



SWITCH

Briefing note: On-site wastewater treatment, recycling and reuse

prepared by the NTUA

On-site water recycling and reuse systems involve reclaiming wastewater on site, as well as harvesting rainwater and distributing reclaimed water within the buildings for non-potable use. They have great potential as water conservation measures, and can also reduce the need for infrastructure expansion required for water distribution and wastewater collection. Although there are some applications of such systems in the domestic sector, this approach to water conservation is still largely unknown and is consequently often overlooked as a possibility.

Introduction

Water reuse is the use of wastewater or water reclaimed from one application, such as clothes washing, for another application, such as landscape watering. **Water recycling** is a subset of water reuse, and involves re-using water for the same application for which it was originally used.

The traditional and prevailing concept in water supply and wastewater treatment infrastructure is characterized by “open-loop” design, involving centralized structures and mixed wastewater streams of various qualities. However, individual households, public and commercial buildings and industrial facilities can each adopt their own water supply and wastewater systems, based on on-site water treatment methods. Rainfall can provide a source of potentially potable water supply. The systematic separation of the various water and wastewater streams can enable highly efficient processes, and open the way for reclamation and reuse of water of various qualities.

In the home, wastewater can be used to flush toilets, water gardens, and in some cases even for clothes washing. By using wastewater as a resource rather than a waste product, households can reduce water bills, use



Making greywater blue

less freshwater resources, reduce the amount of pollution going into waterways and help save money on new infrastructure for water provision and wastewater treatment. Similarly, through collection and storage in rainwater tanks, roof rainwater run-off can be a valuable water source for flushing toilets, in washing machines, watering gardens and washing cars, and therefore contribute to significant fresh water savings.

On-site wastewater treatment and re-use methods

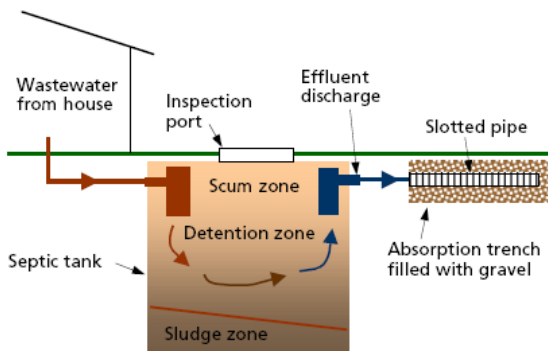
There are two main types of domestic wastewater, blackwater and greywater. **Blackwater** is the term used to describe wastewater with high concentrations of fecal matter and urine. It is heavily polluted and difficult to treat because of the high concentrations of organic pollution. **Greywater** refers to all other wastewater generated from domestic processes, such as washing dishes, laundry and bathing. It comprises 50-80% of residential wastewater.

On-site wastewater treatment can be performed through:

- **Septic tanks**
- **On-site aerated wastewater treatment systems**
- **Primary and secondary systems for greywater reuse**

Septic tanks

Septic tanks treat both greywater (from shower, sinks and washing machines) and blackwater (toilet water). A conventional septic tank system involves the underground installation of a tank made of concrete and an absorption trench. Wastewater treatment is performed through anaerobic processes, whereas the final treatment occurs via the absorption trench.

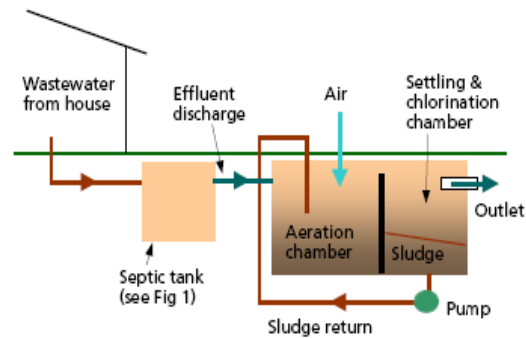


Septic tank and absorption trench

Septic tanks provide only limited treatment through the settling of solids and the flotation of fats and greases. Bacteria in the tank break down the solids over a period of time. Wastewater that has been treated in a septic tank can only be applied to the land through the covered soil absorption system, as the effluent is still too contaminated for above ground or near surface irrigation.

On-site wastewater treatment

On-site aerated wastewater systems rely on mechanical devices that mix, aerate and pump the effluent. Subject to accelerated aerobic and anaerobic decomposition, these systems use one or two tanks. The treated water can be used for surface or under ground irrigation (the reuse of blackwater inside the home is not advisable, even after treatment and disinfection). A minimum irrigation area of 200m² is usually required.



Aerated wastewater treatment system

As shown in Table 1, wastewater treatment costs can vary substantially, especially in the case of aerated systems.

