4th International Conference on Water Resources and Arid Environments (ICWRAE 4): 73-79
5-8 December 2010, Riyadh, Saudi Arabia

Greywater Management in Egypt

Eman Salama

National Water Research Center, Egypt

Abstract: In Egypt water is becoming an increasing scarce resource so the utilization of low quality water–greywater for specific purpose saves conventional resources. Greywater is generated from domestic usages including showers, bathroom sinks, kitchen sinks, dishwaters and washing machines. It is distinguished from blackwater- sewage - which is regarded as heavily polluted wastewater generated from toilet and contains large concentrations of fecal matter and urine. Greywater can be reused after appropriate treatment in myriad activities such as crop production, irrigation green spaces and golf courses, groundwater recharge, influent for industrial cooling systems and domestic cleaning. The objective of this research is to study the possibility of greywater reuse management and highlight the main obstacles and requirement for its reuse. This study covers greywater management system, greywater generation, potential for reuse and water balance. Moreover, cost / benefit, positive and negative impacts of greywater reuse are covered. The study revealed that the application of greywater management strategy saves fresh water but needs building capacity and awareness, modification of wastewater networks and codes of building.

Key words: Greywater • Management • Domestic water • Reuse

INTRODUCTION

The gap between fresh water supplies and demands in arid zones is rapidly increasing due to population growth and limited water resources. The population of Egypt increased from 23 million in 1955 to about 82 million in 2008. The major part of Egypt water resources is limited to Egypt's share from the Nile waters due to 1959 treaty between Egypt and Sudan. Effort to overcome the unsatisfied water demand in Egypt include water demand management and mobilization of non-conventional water resources like sea water desalination, water harvesting, cloud seeding, wastewater reuse and domestic greywater reuse.

Greywater is wastewater from baths, sinks and washing machines, accounting for about 60% of the outflow from homes. It contains little pathogens and 90% less nitrogen than toilet water, so does not require the same treatment process [1]. With the increasing demand for freshwater, greywater use may reduce irrigation water needs, increasing its availability of freshwater for other primary uses.

Greywater from residential premises (single households) is a resource and can be reused on-site for garden or lawn irrigation or if treated appropriately for toilet flushing and laundry use washing machine only [2].

In the Middle East and North Africa (MENA), the Urban Poverty and Environmental Programme of the International Development Research Center (IDRC) has worked with partners in the Phalestinian Territories, Jordan and Lebanon to capture local knowledge on greywater treatment and reuse in MENA region.

In Jordan, IDRC provided financial assistance to an applied research project on greywater treatment and reuse for home garden irrigation in 25 low-income households in Ein Al Beid village, southern Jordan. The project had several direct and indirect benefits for the community and the environment. The monthly domestic water bills decreased by about 30%, and the reduced septic tank activities also lowered the overall costs [2].

In Kingdom of Saudi Arabia, greywater quantity which can be treated as an effluent of washers, cloth washing except toilets and kitchen is approx (55%) of the daily water consumption per capita [3].

In South Australia, the continued drought conditions has made the house-holders look at new and innovative ways of saving water and reusing waster water. One area that has received a lot of publicity is domestic greywater reuse. There are two water system approved by the department of health for greywater reuse, diverter system

Corresponding Author: Eman Salama, Associate Professor, National Water Research Center, Egypt

and aerobic waste water system [4]. In Sydney the bathroom greywater (bath, basin and shower) contributes about 59% of the total usable greywater volume in a typical household [5].

In Norway, a simple vertical flow bio-filter (of diminutions of 2m width and 0.6 m height filled with grain size of 2-10 mm gravel, crushed concrete and brick) followed by a compact horizontal flow wetland filter was developed and resulted in suitable effluent for subsequent treatment producing water quality for in house use [6].

The reuse of treated greywater helps to ease the increasing burdens on global water supplies and there are two major uses for treated greywater, toilet flushing and irrigation [7].

The objective of this research is to study the possibility of greywater reuse management in Egypt and highlight the main obstacles and requirement for its reuse.

MATERIALS AND METHODS

Greywater management possibility necessitates studying the following items:

- Household water usage volume and greywater generation
- Potential of greywater reuse
- Ggreywater management systems.
- Cost of greywater management systems
- Health consideration
- Positive and negative impact of greywater management systems
- Requirements for greywater management systems

This is done through literature review of countries that used treated greywater or greywater management systems, in addition, field trips were done to the study area to carry out a comprehensive survey and collect the required data and information for this research through questionnaire. Based on the collected data several greywater management systems were suggested, compared and evaluated according to type of treatment, potential of greywater reused, residential time and cost and health consideration. Moreover, positive and negative impact of greywater reuse on the environment is studied.

