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Greywater Treatment Plant

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Abstract: **This paper presents a literature review of the quality of greywater generated in different, especially developing, countries, constituents found in greywater, some treatment systems, natural materials for treatment, some reuse strategies and public perception regarding greywater reuse. The review shows that generation rates are mostly influenced by lifestyle, types of fixtures used and climatic conditions. Contaminants found in greywater are largely associated with the type of detergent used and influenced by other household practices. Many of the treatment systems reviewed were unable to provide total treatment as each system has its unique strength in removing a group of targeted pollutants. The review revealed that some naturally occurring materials such as *Moringa oleifera*, sawdust, can be used to remove targeted pollutants in greywater. The study further showed that user perceptions towards greywater treatment and reuse were only favorable towards non-potable purposes, mostly due to perceived contamination or lack of trust in the level of treatment offered by the treatment system.**

Keywords: **Grey water, Reuse, Natural media, Treatment Systems**

Introduction

As pressures on freshwater resources grow around the world and as new sources of supply become increasingly scarce, expensive, or politically controversial, efforts are underway to identify new ways for meeting water needs by increasing the efficiency of water use and to expand the usefulness of alternative sources of water previously considered unusable, among these potential new sources of supply is “grey water”

Grey Water Definition Grey water gets its name from its cloudy appearance and from its status as being between fresh, potable water (known as “white water”) and sewage water (“black Water”). Grey water is wastewater from showers, baths, washbasins, washing machines and kitchen sinks. while kitchen wastewater is not recommended for use as grey water if untreated. Grey water does not include wastewater from toilets, urinals, or bidets. This is referred to as black water (water containing human excrement). Grey water can be collected from some or all of these sources and, after treatment, used for purposes around the home such as toilet flushing or garden watering that do not require drinking water quality

LITERATURE SURVEY

Shaikh et al(2015) Demonstrated he reuse and treatment of residential bathrooms, basinswastewater called as greywater for the purpose of landscaping, gardening, irrigations, plant growths and toilet flushing. Based on finding of this study, this treatment technology can be considered as a viable alternative to conventional treatment plants in rural region since they are characterized by high potential for BOD, TDS, TSS, total hardness, oil and grease, anions and cations removal. The benefits found are low energy demand, less operating and maintenance cost, lower load on freshwater, less strain on septic tank, highly effective purification, and ground water recharge.

Hegokar, (2015) presented the design of laboratory scale grey water treatment system which is restricted to 5 stages of physical operation such as raw grey water. 1st Filtration unit of sand and gravel, 2nd dualfiltration and scoring unitfor treated grey water. The research pa[er is related to physic-chemical characterization of grey water sample by using low cost technological option.

Ayoub et al(2012) Water Installation of decentralized grey water treatment systems in small rural communities contributes to a more sustainable supply. In order to gauge community attitudes about collection and use of greywater, a door-to-door survey in the farming community of DeirAlla, Jordan was conducted by Royal Scientific Society interviewers. The survey results showed that the socio-economic characteristics of the study area are generally very difficult. The families are poor and with low education levels. The main source of income for the local people is derived from agricultural activities. However, in spite of all these

considerations, people are still willing to accept the reuse of greywater and to adapt its treatment in order to secure their water needs for irrigation due to severe shortage of water resources in the study area.

Friedler et al (2005) With pilot plant treating light grey water for seven flats. The pilot plant combines biological treatment (RBC) with physicochemical treatment (sand filtration and disinfection). The pilot plant produced effluent of excellent quality, meeting the urban reuse quality regulations, and was very efficient in TSS turbidity and BOD removal: 82%, 98% and 96%, respectively. The overall performance of the pilot plant was excellent, producing very high-quality effluent which meets the highest requirements of the Israeli Ministry of Health urban reuse regulations. Overall removal efficiency ranged from 64% (COD) to 98% (turbidity), producing very low effluent BOD (2.3 mg/l) and turbidity (0.6 NTU). The RBC SB successfully retained bio solids produced in the process, discharging effluent with less than 20 mg/l TSS. The pilot plant successfully removed 58%, 87%, 96% and 72% of the TP, TKN, ammonia and organic nitrogen, respectively. This produced effluent with low nutrient content which together with low BOD reduces the regrowth and fouling potential in the reuse system.

