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# Household level Grey Water Treatment in Irbid Area in the North of Jordan

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**Abstract:** One of the means of meeting the water needs in the areas of scarcity is the reuse of grey water generated at the household level. This is water that comes out of the kitchen, bathtubs, washing machines and dishes. The water that coming out of the toilets is black water.

This study aims to evaluate the potential of grey water availability in Irbid Area in north of Jordan, by testing and comparing between grey water quality before and after household level treatment using a vertical multi-layer filter of sand and gravel then, reuse it for home gardens.

Total grey water generation from different household sources were measured by water meters in five selected household during summer and winter. The physical, chemical and biological analysis of the samples revealed that grey water contains significant levels of suspended solid, chemical &biochemical oxygen demands, and inorganic compounds. Statistical analysis results indicated that there is a various removal percentage of the above parameters. Experimental results indicate that the percentage removal of BOD5 is 37.5%, the percentage removal of COD is 10%, the percentage removal of TDS is 68%, and a small decrease in pH value about 5%.

The generation rates of grey water are mostly influenced by lifestyle and climatic conditions. Contaminants found in grey water are largely associated with the type of detergent used and influenced by other household practices.

It is recommended to applied the Restricted irrigation that means irrigation of all types of crops with treated grey water except vegetables and plants including edible parts that can get in direct contact with irrigation water wither these parts are eaten raw or cooked.

**Keywords:** Grey water, Total suspended solid, Chemical oxygen demand COD, biochemical oxygen demands BOD5, inorganic compounds, pH.

# معالجة المياه الرمادية- على المستوى المنزلي- في منطقة إربد شمال المملكة الأردنية الهاشمية

**وفاء أحمد بخيت**

قسم إشراف الأغوار الشمالية || وزارة التربية والتعليم || المملكة الأردنية الهاشمية

**الملخص:** من وسائل تلبية الاحتياجات المائية في مناطق الشح إعادة استعمال "المياه الرمادية" التي تتولد على المستوى المنزلي. وهذه هي المياه المبتذلة التي تخرج من بواليع المطبخ وأحواض الاستحمام وغسالات الملابس والصحون. أما المياه المبتذلة التي تخرج من المراحيض فهي "مياه سوداء."

تهدف هده الدراسة إلى معالجة المياه الرمادية - على المستوى المنزلي- في عينة عشوائية مكونة من 5 منازل في منطقة إربد شمال المملكة الأردنية الهاشمية باستخدام فلتر مكون من مواد طبيعية - الرمل والحصى مرتبة عموديا في برميل بحيث تمر المياه من خلاله.

وبعد إجراء التجارب المخبرية على عينات المياه الرمادية قبل وبعد المعالجة، تم ملاحظة وجود انخفاض الأكسجين المستهلك حيويا BOD5 بنسبة 37.5%، والأكسجين المستهلك كيميائيا COD بنسبة 10% أما المواد الصلبة الذائبة نقصت TDS بنسبة 69% أما الحموضة pH انخفضت بنسبة 5%.

تتأثر معظم معدلات توليد المياه الرمادية بأسلوب الحياة والظروف الجوية. ترتبط الملوثات الموجودة في المياه الرمادية إلى حد كبير بنوع المنظفات المستخدمة وتتأثر بالممارسات المنزلية الأخرى.

لا يفضل استعمال المياه الرمادية في ري الخضراوات التي تؤكل ثمارها وأوراقها نيئة وذلك لتجنب انتقال بعض المواد القادمة من المنظفات اليها، فيما يعتبر ري الأشجار بهذه المياه فضل بكثير بسبب نظام التنقية الذاتي الذي تتميز به الأشجار، وفي حال الاضطرار لري الخضراوات يجب غسل إنتاجها من الثمار والأوراق بصورة جيدة عدة مرات.

**الكلمات المفتاحية:** المياه الرمادية، الأكسجين المستهلك حيويا BOD5، الاكسجين المستهلك كيميائيا COD، مجموع المواد الصلبة TDS، الحموضة والقاعدية pH.

## 1. Introduction:

The total volume of freshwater on Earth far outweighs the human demands. Out of the overall water resources on Earth, about 97% can be found in the oceans while the remaining 3% remains available for direct exploitation; however, out of this 3%, the quantity of water that is available for use by humans is estimated at one-hundredth (Eakin et al., 2010). Uneven distribution of water in both time and space sways the use of water to other geographical areas depriving others of this resource. Biological survival remains one of the key factors of water use with its associated use also for household needs and for food production and other developmental needs.