Study Area: The research was carried in residential compound in Six of October Governorate, Egypt where each house has a cultivated garden of about 40% of its area. A pre-designed questionnaire was distributed and filled out by each residential household. The questionnaire is developed in three parts, Part 1, which highlights in indirect way the value of water, the meaning of greywater, its sources, uses and covers several questions about residential household point of view of greywater reuse after primary treatment in irrigation of their garden. Part 2 which includes information about the type and area of each house, the sanitary system (one or two pipes), the area of the garden and type of cultivation, grass or tree, the source of water used for irrigation of this area and method of irrigation (sprinkler method or trickle). Part 3, information about the number of person in each residential house, average consumed water quantity per month and the value of domestic water bills.

The questionnaire was distributed to 50 households; a statistical analysis was carried out to the collected data from the gathered questioners. A simple model was designed to predict the daily volume of greywater that discharged from each residential household.

RESULTS AND DISCUSSION

Public Awareness: The statistical analysis of the gathered information from questionnaire proved that 10% of households didn't respond and more than 50% from the household couldn't define greywater and didn't aware of water value and problem. About 40% positively react and encourage idea of greywater reuse Figure (1).

Household Water Usage Volume and Greywater Generation: The data analysis of questioner proved that most of the householders use fresh water for irrigation of their gardens and paid for that quantity of water. Figure (2) illustrates the daily consumption of water in the study area and the generated greywater. The average daily consumption of domestic water which included irrigation water is 267 liter per capita per day (L/p/d.). Based on this value the expected average generated greywater volume is about 149l/p/d. The amount of wastewater generated by any household will vary greatly according to the dynamics of the household, and is influenced by such factors as the number of occupants, the age distribution of the occupants, their life style characteristics, water usage pattern, the cost of water and the climate.

Potential of Greywater Reuse: The potential of greywater reuse of house's garden means the water quantity for garden irrigation [8]. The water requirement for grass cultivation depends on the evapotranspiration rate, usually 2-15 liters per square meter per day [9].

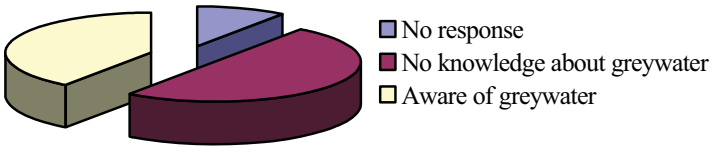

Fig. 1: Household awareness of greywater reuse

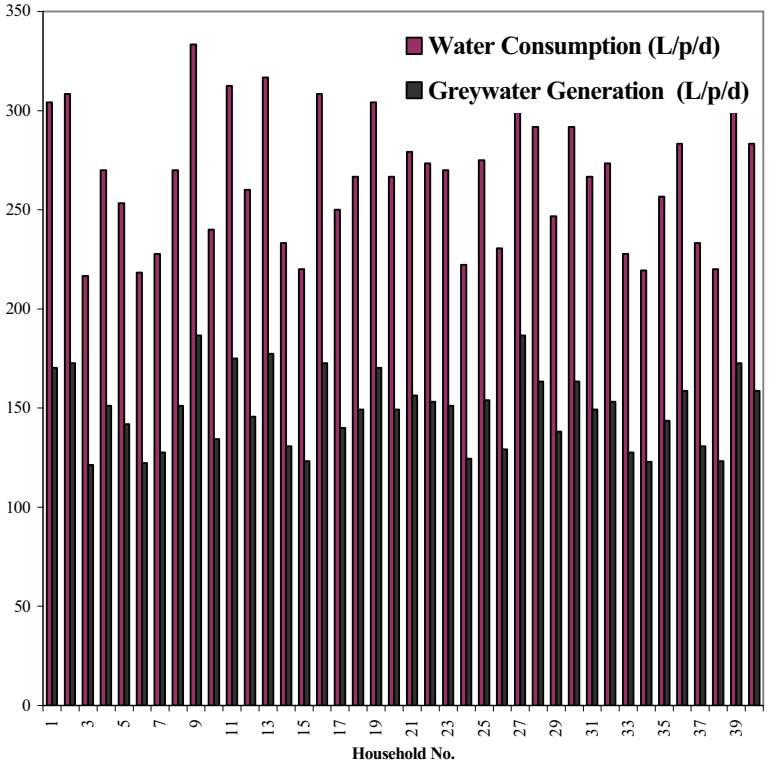

Fig. 2: Average water consumption per household (Liter/capita/day)

Greywater Management Systems: 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% [9].