Friedler et al (2005) Analyzed the economic feasibility of on-site grey water reuse in the urban sector. RBC- and MBR-based systems were selected as model systems for the economic analysis. The analysis showed that the investment costs of an RBCbased system consist of less than 0.5% of the price of a flat for buildings of more than 20 flats (five storeys). This paper analysed the economic feasibility of on-site grey water reuse systems in new buildings in the urban sector, since a prerequisite for this practice to become widespread is its economic feasibility to the individual consumer. The analysis demonstrated that on-site grey water reuse is a feasible solution for decreasing overall urban water demand, not only from an environmental standpoint, but also from economic profitability under typical conditions.

Mama1 et al (2013) studied the performance and economic viability of a simple inexpensive grey water treatment system consisting of a filtration unit and an adsorption unit was evaluated. At steady state, the overall performance of the combined system was 85.68% BOD removal, 57.09% COD removal and 70.74% TSS removal. An economic analysis showed that 77.5% savings in water expenditure can be achieved if a simple grey water treatment is installed for toilet flushing. The overall performance of the pilot scale was commendable producing an appreciably improved quality of greywater. The final effluent at a steady state had a BOD of 13.7 mg/L which is close to values obtainable with some standardized water treatment technologies.

Benefits of Grey Water Treatment

Recycling grey water not only reduces the consumption of water, it also reduces the volume of water discharged into the sewerage system. Consumers with water meters could therefore save money on both their water supply and wastewater bills. There are many ecological benefits of grey water recycling could be summarized as follows:

• Lowering the fresh water use Grey water can replace fresh water in many instances, saving money and increasing the effective water supply in regions where irrigation is needed. Residential water use is almost evenly split between indoor and outdoor. All except toilet water could be recycled outdoors, achieving the same result with significantly less water diverted from nature.

• Less strain on septic tank or treatment plant Grey water use greatly extends the useful life and capacity of septic systems. For municipal treatment system by decreasing the wastewater flow which in turn means higher treatment effectiveness and lower treatment costs.

• Less energy and chemical use Less energy and chemicals are used due to the reduced amount of both fresh wastewater that needs pumping and treatment. For those providing their own water or electricity, the advantage of a reduced burden on the infrastructure is felt directly. also, treating your wastewater in the soil under your own fruit trees definitely encourages you to dump fewer toxic chemicals down the drain.

• Highly effective purification Grey water is purified to a spectacularly high degree in the upper, most biologically active region of the soil. This protects the quality of natural surface and ground waters.

• Groundwater recharge Grey water application in excess of plant needs recharges groundwater.

• Plant growth Grey water enables a landscape to flourish where water may not otherwise be available to support much plant growth.