Many parts of the world are hit by acute water shortage, over-exploitation of water resources leading to gradual destruction of these water resources and high levels of freshwater pollution resulting from anthropogenic factors. Currently, it has been estimated that about 800 million people live under a threshold of water stress and this number is expected to reach 3 billion in 2025 (Qureshi and Hanjra: 2010). Due to urbanization, industrialization and population growth, the demand for water is evident; however, will the available water resources meet the ever-growing needs in a sustainable manner. Where will the extra water that is required to sustain human activities come from? What are the properties and dangers of grey water? How are sand and gravel filters remove pollutants from grey water? These questions calls for interventions and strategies that will help address these concerns. The research reported here in tests the hypothesis that household level treatment of greywater may improve the feasibility of, and hence make more sustainable, greywater recycling as a part of urban water management.

Agriculture and urban irrigation import large volumes of clean water to provide for water needs. Jordan is an arid to semi-arid country suffering from water shortage due to the aridity, natural growth, and forced immigration, water demands for domestic, agriculture and industrial sector is significantly increased. The major water problems in Jordan are being encountered nowadays and those are expected to increase in the future, unless suitable solutions are approached (Bannayan, 1990; Abed, 2000).

The greatest opportunity for increasing water supply is to improve water management at all levels (Haddad and Bakir., 1998). The use of wastewater (grey water &black water) effluent, building of more dams, rain harvesting (Oweis and Taime., 1996).

The objective of this study is to evaluate the potential of grey water availability in Irbid Area in north of Jordan by testing and comparing between grey water quality before and after household level treatment using a vertical multi-layer filter of sand and gravel then, reuse it in home gardens.

Grey water is defined as urban wastewater without any input from toilets and so generally includes source from baths, showers, hand basins, washing machines, dish washers and kitchen sinks (Casanova et al. 2001; Modi, 2006; Birdie, 2000).The selection of which source to include is a balance between available water and the level of pollution contained within. Grey water is a major proportion of domestic wastewater (around 50 to 80%) (Birdie 2000). Agriculture is the major consumer of water in Jordan, where about 64% of water demand goes for agricultural uses. The improvement of grey water and utilize it for agricultural application rationally are essentials.

### 1.2 Composition of grey water:

The composition of grey water strongly depends on the behaviour of the inhabitants and the individual choice of soaps and detergents in the household. Therefore, the overdosing of shampoos and detergents as well as the use of strong detergents (e.g. with high sodium content, phosphate content or chlorite) should be avoided.

***Grey water From Bathroom:**

Water used in hand washing and bathing generates around 50-60% of total grey water and is considered to be the least contaminated type of greywater. Common chemical contaminants include soap, shampoo, hair dye, toothpaste and cleaning products. It also has some faecal contamination (and the associated bacteria and viruses) through body washing.

*** Grey water from Cloth Washing:**

Water used in cloth washing generates around 25-35% of total grey water. Wastewater from the cloth washing varies in quality from wash water to rinse water to second rinse water. Grey water generated due to cloth washing can have faecal contamination with the associated pathogens and parasites such as bacteria.

***Grey water from Kitchen:**

Kitchen grey water contributes about 10% of the total grey water volume. It is contaminated with food particles, oils, fats and other wastes. It readily promotes and supports the growth of micro-organisms. Kitchen grey water also contains chemical pollutants such as detergents and cleaning agents which are alkaline in nature and contain various chemicals. Therefore kitchen wastewater may not be well suited for reuse in all types of grey water systems.

Reuse of grey water for growing plants may affect the microbial activity in the rizosphere that degrades the surfactants and the use by plant for transpiration. Also grey water has the potential to increase the soil alkalinity if applied on garden beds over a long time. Grey water with pH values higher than 8 can lead to increase soil pH and reduce availability of some micronutrients for plants (Hammer, 1998). Grey water contains variable levels of microorganisms, sometimes including pathogens(harmful microorganisms) that can cause gastroenteritis. The risk of infection from such pathogens is considered to be the most significant human health risk associated with grey water reuse (Gideon 2007).

## 2. Methodology of Household Level Grey water Treatment and Reuse:

Grey water reuse has been considered as a reliable method of ensuring water security as compared to other methods of water capture such as rainwater harvesting which is dependent on hydrological conditions. The amount of grey water produced in a household can vary greatly ranging from as low as 15 L per person per day for poor areas to several hundred per person per day. Factors that account for such huge disparities are mostly attributed to geographical location, lifestyle, climatic conditions, type of infrastructure, culture and habits, among others. Grey water accounts for up to 75% of the wastewater volume produced by households, and this can increase to about 90% if dry toilets are used. It has also been estimated that grey water produced accounts for about 69% of domestic water consumption (Jamrah et al. 2011).

Grey water treatment at the house hold level mainly involves screening( grease &silt removal), soap forth removal, equalization & filtration. Grey water treatment can help you save 35% to 40% on your annual water bill, and while saving money, you will also help save the environment and provide a better future for our children.

