Domestic grey water treatment and recovery to meet up the standards of characteristics of irrigation water

Adnan Khalil
Department of Chemical Engineering
Al-Balqa' Applied University, Faculty of Engineering Technology
P.O. Box (15008), 11134 Marka, Amman – Jordan.
Email: dr_adnan_khalil@hotmail.com

Abstract

In arid and semi-arid regions where water is in short supply, greywater treatment offers the possibility of supplemental water resources of reuse in irrigation at household and farm levels. The greatest environmental challenge that Jordan faces today is water scarcity. Jordan has one of the lowest per capita levels of water resources in the world.

In this work, an overview of the types and characteristics of household greywater was made.

An experimental pilot plant for greywater treatment was constructed at a residential house in Al-Faysaliya village five kilometers east of Madaba city in Jordan

Household greywater (from showers, sinks, washing machines, and dishwashing machine.) Was separated from black water (from toilet) and collected in a separate pipe system. The collected greywater was subjected to a processes of filtration, sedimentation, aeration, and pumping into irrigation system to irrigate a number of olive trees in the house garden.

Samples of untreated and treated grey water have been taken and analyzed for chemical and biochemical parameters.

The quantity of fresh water consumption and greywater generation has been recorded. Analysis of available experimental data has been done.

Results of analysis and calculations, showed that the treatment and reuse of household greywater leads to reducing the use of fresh water, saving of drinking water, less strain on septic tanks, enhancing plant growth; reclamation of nutrients.

Keywords: Greywater, Domestic Wastewater, Septic Tanks, Greywater Reuse.

I. INTRODUCTION

Jordan has one of the lowest Per capita levels of water levels of water resources in the world. Regions with fewer than 1000m3 per person per year are defined as water-scare.

Water-scarcity hinders economic development, strains the environment, and drastically limits food availability [1].

The renewable internal fresh water resources per capita in Jordan was 115.3m3 in 2009, according to World Bank report, published in 2010. While the point of concern for water scarcity is estimated at 500m3 per capita per year. [2]

Graywater can be considered as a good alternative providing non-potable water for household usage, and thus reducing per capita water use by 50%. [3], for this reason it is an attractive and sustainable low cost water source especially in arid and semi-arid areas, such as Jordan due to water scarcity and fluctuation in rainfall patterns. [4]

The site of this project is at Al-Faysaliya village in Madaba region. People of Madaba suffer from a chronic water shortage encountering severe water problem, most of Madaba's villages are not served with centralized sewerage systems. Individual

household cesspits and waste discharge into open environments are the only options for waste managements, which likely to contribute in high contamination of groundwater with coliform bacteria, nitrates and heavy metals. The quality of graywater varies depending on the volume of supply water consumed per person in a household, the initial quality of water supply, the source of graywater, and on chemicals used in the washing/bathing process. The volume of water supply consumed by a household depends on the scarcity, costs of water supply and on the water conservation measures been taken within the household. The health risk associated with graywater is related to the microbial quality of graywater at the point of irrigation, on how irrigation is carried out, and the type of crops being irrigated. [5] The use of graywater as an alternative irrigation source in Jordan considered an effective method for saving fresh water and increasing green areas. [6]

II. CHARACTERISTIC OF GRAYWATER

Wastewater generally classified as Blackwater and graywater.

Graywater is non-industrial wastewater generated from domestic processes such as bathing, laundry, washing dishes, hand basin, washing sinks. In other words, it is a domestic sewage, which does not come from a toilet, or urinal, which called black water. [7]

Graywater quality is highly variable because of its different sources in household fresh water uses.

Residential greywater can be categorized as light greywater and heavy (dark) greywater. [4]

Light greywater is untreated household wastewater that has not come into contact with sewage or Blackwater, and from some definitions, from kitchens. [7]

Heavy or dark greywater is untreated household wastewater that has not come into contact with Blackwater, but is from lower quality sources such as kitchens sinks and dishwashers.

Fig. (1) Gives an illustration of domestic wastes categories.

Greywater is typically wastewater low in turbidity and odor, cleaner in color. Greywater comprises (50-80) percentage of residential wastewater and generally about 99.9 % of water with the remaining 0.1 % comprising various solids in dissolved or suspended form. [8]

The quality of greywater varies depending on the source of the water, and the use to which the water has been put. Table (1) indicates the likely constituents of water from various household. [9]

Table (1): common constituents of graywater.