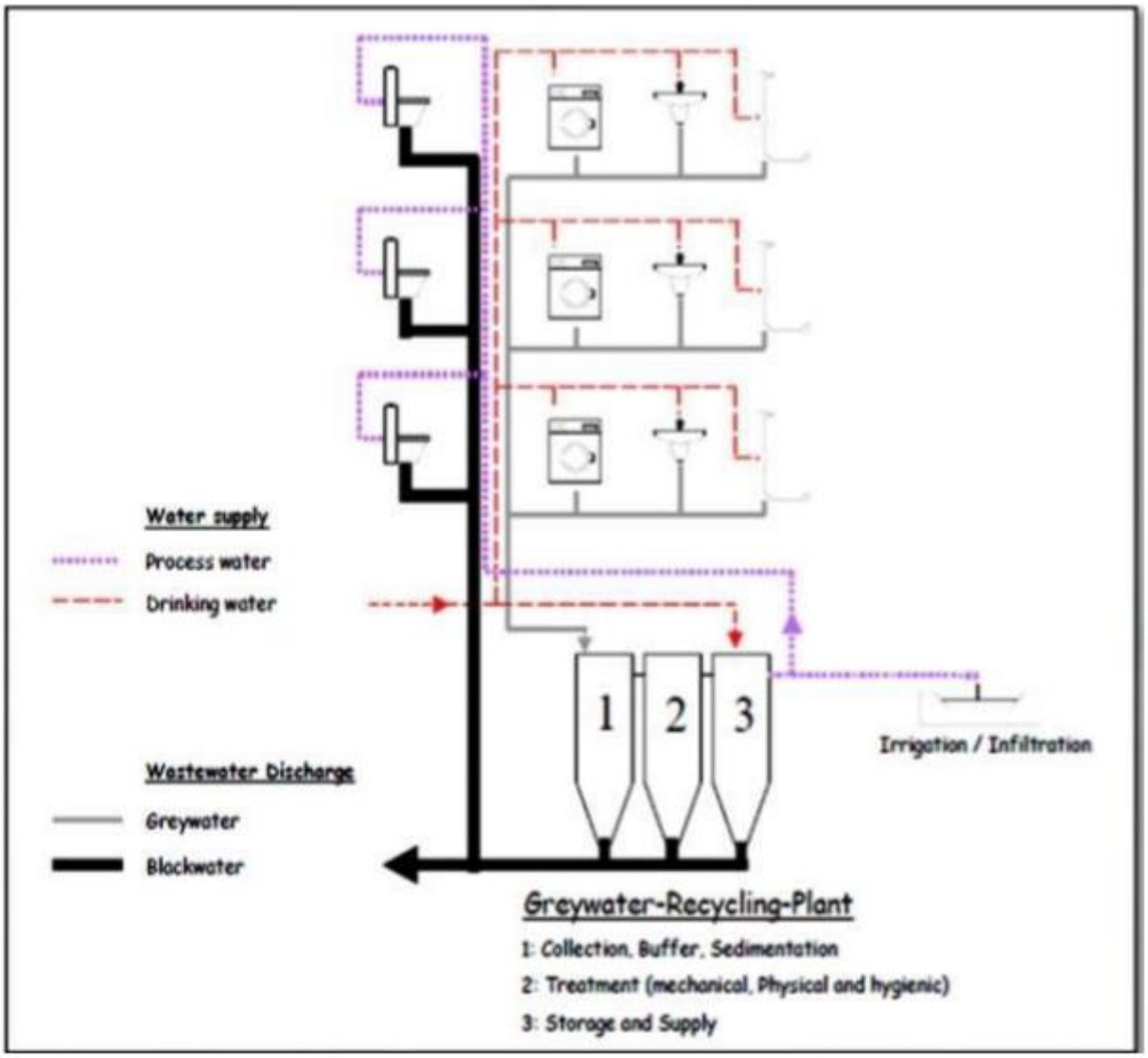
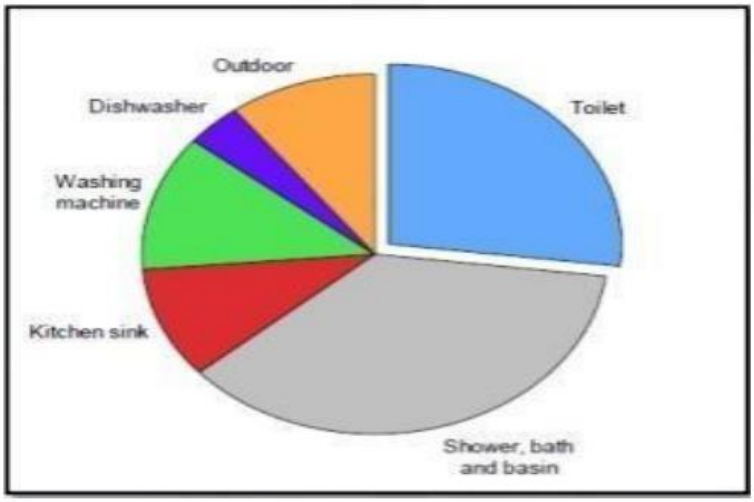


Figure 1: Typical application of grey water recycling from several households

Grey water Volumes and Sources The percentage of household water that is grey water varies regionally and between households, depending on the primary uses of water in a home and how efficiently water is used, but is generally between 50% and 80% of the total water used