The water balance of greywater management system means the balance between the quantity of generated greywater and the potential of greywater reuse.

Based on the result of the water balance and the household awareness, willingness and budget to operate a greywater management system there is several management (treatment) systems has developed and implemented by the Inter-Islamic Network on Water Resources Development and Management (INWRDAM) which based in Amman Jordan and could be used [10]:

- Primary Diversion System
- Barrel system
- 4-barrel system

Primary Diversion System: Primary diversion methods use coarse screen filters or sedimentation to remove oils/grease and solids prior to discharge to the land application areas. These systems are likely to be considered the most economically attractive for greywater use because maintenance can usually be carried out by the homeowner, and they generally do not rely heavily on electricity or chemicals to operate. These include the gravity diversion system and the pump diversion system.

A gravity diversion device incorporates a tank –activated valve, switch or tap that is fitted to the outlet of the waste pipe of the plumbing fixtures, such as laundry tub. The plumbing diversion device can be

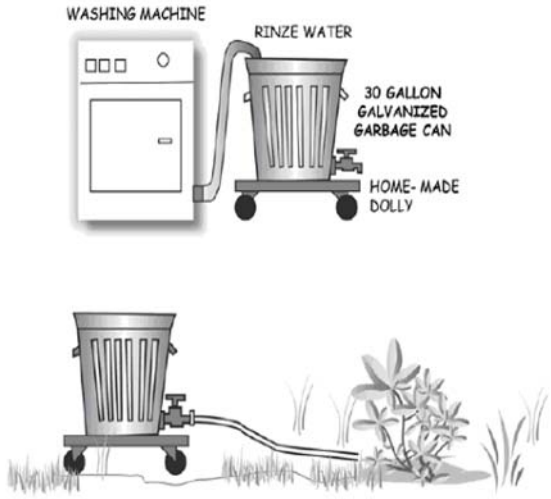

Fig. 3: Gravity system with potable tanks

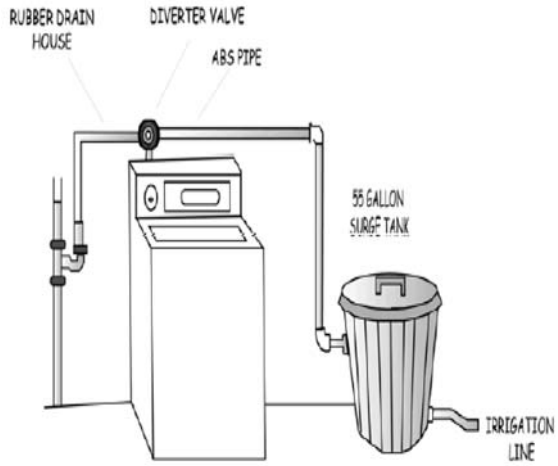

Fig. 4: Gravity system with surge tanks [11]

switched by the householder to divert greywater from the laundry tube by gravity directly to the diversion line and the proposed land application area as shown in Figures (3 and 4).

Two-Barrel System: A 160 L plastic barrel acts as setting tank where oil, grease and settable are retained. The greywater then flows into a second barrel (160L) acting as a storage tank. A small water pump feeds a drip irrigation system as soon as the storage tank is full Figure (5).

Four-Barrel System: The 4- barrel unit consists of four recycled plastic barrels connected together by 3" diameter plastic pipes. The first barrel of 160-liter capacity receives greywater coming from the house and removes grease, oil and settable solids. After that, two 200 liter capacity barrels are connected by pipes in such a way that greywater passes in an up flow mode through a bed of crushed stones or gravel and achieves physical and biological treatment. A last barrel of 160-liter capacity is fitted with a small electric pump and float switch that delivers treated greywater to a trickle irrigation system serving a small garden of trees Figure (5).

Table (1) shows the characteristics of the suggested management systems, treatment type whether primary or secondary treatment, hydraulic detention time (resident time), greywater stream type, volume and pollutants. Moreover, the cost of the greywater system and irrigation network. Four-barrier management system is efficient in terms of treatment but not cost effective while 2-barrel system proved to be cheep but not so efficient.