Possible contents	Graywater source
Suspended solids (dirt, lint), organic material, oil and grease, sodium, nitrates and phosphates (from detergents), increased salinity and pH, bleach, heat.	Automatic clothes washer
Bacteria, hair, organic material and suspended solids (skin, particles, lint), oil and grease, soap and detergent reside, heat.	Bathtub and shower
Bacteria, hair, organic material and suspended solids (skin, particles, lint), oil and grease, soap and detergent residue, heat.	Sinks
Chlorine, organic material, suspended solids	Swimming pool

III. TREATMENT SYSTEM:

The treatment of household graywater has the following components: graywater source, separated from Blackwater water sources and pipe collection, treatment plant (station) storage container and distribution system for irrigation of plants.

Treatment plant:

The treatment station as shown in fig. (2) Consists of:

- A filter, which is used to prevent solid Martials (hair, lint, food, particles, etc.) form entering the graywater system.
- A settling tank as a mean of removing solids from greywater. Substances denser

than water will gradually fall out of suspension to the bottom of the tank.

- Grease oil separation tank: grease, oils and other small particles will float to form a surface scum layer. This layer is removed, periodically.
- After that, the water passes to a basin filled with so-called tuff stones, which are porous black stones from volcanic origins.
- In this basin the water is subjected to biological treatment and subsequent collecting in a storage tank
- From which the water is directed to irrigation system through a pump-sump from where is pumped by a submerged pump regulated by water level control.
- An appropriate system for irrigation system, which consists of a plastic pipe system laying on the ground with drilled holes.

IV. RESULT AND DISCUSSIONS:

The site of the household where the experimental system built and is located in Al-Fayaslaisa village, Madaba region.

The number of the family members are six adults; the house has a big garden with olive trees.

The experimental plant was set to run and monitored for period of 6 months. The chemical and physical parameters where monitored by taking samples of graywater before and after treating.

The samples were analyzed for Do (dissolved oxygen), BOD (biological oxygen demand) and COD (chemical oxygen demand).

In addition, the economic effect and cost was investigated to calculate the percent saving effect.

The black water waste is collecting in a septic tank.

Experiments and analysis lead to the following results and conclusions

1. Pollutants where decreased in graywater significantly as shown in table (2).

Table (2): average results of treatment using volcanic tuff as a filtering media

Parameter	Unit	Graywater influent	Graywater effluent
DO	mg/L	0	0.5-2
PH		6.6-6.8	6.7-8
BOD	mg/L	444	121
COD	mg/L	860	301

2. Graywater treatment has a good effect for environmental in general and for plants and trees since graywater contains nutrients as phosphorous, nitrogen and other mineral compounds it acts as fertilizer for plants and enhancing growth
3. Graywater separation and treatment have a significant economic impact for household owner and the community in general.
4. Water balance and calculations of saving are made by the following procedure. First, a water balance is made by comparing freshwater supply and effluent water. Water supply and sewer regeneration are given in table (3).

Table (3): water supply and regenerated sewers balance.

Water supply and waste regenerated	Without graywater treatment (m^3)	With gray water treatment (m^3)
Fresh water supply	13	9
Fresh water for drinking and other	6	6

activates		
Fresh water for irrigation	7	3
Graywater generated	4	4
Blackwater generated	6	2

Second, costs of water supply and Blackwater discharge calculated for both with and without graywater separation as shown in table (4). Taking consideration that the average price of (1) m^3 fresh water is (7) JD and the price of each discharge of Blackwater from septic tank is (15) JD.

Sample of calculations (this sample is for cost without graywater treatment)

Freshwater supply (JD/week)	13*.7 = 9.1 JD/week
Blackwater discharge (JD/week)	15/3 = 5 JD/week
Total cost per week (JD)	9.1+5 = 14.1 JD
Total cost per year (JD)	14.1*52 = 733.25 JD
Total cost per month (JD)	733.25/12 = 61.1 JD

Table (4): results for cost saving

Cost	Without graywater separation (JD)	With greywater separation (JD)
Freshwater supply per week	9.1	6.35
Blackwater discharge per week	5	1.66
Total cost per week	14.1	7.9
Total cost per year	733.25	410
Total cost per month	61.1	34.2

From that saving per month is (61.1-34.2) = 26.95 JD, and saving percentage (26.95/61.1) *100% = 44%

V. CONCLUSION AND RECOMMENDATION:

1. effluent water from the station was sutiable for irrigation purposes and enchance plants growth also for increasing corps yield.
2. The capacity of the station is suitable for a single house with small family members.
3. Treatment and reuse of greywater reduce the need for fresh water significantly and leads to economical reduction in water fees per household.
4. Bigger stations can be built for a complex of households with pre-planning for grey water separation, which can be used for other uses in addition to irrigation as cleaning yards.
5. The tuff stones must be flushed and wash every 3 month.
6. If effluent water to be stored before use, it must be disinfected.
7. Maintenance of irrigation system must be carried out periodically.

