Introduction to Greywater Management*

What is greywater?

All household wastewater, except toilet waste, is called greywater. This includes water from showering, bathing, and washing dishes and clothes. The amount of greywater varies enormously between households. Consumption in poor areas can be as low as 15-20 litres per person per day, and in rich areas people may generate more than ten times as much. In ecological sanitation, greywater is source-separated from toilet systems, allowing for simpler treatment systems than conventional sewage treatment plants. Successful management of greywater includes both technical methods and user participation in running and maintaining the system. All parts of the system, from the point of origin to the final discharge, should be considered when planning.

Composition of greywater

The composition of greywater varies greatly, reflecting the lifestyle of the residents and the choice of household chemicals for laundry, bathing, etc. Greywater typically contains high concentrations of easily degradable organic material, such as fat and oil from cooking, and tensides and other residues from soap and other detergents.

Pathogens essentially only exist in the greywater fraction if contaminated by faeces. Still, the greywater environment is favourable for bacterial growth which means that it needs to be treated before reuse. Furthermore, untreated greywater easily turns anaerobic (its oxygen is depleted) and thus creates foul odours.

Nutrients in greywater

The nutrient content in greywater is generally low compared to normal mixed wastewater (sewage). In some cases there can be high concentrations of phosphorus (P), but the levels of nitrogen are always low. The P-content could be reduced to levels lower than normally found in advanced treated wastewater if people used only P-free detergents, thus minimizing this step in the processing before reuse.

Other pollutants

Although generally low, the content of metals and organic pollutants in greywater can increase if environmentally hazardous substances are added to the wastewater. Metals originate from the water itself, from corrosion of the pipe system and from cutlery and shampoos used in the household. Organic pollutants are present in many of our ordinary household chemicals, such as shampoos, glues, preservatives and cleaners. In this case as well, people can greatly influence the greywater content. By using environmentally-friendly chemicals and not pouring hazardous substances such as paint and solvents down the drain, the levels of metals and organic pollutants in greywater can be kept low.

Source control

Preventing the need for treatment should be seen as a vital part in all greywater management. This can be done by controlling the pollution load and the amount of water used. Therefore, it is essential that all greywater systems include information for the users regarding environment-friendly household chemicals and water-conserving techniques. By combining water-saving equipment with economical incentives, such as a fee system for water consumed, greywater production can be reduced significantly.

When planning for urban sanitation, the aim should be for every person to produce less than 80 litres of greywater per day.

Setting up a system

A pipe system is needed for collection and transportation of the greywater. The difference from a traditional mixed wastewater system is that thinner pipes can be used since there is no need to transport toilet waste. To prevent clogging from grease, the pipes should be installed straight (no necks or depressions) with a gradient of at least 0.5%.

In smaller systems, greywater can often be led directly to a mulch bed where the water is used for growing plants or trees. The design and dimensions of the systems needs to allow for the water to be assimilated by the soil-ecosystem.

For larger systems where the water may be stored for long periods, a need for pre-treatment arises. Suspended solids (SS) need to be removed because they may clog the system or create bad odours. The SS-particles can be removed mechanically by gravity, as in a septic tank system, by screens or filters on prefabricated equipment or as cheaper gravel filters for the smaller scale.

Treatment of greywater

Greywater is relatively harmless from an environmental and hygienic point of view. Problems are often small and local. But if not managed properly, greywater will be a strong source of smell due to the high levels of easily degradable compounds. When these compounds are broken down, natural processes can create

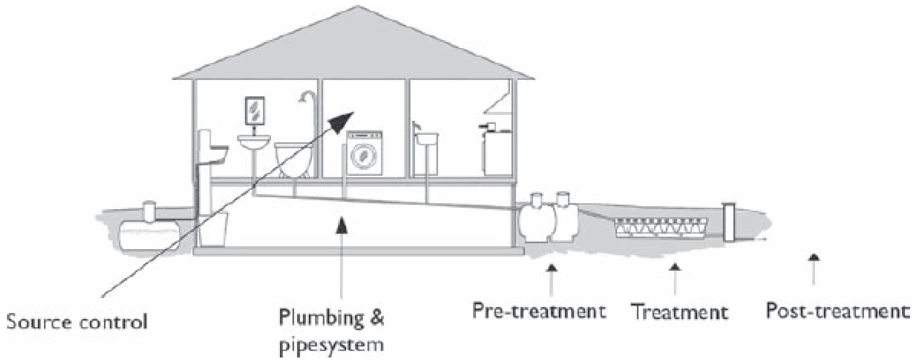

Figure 1: Technical components of a greywater management system

*Based on Ridderstolpe, P. 2004. Introduction to Greywater Management. EcoSanRes Publication Series. Report 2004-4. Stockholm Environment Institute; Stockholm, Sweden. Available from www.ecosanres.org anaerobic conditions within hours, causing bad odours. Other treatment targets are to reduce the levels of organic pollutants, heavy metals, pathogens, and other micro-organisms.