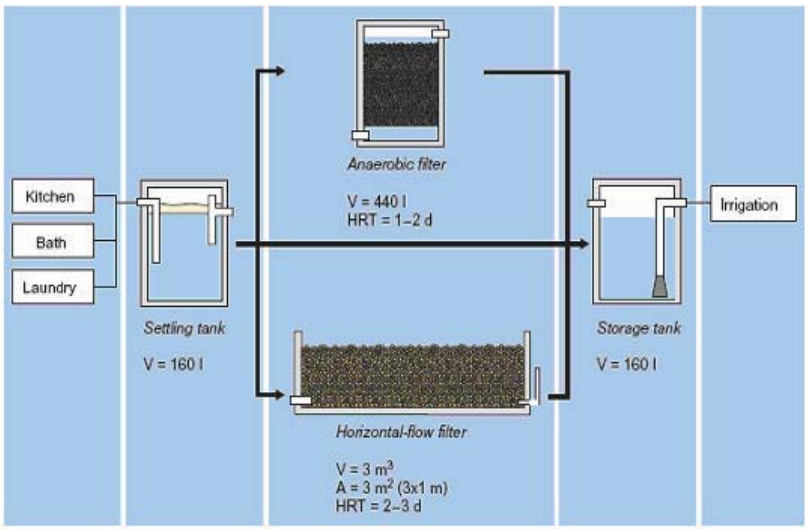

Fig. 5: 4-barrel system [10].

Table 1: the suggested greywater management systems characteristics

No.	Greywater system	Treatment type	Greywater Source	Greywater Volume (Liter)	Greywater Pollutants	Residence time (HDT)	Cost	Health Consideration
1	Gravity system with potable tanks	Primary treatment (coarse screen filters or sedimentation to remove oils/grease and solids)	Washing machine	113	-Lint, oils, greases, laundry detergents, chemical, soaps, nutrients and other compounds. - Fecal contamination ,patho gens through washing contaminated clothes	Immediately	30 USD	Prevent human contact
2	Two –barrel system	Primary treatment	Washing machine +hand basin + baths	160	-Hair, soaps, shampoos, hair dyes, toothpaste, lint, nutrients, body fats, oils and cleaning products. - Fecal contamination and pathogens through body washing.	1-2 days 2-3 days	230 USD 370 USD	Prevent human contact Meet the world health
3	Four –barrel system	secondary treatment (physical & biological)	All waste water except toilet	160	All pervious pollutants plus food particles.			organization for restricted irrigation.

Table 2: Impact of greywater on the environment

Item	Adverse Impact of Greywater	Mitigation Measures
Soil	• A tendency to raise soil alkalinity and salinity; • A reduction in the ability of soil to absorb and retain water • An increase in alkalinity due to the presence of sodium, potassium or calcium salts in the greywater, particularly from laundry detergents.	- Application of gypsum (calcium sulfate) to the soil in order to reduce the pH levels. - Dilution of greywater by fresh water before irrigation helps to clean the soil from the build-up of sodium, excess salts, and other soil contaminants; - The soil should not be allowed to dry out as this causes the concentration of salts in the remaining water to become very high. - Select garden-friendly detergents that are biodegradable and low in phosphorus, sodium, boron and Chloride.
Ground water	Groundwater contamination	Water quality and nutrients to be used for irrigation must be monitored and applied at a rate required to meet the demand of the vegetation [15].
Plant Health	Sign of plant injury appear	- greywater use must be discontinued or reduced. - Greywater should only be used on well-established plants, not on seedlings or young plants, as they are more sensitive to the impurities in the greywater.

Cost of Greywater Management System: The cost of greywater management system in case of garden irrigation comprises irrigation network cost, in addition to capital cost of the management system and the operational cost that includes the cost of utilities requirements such as energy, fuel as well as maintenance cost.

Health Considerations: Greywater is contaminated with excretions from bathing and laundry. Microbial and chemical contamination of greywater poses a potential risk to human health, a risk that is likely to be increased if microbial contamination is increased [12]. It is important to recognize that greywater does have the potential to transmit disease. The environmental transmission of pathogens occurs through several different routes like direct contact with greywater and direct contact with contaminated drinking water [13].

To minimize the risk to human health from greywater reuse, the following considerations are important:

- Greywater systems must dispose of greywater below ground surface unless treated and disinfected to meet an appropriate standard.
- The system must be designed and operated to prevent human contact with greywater.

Positive and Negative Impact of Greywater Reuse: There are many economical benefits, which may result, from the greywater management system but these benefits do not have direct market values and can classified as positive impact of the greywater management system.

Positive Impact of Greywater Management System:

- Water conservation through sustainable development of environment:
- Minimize use of existing fresh water by 12852 m^3/fed/year, which is used in irrigation house's garden.
- Release pressure on sanitary system by 12852 m^3/fed/year, which is used in irrigation house's garden.
- Job opportunities for local plumbers
- Reduction of water purchasing costs [14]
- Change in property value, as the result of more green areas around houses.
- Reduce carbon dioxide gas that absorbed by green plants and hence minimize climate change causes.