VI. FIGURES:

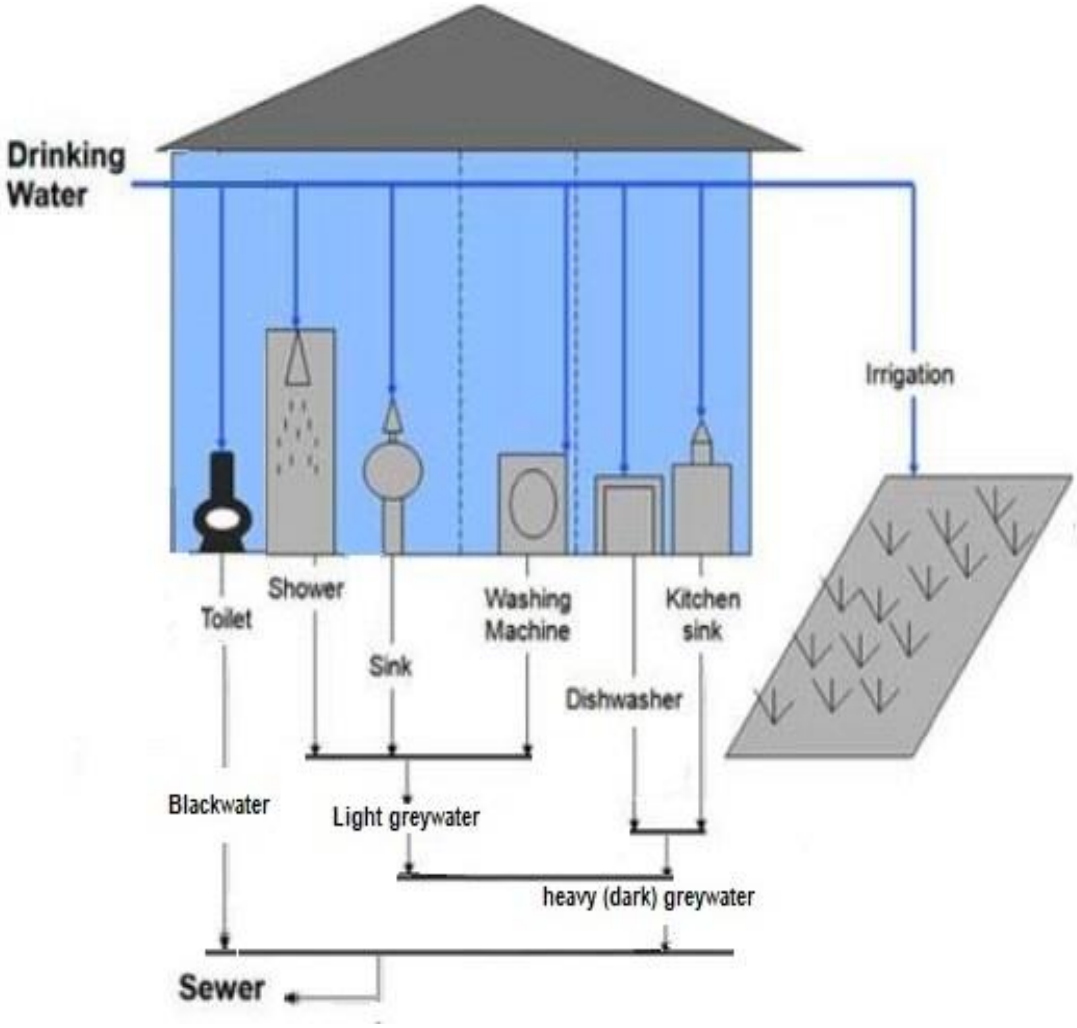
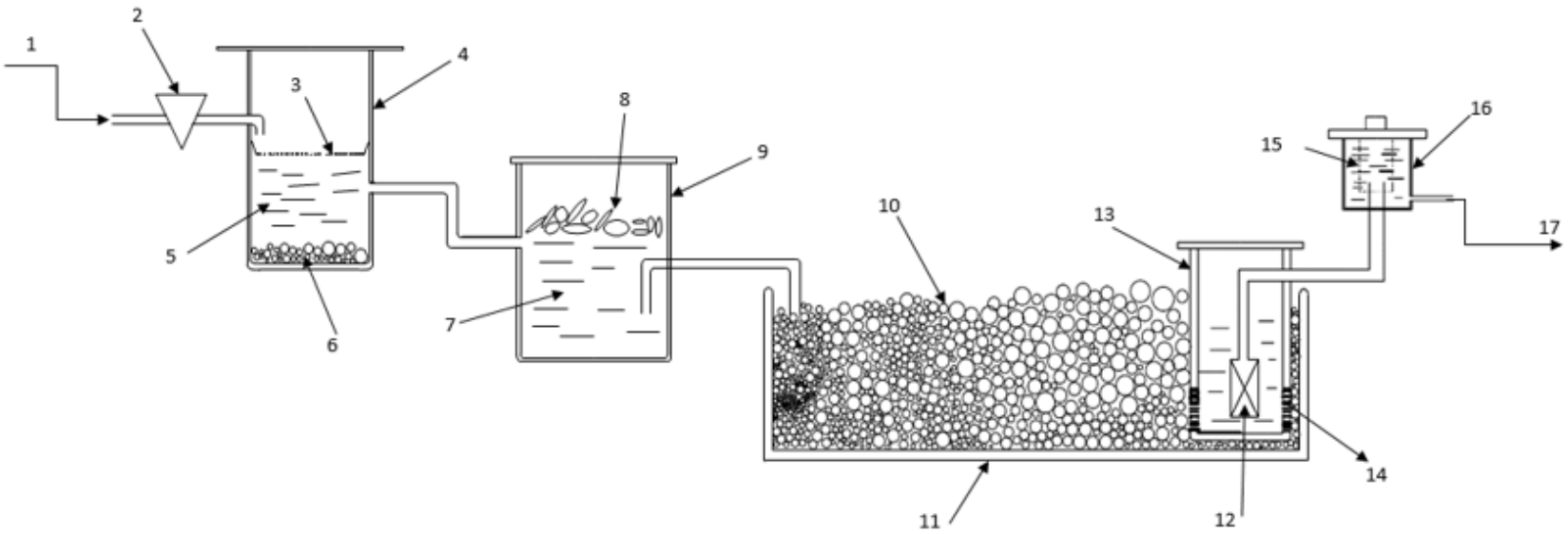


