carbon in greywater are generally too high, which could pose risks to human health.

Is the Water Wall commercially available?

Not yet. The technology is mature and effective, having been field-tested in Switzerland, Uganda, Kenya and South Africa. However, Eawag is still seeking a suitable industrial partner to make commercialisation possible.

Cover photo: "Water Wall" handwashing station with a membrane filtration system; Michel Riechmann, Eawag

References:

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Further information: www.eawag.ch/waterhub , www.autarky.ch , www.eawag.ch/membranefilter

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