Negative Impact of Greywater Management System:

- Effects of greywater reuse on the environment such as groundwater contamination.
- Effects on soil physical and mechanical properties.
- Effects on plant health.

Table (2) shows the adverse impact of greywater reuse on the soil, groundwater and plant health and mitigation measures. Soil salinity will increase and the required action is to dilute the greywater with fresh water. Regarding ground water contamination, monotring of water quality and nutrients must be done. Finally for plant health Greywater should only be used on well-established plants.

Requirements for Greywater Reuse

Wastewater Networks and Building Codes: Greywater reuse from houses requires construction of two wastewater networks, the first for greywater drainage where it is collected in ground tank for treatment then recycled to agriculture purposes and flushing tank and the second for black water drainage. This linked to building codes and institutional arrangements and low enforcement.

Building Public Awareness: It is essential to build, raise awareness of household and public communities of water value and greywater reuse. The development of an appropriate public awareness strategy needs to be complimentary and consistent with Non-Governmental Organizations (NGOs), people's committee and worship places leaders. Meanwhile, incentives have to be regulated for households who use greywater management in irrigation of their gardens and this can do by the Egyptian Environmental Affairs Agency (EEAA).

Conclusions and Recommendations: Greywater management is one of the non-conventional water resources and from the best solutions for water problem in Egypt. Among the suggested greywater management systems, a four-barrier management system is efficient in terms of treatment and meets the world health organization for restricted irrigation. While, the 2-barrel system proved to be cheep but not so efficient. Geywater management has positive impact on the environment such as water conservation, and pressure release on sanitary system, job opportunities for local plumbers and reduction of water purchasing costs. An amount of fresh water of about 12852 m^3/fed can be saved annually by using greywater reuse in irrigation of house's gardens. Health consideration and mitigation measures for soil and plant must be taken. Application of greywater management strategy needs building capacity and awareness, modification of wastewater networks and codes of building.

REFERENCES

1. Al-Beiruti, S., 2004. The Potential of Greywater Treatment and Reuse in Jordan: Exchange of Know-How between Islamic Countries. 55th Meeting of IEC International Commission on Irrigation and Drainage. International workshop on management of poor quality water for irrigation; institutional, health and environmental aspects, Moscow, Russia.
2. Morel, A. and S. Diener, 2006. Greywater Management in Low and Middle-Income Countries, Review of different treatment systems for households or neighborhoods. Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland.
3. Kingdom of Sudia Arabia Guidelines for Reuse of Greywater, 2008G. Ministry of water and electricity.
4. The District Council of Mount Barker, Policy and information on grey water reuse. Government of South Australia, Department of Health http://www.dh.sa.gov.au/pehs/Default.aspx.
5. Loh and Coghlan, 2003. Domestic Water Use Study: in Perth, Western Australia 1998-2001. Water Corporation. Perth, Australia.
6. Jessen, Petter D., 2005. On-nutrient greywater treatment systems. Greywater Management. Department of Engineering, Norwegian University of life science (www.ecosan.no).
7. AbdeL-Kader and S.M. Abdel–Rassoul, 2010. Prospects of Water Conservation in Egypt (Special Reference to Wastewater Reuse). The Fourteenth International Water Technology Conference, Cairo. Egypt.
8. NSW., 2007. Guidelines for Greywater reuse in Sewered, Single Household Residential Premises, Department of Energy, Utilities and sustainability, Sydney NSW 2000. WWW.Deus.nsw.gov.au.
9. Eco SanRes Factsheet 8, 2008. http://www.ecosanres. org.

10. Bino, M.J., 2004. Greywater reuse for sustainable water demand management, presented at the international water demand management conference, Amman, Jordan.
11. The Water Conservation Alliance of Southern Arizona, 2001. Greywater Guidelines. Arizona, USA, Val L. Little, Water CASA.
12. WHO., 2006. Overview of greywater management Health Considerations. World Health Organization, Regional Office for the Eastern Mediterranean, Centre for Environmental Health Activities Amman, Jordan.
13. Ludwig, A., 2000. Create an oasis with greywater. Santa Barbara: Oasis Design.
14. Technical Bulletin on Greywater Treatment and Reuse in the MENA Region, 2007. International Development Research Center in cooperation with Regional Water Demand Initiative.
15. Wilson, P., D. Wheeler and D. Kennedy, 1995. Greywater Guide. California, USA.