Fig (1): Domestic sewer types



1. Greywater influent
2. Flow meter
3. Filtration screen
4. Settling tank
5. Liquid layer
6. Sloid precipitate
7. Liquid layer
8. Grease and oil layer (scum)
9. Grease & oil separating tank
10. Volcanic stones (tuff)
11. Concrete basin (covered with plastic sheet)
12. Submerged pump
13. Treated greywater collecting tank
14. Small holes for water inlet
15. Internal filter screen
16. Filter
17. To irrigation system greywater effluent

Fig (2): Station Scheme

Fig (3): Greywater Station

Fig (4): Submerged Pump and Filter

Fig (5): Irrigation System

Fig (6): Olive Tree Irrigated by Greywater

VII. ACKNOWLEDGMENT

"this work has been carried out during sabbatical leave granted to the author Adnan Khail from Al-Balqa' Applied University (BAU) during the academic year 2016/2017

VIII. REFERENCES

[1] Population institute reports: Population and water; 2010

[2] Brooks DB, Mehmet O. Water Balances In The Eastren Meditrranean. Ed. Ottawa Canada: International Development Reserch Center (IDRC); 2000

[3] Food and Agriculture Organization of untied nations (F.A.O), water reports: Review Of World Water Resources By Country. ED. ISSN. 2003; 1020-1203

[4] Al-Jayyousi OP. Greywater reuse: towards sustainable water management. Destilation. 2033; 181-192

[5] Engelbrecht JF, Murphy KO. What stops me from using greywater. CSIR; 2006

[6] Pinto Uk Maheshśhwari BL, Grewal HS. Effect \s of greywater irrigation on palnts growth, water use and soil properties. Resourse conserv Recy. 2010; 54 : 429-435

[7] Capital Regional District. "Greywater Reuse Study Report". November 1,2004.

[8] Kreissl, J.F. (1994). Wast water collection systems for small communities, New World Water, 137-146

[9] "Greywater Reuse in other Countries and it's Applicability to Jordan." Funded by the Ministery of Planning, Kingdom of Jordan. 2003.