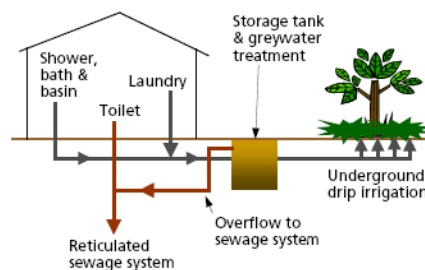
Table 1: Typical costs for on-site wastewater treatment

Treatment system	Installation Cost (AU\$)	Maintenance Cost (AU\$/yr)
Septic System	4,300	-
Aerated wastewater system	6,000-\$8,000	\$260

Primary and Secondary Greywater Reuse Systems

If collected using a separate plumbing system to blackwater, domestic greywater can be recycled directly within the home and garden.

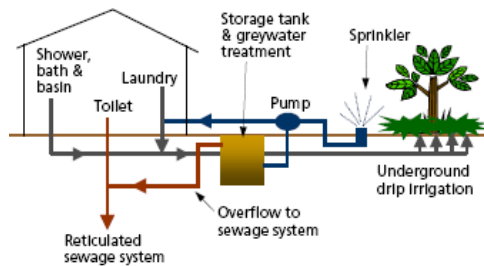
Recycled greywater of this kind is never clean enough to drink; however relatively clean greywater can be applied directly from the sink to the garden, as it receives high level treatment from soil and plant roots. In such, **primary systems**, greywater is collected and directly distributed by gravity, or a pump for **subsurface irrigation**.



Primary greywater reuse system

In general, greywater storage and reuse requires treatment and disinfection, due to the presence of pathogens and other contaminants. Through a number of stages of

filtration and microbial digestion in a **secondary reuse system**, greywater can be used for **flushing toilets** and for underground drip garden irrigation.



Secondary greywater reuse system

Table 2 provides installation costs for greywater systems, which can range from several hundred dollars to more than US\$5,000. Costs depend on whether the system is to be installed in an existing or a new building, and whether the building has a raised or slab foundation. Costs are usually lowest for new constructions and highest for existing buildings with slab foundations. In fact, it is so expensive to install a complete greywater system in an existing home with a slab foundation that only effluent from the washing machine should be considered in this situation.

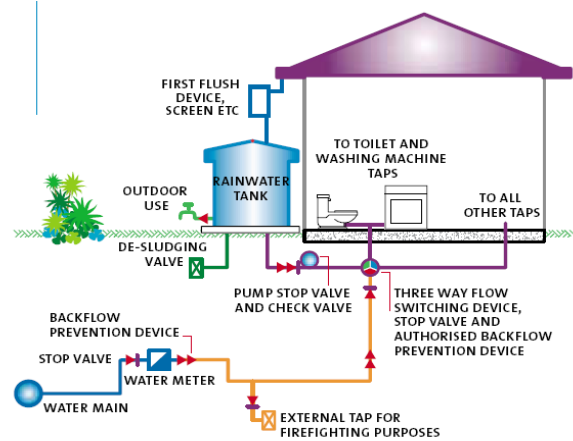
Stormwater & Rainwater harvesting

Stormwater is the term used to describe water that originates during precipitation events. Surface run-off from impervious surfaces, such as roofs, roads, driveways and parking lots needs to be treated for use, as it can contain pollutants originating from accidental spills, leakages, materials handling practices or the application of chemicals (including fertilisers), or wastes deposited onto exposed areas. However, **rainwater** collected in **rainwater tanks** is suitable for some house-

hold uses, such as clothes washing and toilet flushing, without prior treatment.

The design and installation of rainwater tanks involves defining:

- the location of the tank and its relationship to nearby buildings,
- tank capacity, dimensions and other structural details, and
- the purposes for which the tank will be used.



Residential rainwater tank connected to a 'top-up' system providing rainwater for outdoor use, toilet flushing and the washing machine

Rainwater tank design should make provisions for:

- A minimum available volume, in order to ensure that water supply is always available,
- A rainwater storage volume
- An air space for additional stormwater management

In general, the size of the tank is determined by the purpose of use:

- For **supplying all non-potable domestic uses** (toilet flushing, clothes washing, garden irrigation and car washing), and for stormwater

Table 2: Costs for greywater reuse systems

System Type	Greywater sources	Technical Features	Cost (US\$)
Low -tech owner or	Washing machine	200 micron mesh filter	400
Medium-tech	All	Sump pump to pvc tubing Subsurface drip irrigation 200-micron mesh filter	1,000 1,500
Fully automated professional installation	All	Automatically back-washed sand filter; 250 gallon storage tanks; Pumps at both source and tank/filter; 3-way valve, backflow preventers; Micro-processor controls all flows; Backed by	2,500 5,000

management, a minimum capacity of 5 m³ is required.