"UNESCO has predicted that by 2020 water shortage will be a serious worldwide problem." The Grey Water Recycling System is a must for anyone who cares about the environment to replenish the water shortage and reduces environmental pollution as well as waste water production. Flow diagram of house hold level of grey water treatment system is shown below fig. 1.

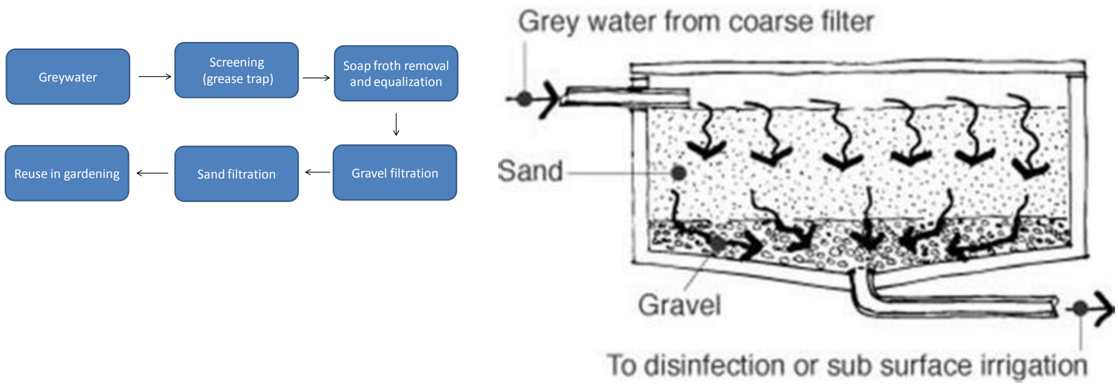


**Fig (1) House hold level of grey water treatment system.**

### 2.1 Literature Reviews:

A general overview of previous research work on quantification, characterization & treatment of grey water and reuse for sustainable development.

A. Glenda Emmerson (1998), suggested alternative source of water is grey water. Grey water is the water that goes down domestic bathroom and laundry drains. If this water is diverted for relatively safe applications such as garden irrigation, then a family can reduce their water usage by around 30-50 percent saving. Grey water reuse also offers environmental benefit but a caution should be exercised to avoid public

B. Dr. Mark Pidou et.al 2007, reported a review of existing technologies and application collating a disparate information bas and comparing strength and weaknesses of different approaches. The best overall performance is observed within the scheme combining different type of treatment to ensure effective treatment of all the fractions.

C. I.Sam Godfrey, et.al 2009, presented grey water treatment and reuse system in residential schools in Madhya Pradesh, India and treated grey water used for toilet flushing and irrigating the food crops. In this study the cost-benefit analysis was undertaken for grey water reuse by considering internal and external costs and benefits. The analysis carried out indicates that the benefit exceeds the cost of the system.

D. J. Jonathan Glassman, et.al. (2009), suggested the design recommendation for the vertical intermittent sand filter in place of the current multi-media filter. The sand filter is easier to maintain than the existing multi-media filter because only the top layer of sand media in the filter has to be regularly replaced, compared to digging out and replacing all of the particle media in the drum.

E. K. Bhausaheb L. Pangarkar, et.al (2010), investigated the economic performance of the plant for treatment of bathrooms, basins and laundries grey water showed in terms of deduction competency of water pollutants such as COD (83%), TDS (70%), TSS *83%), total hardness (50%), oil and grease (97%), anions (46%) and captions (49%).The authors suggested that this technology could be a good alternative to treat grey water in residential rural area. c health and the environment risk.

F. Gideon Paul Winward, (2007) investigates pathogen removal through treatment and disinfection processes. Also the impacts of organic and particulate material in grey water on the efficiency of disinfection processes are investigated in depth.

In this study, the grey water were flow through a vertical filter medium- sand and gravel. The main treatment process encompasses the retention of particles by the filter material and cleaning processes due to biological activity in the bio film on the sand and gravel.

After passing the filter media, the treated grey water can be used for irrigation according to WHO guidelines (2006)

**2.2 Case study:**

Collecting and analyzing grey water samples from the studied area (Irbid area). Designing a multi-layer filter of sand & gravels to be scale up for the field as a pilot scale Fig (2). Grey water samples were taken from the effluent of five houses in Irbid area before and after household level treatment. These samples were preserved in polyethylene bottles and transported to the laboratory for further analysis. These analysis includes chemical& biochemical tests of pH, BOD5, COD, and TDS. Laboratory work was carried out in the Laboratory Of Irbid Sewage Treatment Plant. The results of the analysis was assessed with reference to the Jordanian standard for irrigation water. A descriptive statistics used in this study.

**Fig (2) multi-layer filter of the household treatment system.**

## 3. Discussion of Results:

In this study, the analytical method was used because of its suitability. The data were collected and a statistical analysis was conducted to extract the required results.