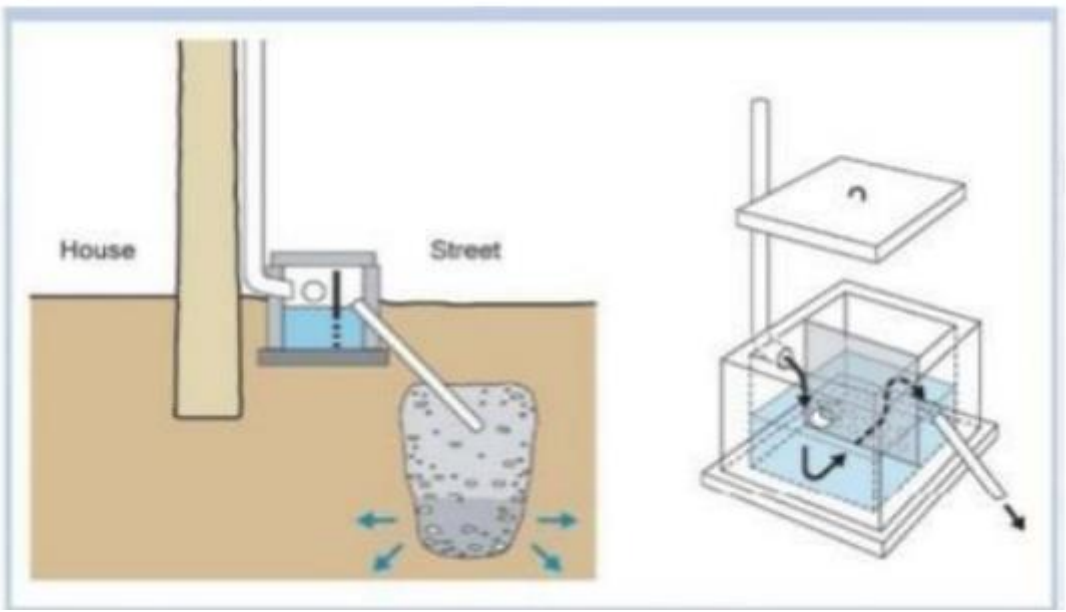
On average the volume of water use in the house per day is 135 L/person/day. Approximately 84% (113 L/person/day) of this water can be captured and recycled from the grey water. In the following, the different sources of grey water are classified and explained. Bathroom grey water (bath, basin and shower) contributes approximately 50% of the total grey water volume. Bathroom grey water can be contaminated with hair, soaps, shampoos, hair dyes, toothpaste, lint, nutrients, body fats, oils and cleaning products. Laundry grey

water contributes approximately 30% of total grey water volume. Wastewater from the laundry varies in quality from wash water to rinse water to second Rinse water. Laundry grey water can be contaminated with lint, oils, grease, laundry detergents, chemicals, soaps, nutrients and other compounds. Kitchen wastewater is sometimes considered as a grey water source. If a suitable treatment is not available, kitchen wastewater should not be used due to the amount of contaminants (food particles, oil, grease, etc.) it contains. Fortunately kitchen grey water contributes a relatively small portion of the total available grey water (15%).

Table 1: Water-quality characteristics of selected domestic grey water

Water Source	Characteristics
Automatic Clothes Washer	Bleach, Foam, High pH, Hot water, Nitrate, Oil and Grease, Oxygen demand, Phosphate, Salinity, Soaps, Sodium, Suspended solids, and Turbidity
Automatic Dish Washer	Bacteria, Foam, Food particles, High pH, Hot water, Odor, Oil and grease, Organic matter, Oxygen demand, Salinity, Soaps, Suspended solids, and Turbidity
Bath tub and shower	Bacteria, Hair, Hot water, Odor, Oil and grease, Oxygen demand, Soaps, Suspended solids, and Turbidity
Sinks, including kitchen	Bacteria, Food particles, Hot water, Odor, Oil and grease, Organic matter, Oxygen demand, Soaps, Suspended solids, and Turbidity

• Grey water management system Grey water from kitchen, bath and laundry flows through a PVC pipe, covered with local pottery so as to blend in with the adobe buildings, into a grease and grit trap (Figure 3-1). The trap, located at the bottom of the outer wall of the house, is easily accessible for maintenance. The pretreated grey water leaves the grease and grit trap through a small bore pipe entering the infiltration trench.