- For **toilet flushing and irrigating a small garden** a capacity of 2 m³ would be sufficient.

The roof should be large enough to collect the amount of water required. Gutters and downpipes are used to maximize the amount of rainwater entering the tank. Rainwater tank overflows should be diverted to the stormwater system, if a separate system exists. Representative costs are provided in Table 3.

Table 3: Costs for rainwater tank systems

Rainwater tank size (m ³)	Cost (AU\$)	Annual Savings (AU\$)	Long-term savings (AU\$/m ³)
5	1,600	07	0.15
10	2,000	132	0.28

Another way of using rainwater on-site involves the development of **green roofs**, which provide a reed bed-type biological cleansing system that can be located on the roofs of houses, multiple-occupancies and multi-storey urban dwelling, such as a block of flats.

Economic Implications

The cost-effectiveness of on-site water reuse and recycling systems is governed by many factors, such as:

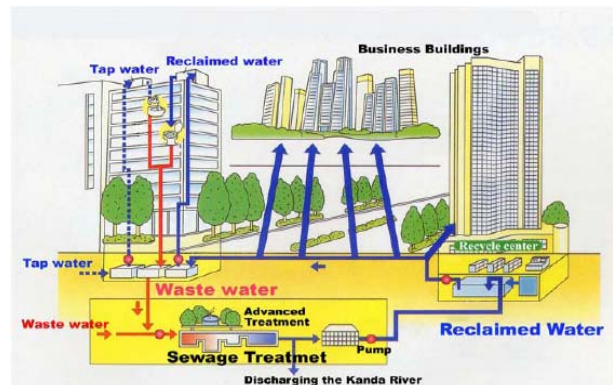
- **The cost of public water supply**, as in most areas, water is considered cheap. Water is underpriced, and consumer charges do not reflect water availability limitations and the cost of water infrastructure.
- **The cost of treatment technologies**, which is influenced by the quality of the source water (black or grey water) and economies of scale.
- **The cost of discharging and treating wastewater and stormwater**, to ensure that the receiving environments are adequately protected.
- **The headwork charges for the water, wastewater and stormwater infrastructure** to cater for increased demand on water services due to development and the increase in population density.

Technology applications - Case Studies

Shinjuku, Tokyo, Japan

Tokyo is one of the leading cities in the successful implementation of wastewater reuse, such as dual distribution

systems and stream augmentation. In a water reuse project in the Shinjuku area of Tokyo, a dual distribution system has been adopted and sand-filtered water from the Ochiai Municipal Wastewater Treatment Plant is chlorinated and used as toilet-flushing water in 25 high-rise business premises and for stream augmentation, as illustrated in the figure. The system, which has been successfully operated since 1984, is supplying treated wastewater up to a maximum 8,000 m³/day.



There is also a small-scale on-site system where the grey water is recycled as an in-building water resource, with a dual distribution system. Reclaimed water can be used for toilet flushing, car washing, stream augmentation or landscape purposes.

Menard ISD Elementary School, Menard, Texas

In the Menard Elementary School, rainwater is diverted from the roof using existing gutters and downspouts, into two 1,000-gallon green polypropylene tanks. One tank supplies a birdbath made of rocks with natural cavities and a prefabricated pond. Both water features are supplied with water conveyed by gravity pressure through 3/4-inch PVC pipe and drip emitters.



A “healthy home” in the Gold Coast Urban Site, Australia

The “healthy home” is an innovative ecologically designed house on a 460m² urban site on the Gold Coast. The advanced water system includes rainwater harvesting for potable use, greywater collection and treatment, and solar water heating.

A roof area of 150 m² supplies roof runoff via a first flush diverter to a 22m³ concrete tank below the house. From this tank, a 0.7kW pump and pressure vessel supplies all water to the house. The tank is backed up by the public water supply system.

Greywater from the household is collected to a surge tank/treatment system also located under the house. Greywater from the bathroom and laundry entering the tank is circulated by pump through a sand filter within the tank. The sand filter is dosed by a programmed flow controller to maximise contact time and allow for biological treatment.

Analysis of water usage estimated that an 80% reduction in potable water use could be expected from the combined rain tank and greywater system if fully installed. However, significant reductions in potable water usage and stormwater runoff from the site have been shown.

Chemical analysis has shown that the recirculating sand filter effectively removes organic and suspended solids. The pumps on the rainwater and greywater systems were found to use 1.7 kWh per day. Energy use for small pumps is a weak point of advanced water reuse systems and needs to be considered.

However, a financial analysis depicted that rainwater and greywater systems are not currently cost effective in the region, as the payback times have been calculated at 23 and 100 years respectively.

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