The most common treatment technique is to use biofilm systems that filter greywater through substrates colonized by attached bacteria so that biological degradation of organic matters takes place under aerated conditions. With a good oxygen supply, foul odours can be avoided. These systems range from extensive land systems to intensive and energy-demanding applications such as trickling filters and biorotors.

1. Sorption and irrigation

These slow rate systems use the soil ecosystem to convert polluted water into valuable plant production. They should be dimensioned from the requirements of the green plants. Too much water leads to saturation and the crops will suffer. Too little water on the other hand stresses the plants and makes them sensitive. The amount of water applied depends on the evapotranspiration rate, usually 2-15 litres per m^2 per day. An alternative to watering the whole area is to use mulch beds for direct application close to the crops or the trees.

2. Vertical soil filter systems

The somewhat confusing concept "constructed wetland" often appears in the literature. A soil filter should not be designed and operated as wetland. For efficient filtering and aeration, it is important that the soil is not saturated with water. The water should percolate through the soil in the small pores, leaving the bigger pores open and aerated to allow for better gas exchange.

A vertical soil filter system that is properly designed and operated has a removal efficiency for suspended solids and organic compounds of 90-99%. Pathogens, including bacteria and viruses, can be expected to decrease by 95-99.9%. Phosphorus (P) and heavy metal removal is significant. P removal is estimated between 30 and 95%, depending on soil properties, depth of the unsaturated zone and wastewater load. Nitrogen is reduced by nitrification and denitrification, usually in the range of about 30%.

To be used for filtering, the soil must not be too coarsely or too finely textured. Normally the levels of fine particles decide the suitability for infiltration, since too many fine particles will clog the soil. If the natural soil is not suitable, a sand filter with a drainage layer in the bottom for collecting and discharging treated water can be used.

Greywater application

It is important that the water is spread evenly on the surface of the filter. Uneven distribution causes deep clogging zones where little or no treatment can occur, while the main part of the filter is left unused. In the worst case, the water will flow through the deep pores directly to the groundwater with little or no pollutant removal.

The use of 'controlled clogging' in gravity systems can help overcome the problem. This can be achieved if water is applied in a narrow trench where the bottom is allowed to be clogged with biofilm. Water will impound, spread horizontally and infiltrate through the walls of the trench. Bacteria communities in the interface between water and soil will help decompose organic pollutants.

Other distribution options for soil filters include:

- *Surface flooding*. High amount of water is applied in a short time (5 cm column in 5 minutes), to allow for even infiltration.
- *Perforated horizontal pipes*. Plastic pipes with drilled holes. Water can be added in small doses. This system is simple to construct and maintain.
- *Drip irrigation*. Drip irrigation systems are primarily developed for irrigation. They are sensitive to clogging, and should not be the first option for greywater treatment.
- *Spraying techniques*. Wastewater is distributed on the filter by sprinklers.

3. Trickling filters and biorotors

These systems purify water by using attached biofilm in filters heavily loaded with water. A filter media with a large surface area and large pores is used. These systems are compact, but they cannot achieve the same level of removal efficiencies as soil filters and they create a sludge which needs to be taken care of.

Greywater end use

After treatment, the water is normally discharged to surface waters, percolated to groundwater or used in irrigation.

Discharge to surface waters

This is often the easiest and most natural way to return the water to the environment. Normally the water can be discharged in open ditches to soak away with stormwater.

Percolation to groundwater

Greywater that is returned to the groundwater should be treated with tested and reliable methods. The water should then percolate through the ground in an unsaturated zone of one metre or more. The subsoil should consist of sand (or smaller grain size). Safety zones around water extraction wells need to be established. As a rule of thumb, a one-month retention time in a saturated zone must be secured before water extraction (i.e. reuse of groundwater).

Use in irrigation

Water should be applied on the ground or sub-surface rather than sprinkled. Crops where leaves or stems are not eaten directly, such as fruit trees or berry bushes, are most suitable for irrigation. For crops that are consumed raw, e.g. salad or spinach, a period of at least one month between irrigation and harvest is recommended.

www.ecosanres.org

EcoSanRes

Stockholm Environment Institute
Kräftriket 2B, 10691 Stockholm, Sweden
Tel +46 8 674 7070 Fax +46 8 674 7020
www.sei.se

SEI

EcoSanRes is funded by the Swedish International Development Cooperation Agency (Sida)