Treatment Systems

Management of greywater graduates from simple to extremely complex when the necessary strategies and technology is not in place or not properly implemented. Many developed countries have however implemented from simple to advanced methods of handling, managing and treating greywater with some countries recycling the greywater for both potable and non-potable uses. Treatment systems have been used

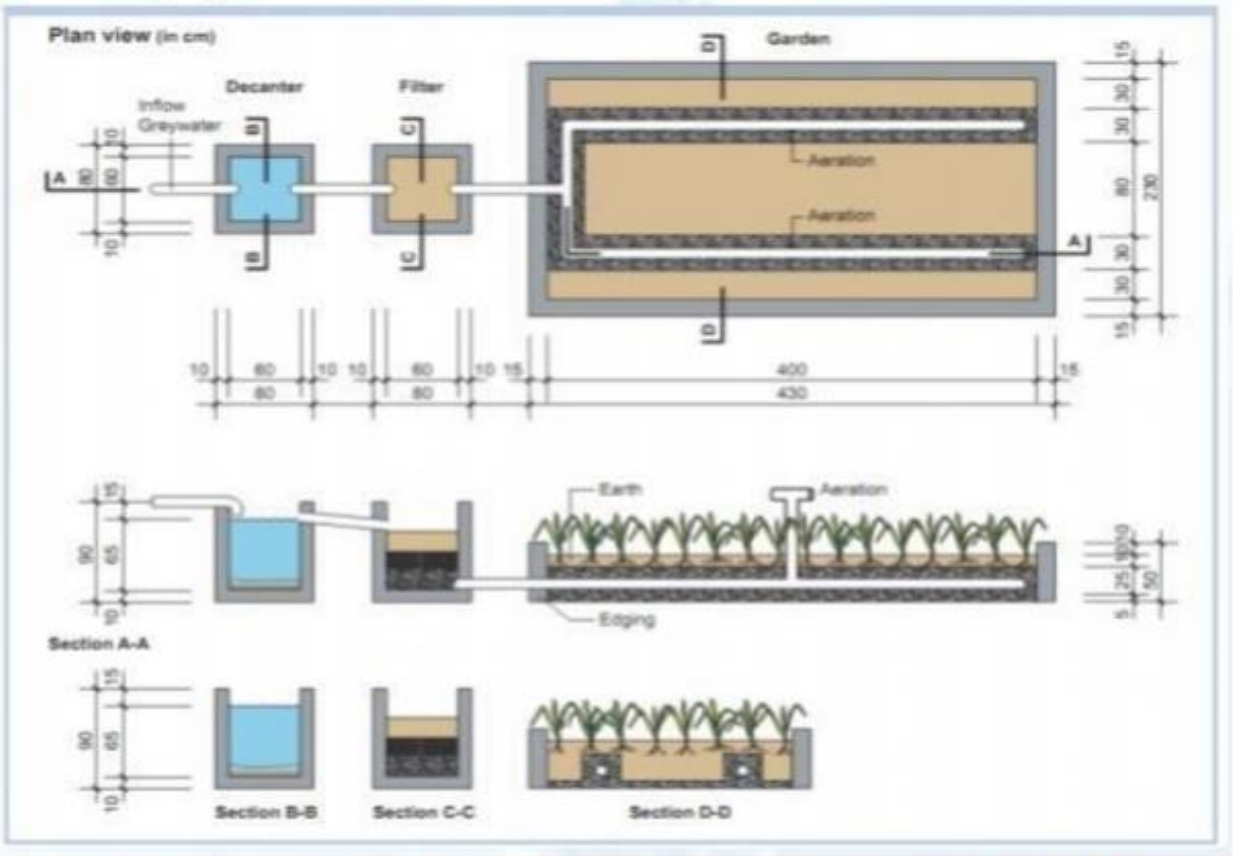
to reduce the level of contamination in greywater before reuse or final disposal. They are contaminant-specific, and each is applied along the conventional wastewater treatment sequence (pre-treatment, primary, secondary and tertiary treatment). Each of these systems adopts either a physicochemical or biological means of treatment. Physicochemical methods adopt physical and/or chemical methods of treatment including filtration, adsorption and reverse osmosis, among others. Biological treatment methods adopt a combination of microbes, sunlight and oxygen manipulation; examples of such systems include activated sludge systems, trickling filters, waste stabilization ponds, rotating biological contactors and many others. The widely used systems have mostly been filtration, rotating biological contactors, membrane bioreactors, constructed wetlands and upflow anaerobic sludge blankets (UASBs). These systems have found their application in addressing the emerging greywater pollution experienced in most developing countries. This review therefore discusses the performance of these systems.