Minimum, maximum, mean and standard deviation values of result analysis ( pH, BOD5, COD and TDS) are shown in Table 1.Jordanian Standard Specification+ International Standard WHO and FAO is shown in Table 2.

**Table (1) minimum, maximum, mean & standard deviation of pH (alkalinity), BOD5 (biochemical oxygen demand for five days), COD (chemical oxygen demand), PO4 (phosphate) TDS( total dissolved solid) values before and after house hold level treatment of grey water.**

| Parameters | Grey water before treatment | | | | Grey water after treatment | | | |
|---|---|---|---|---|---|---|---|---|
| | Minimum value | Maximum value | Mean | Standard deviation | Minimum Value | Maximum value | Mean | Standard deviation |
| pH | 6.3 | 10.1 | 7.2 | 0.7 | 6 | 7.9 | 6.9 | 0.37 |
| BOD5 mg/l | 5 | 30 | 15.2 | 7.45 | 0 | 10 | 5.7 | 3.96 |
| COD mg/l | 2.7 | 41.6 | 27.9 | 10.26 | 8.2 | 48.3 | 25.2 | 9.99 |
| TDS mg/l | 10 | 87 | 40.2 | 18.7 | 7.92 | 30.8 | 13 | 7.6 |

**Table(2) Properties of reclaimed grey water to be reused for plant irrigation (Jordanian Standard Specification+ International Standard WHO and FAO).**

| Parameters | Jordanian allowable limits | International allowable limits |
|---|---|---|
| pH | 6-9 | 6.5- 8.4 |
| BOD5 mg/l | 300 | 300 |
| COD mg/l | 500 | 500 |
| TDS mg/l | 1500 | 2000 |

Experiments were first performed to determine the concentrations of BOD5, COD, TDS and pH value present in the grey water before and after treatment. However, these experimental results indicate that the percentage removal of BOD5 after treatment is 37.5%, the percentage removal of COD is 10%, the percentage removal of TDS is 68%, and a small decrease in pH value.

High percentage removal of TDS is may be due to the precipitation of particles during filtration. The BOD5 and COD concentrations decrease during the sedimentation period when grey water is treated ( Jefferson et al., 2000).. Evidence has shown that 37% removal of BOD5 & 10% of COD.

However, extended storage of grey water may lead to the risk of odour increases and possibly health issues due to enhanced microorganism growth (Jefferson et al., 2001). Furthermore, the BOD5 concentration in, for example, grey water washing hand basins has been reported as being slightly lower than the one generated from mixed resources as well it varies with different discharge patterns (Al-Jayyous., 2003). The pH expresses the concentration of H+ ions in the grey water samples. pH values reflect the mineral content of the parent material. The pH of the grey water is important in controlling mineral dissolution and precipitation reactions as well as ion exchange processes (Hausenbuiller, 1972 ). pH plays an important part in the most of the organic and inorganic reaction occurred in nature. In our study, pH value remains fix before and after treatment.

The values of parameters (pH, BOD5, COD, and TDS), which measured are within specifications the Jordanian & International standard WHO & FAO.

## 4. Conclusions

This study reviewed grey water characteristics before & after household level treatment and reuse strategies. It shows that there is a wide variation in greywater characteristics and volume generation rates which is largely dependent on the water use, lifestyle patterns and type of settlement. The study compares between the composition of grey water before and after household level treatment and using discharged grey water for garden irrigation. Innovation of a multi-layer filter for treating grey water consist of natural adsorbents and combined with septic tank, wet pit pump, disinfection unit and storage to be commercialized as final product which is shown in fig.2. Local community will save money on their water bills and on their cesspools. Adapting the proposed filtration system within the waste water management policy in the rural communities in Jordan.

The benefits of grey water recycling include: Reduced use of freshwater, Less strain on septic tanks or treatment plants, More effective purification, Feasibility for sites unsuitable for a septic tank, Reduced use of energy and chemicals, Groundwater recharge, Plant growth, Reclamation of nutrients, Increased awareness of, and sensitivity, to natural cycles. Saving water per day. Saving of drinking water by reuse of grey water. Grey water reuse for gardening and to irrigate plants is a way to increase the productivity of sustainable backyard ecosystems and farms that produce food. And while grey water may look "dirty, " it is a safe and even beneficial source of irrigation water in a yard.

## 5. Recommendation:

1. It is recommended to applied the Restricted irrigation ( irrigation of all types of crops with treated grey water except vegetables and plants including edible parts that can get in direct contact with irrigation water wither these parts are eaten raw or cooked)
2. it is recommended to concern with public health risks (grey water can contain micro-organisms and may transfer diseases and present health risk).
3. spray irrigation and direct contact with vegetables and plants is forbidden
4. it is recommended to avoid human beings direct contact
5. It is recommended to use detergent that are friendly to environment.

6. It is recommended that reuse purpose- to be suitable to the degree of treatment and method employed for reuse

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