Filtration

Filtration involves removal of particulate matter which is not removed by preceding processes. In filtration systems, both physical and biological processes remove solids; however, this review considers only physical removal of solids because that is the method adopted in most greywater treatment schemes. Filtration media could be in the form of sand, gravel, fine mesh and many others. Gross et al. (2007) studied the performance of a filtration system in greywater treatment using pebbles of 2 cm thick placed over drain holes and followed by a 12-cm middle layer consisting of 12 cm of plastic filter media and finally topped by 4 cm thick layer of peat. Dalahmeh et al. (2012) also studied the performance of a filtration system using pine bark, activated charcoal, polyurethane foam and sand as filter media in treating greywater. The performance of a coarse filtration system followed by slow sand filtration with a hydraulic retention time of 8 and 24 h respectively was studied by Finley et al. (2009). Parjane and Sane (2011) used coconut shell, coarse sawdust, charcoal, bricks and sand as filter materials to assess the performance of greywater treatment. A four-barrel filtration unit has been used to investigate greywater treatment by Al-Hamaiedeh and Bino (2010). These barrels were arranged in series, and the first three were loaded with gravels of 2–3 cm diameter. The final barrel was used to collect the treated effluent for irrigation. Gross (2008) adopted a hybrid filtration system utilizing a 130-μm net filtration, a tuff filter, a sand filter and followed by electrolysis in Israel. Zuma et al. (2009) used a mulch tower system to treat greywater in South Africa. This was constructed by using mulch, coarse sand, fine and coarse gravel. This was contained in a 650-mm high plastic column of 150 mm diameter with a stainless-steel sieve mesh placed on top to remove big particles. From the reviewed filtration systems, only bark filters were able to meet the pH criteria for reuse. More so, only the bark and charcoal filters could meet the BOD_5 regulatory standard for reuse

- **Grey water management system**

A wire mesh covering the outlet of the shower prevents large particles from being washed into the open grease and grit trap. The collected grey water from the grease and grit trap is then conveyed into a vertical-flow filter with an upper layer of sand, a middle layer of charcoal and a bottom layer of gravel. The thereby filtered water then enters a subsurface irrigated bed planted with fruits and vegetables (see Figure 3-3 and 3-4). The grey water fed through perforated pipes into this garden is equipped with two aeration pipes. For hygienic reasons, only crops with above-ground edible parts are planted. The garden is fenced off to prevent damage by domestic animals.



3-3 plan view and cross-sections of the grey water garden implemented in Koulikoro.

Practical experience and lessons learned Some clogging near the inlet of the first filter was observed after two years of operation. Liner leakage discovered in the second filter bed highlighted the importance of avoiding joints in the liner as well as the need for a geotextile layer to protect the liner. Dissemination and replication of the concept is largely dictated by installation and maintenance costs as well as opportunity costs caused by further land requirements. Use of conventional crushed rock influenced construction and operation for the following reasons: Responsible for 25% of the total costs. Increased salary costs, as handling this heavy material was more laborintensive. Increased clogging risk, as fine sand was also present in the crushed rock material. Difficult and expensive repair work (e.g. unclogging inlet section or Repairing liner). Relatively low porosity and hydraulic conductivity.

Grey water management system

A constructed wetland system was built for a 7-person household. The system was designed to treat grey water from bathroom, laundry and kitchen. The grey water is collected in two chambered settling tank. A subsequent dosing tank with a mechanical siphon discharges grey water onto a vertical-flow planted filter 3–4 times a day through a perforated pipe fixed above the surface level of the bed. The filter material of the bed is composed of a layer of gravel at the bottom, fine gravel in the middle and coarse sand on the top (see Figures 3-9a, 3-9b). The treated grey water is then collected in a tank before it is used for irrigation, washing

vehicles and toilet flushing. An average of 500 liters of grey water is treated daily. Hydraulic retention time (HRT) in the settling tank averages 24 hours and hydraulic loading rate (HLR) of the constructed wetland amounts to 8.3 cm/d

Greywater treatment plant





CONCLUSION

Greywater reuse is next to rainwater harvesting the first decision which should be considered both by individuals and the community when it comes to reuse of water. The results obtained from the CW provide excellent treatment for greywater with variable peak flows. Therefore, it can be recommended that this configuration can be used as a benchmark design for other warm climate remote areas or small communities needing to improve and preserve the quality of open water bodies. The SM-SBR is an option where space is limited and high hygienic quality is needed. The unplanted GSF is a very simple technology for low polluted greywater, but needs to be carefully designed to avoid clogging. All described technologies should be considered as solution to gain advantages from a sustainable water management with its many reuse options.

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