

# EVALUATION OF USING GREY WATER AS AN ALTERNATIVE IRRIGATION SOURCE IN JORDAN

## Utvärdering av användandet av gråvatten som en alternativ vattenresurs till bevattning i Jordanien

by MOHAMMAD ALJARADIN and TAREK SELIM

Department of Water Resources Engineering, Lund University, Box 118, 221 00 Lund, Sweden

e-mail: [Mohammad.Aljaradin@tvrl.lth.se](mailto:Mohammad.Aljaradin@tvrl.lth.se), [Tarek\\_selim.aboulila@tvrl.lth.se](mailto:Tarek_selim.aboulila@tvrl.lth.se)



### Abstract

One option for coping with wasteful uses of fresh water in landscape irrigation is to use the treated greywater (GW). In the present study, an evaluation of a simple treatment system for reusing GW to irrigate green areas, trees, and ornamentals all over the campus in Tafila Technical University (TTU), Jordan, is presented. After 12 months of using the treatment system, the necessity for using fresh water as irrigation source was reduced. Meanwhile, the area of tree covered land increased from 2.3 ha to 8.4 ha and a 0.5 ha grass areas were introduced in the campus area. In conclusion, the use of a GW as alternative irrigation source is considered an effective method for saving fresh water and increasing green area at the campus.

*Key words* – Grey water, Landscape irrigation, Tafila Technical University

### Sammanfattning

Ett alternativ för att minska användningen av rent vatten för bevattning av grönområden är att använda renat gråvatten (BDT-vatten). I den föreliggande studien utvärderas ett enkelt system för rening av gråvatten. Vattnet används sedan till bevattning av grönområden i Tafila Technical University (TTU), Jordanien. Efter 12 månaders användning av systemet så har behovet av rent vatten reducerats till ett minimum. Under samma period har grönytorna utökats från 2,3 ha till 8,9 ha. Användandet av gråvatten är således ett utmärkt sätt att spara på vattenresurser, särskilt i arida klimat.

## 1 Introduction

The household wastewater, except toilet waste, is called grey water (GW), this includes water from sinks, showering, bathing, and washing dishes and clothes machines (Al-Jayyousi 2003; Misra et al., 2010). Despite the fact that this water is not clean, the percentage of contaminations is much lower than the wastewater from kitchen sinks and toilets (black water). The GW is usually easy to treat at the same production site, and then reuse. The amount of GW from households is more than 50% of the residential wastewater (Jamrah et al., 2008). The GW can be reused if it is collected separately before going to the sewage system.

In many parts of the world, both in the industrial and

developing countries, there has been an increased interest in the reuse of wastewater and GW in irrigation (Pinto et al., 2010). This is mainly because of water shortage, which is caused by too low amounts of rainfall in combination with high evaporation rates, or by the large demands of freshwater from the population (Eriksson et al., 2002). On the other hand, some countries are driven towards the reuse of wastewater because of environmental and economical considerations (Jamrah and Ayyash, 2008). Hence, laws and regulations for reusing GW have been implemented in some countries such as the state of California in USA, and Australia (Mustow et al., 1997).

Jordan is considered one of the semi-arid countries with low amounts of rainfall and high evaporation rate.

Water resources are far below the water poverty line and the demand of water often exceeds the available supply (Al-Jayyousi, 1995; 2001). Therefore, wastewater collection has been practiced in Jordan in a limited way since the 1930ies in the town of Salt (Nazzal et al., 2000). Some treatment was achieved by utilizing primitive physical processes. This practice resulted in major environmental problems, especially groundwater pollution. The use of domestic GW as an alternative source for watering landscapes makes a significant contribution towards the reduction of potable water use. Jordan is already reusing approximately 70% of the treated wastewater effluents for irrigation purposes (Jamrah and Ayyash, 2008).

GW quality depends mainly on the water source, plumbing system, living habits, personal hygiene of the users and types of GW such as commercial, domestic or industrial. Other factors such as cleaning products used, dishwashing patterns, laundering practices, bathing habits and disposal of household chemicals will influence the characteristics of GW. As a result, the physical, chemical, and biological characteristics of GW vary greatly. Hence, it may cause health risks and affect the surrounding environment. Therefore, the selection of GW treatment methods should be based on the specific characteristics of GW.

In this paper an evaluation of a small scale project which was conducted at the TTU during the year 2009 is presented; this project represents a simple way for collecting and reusing GW instead of using fresh water to irrigate trees, and green areas.

## 2 Materials and Methods

### 2.1 Area & system description

The treatment system was constructed in the TTU during 2009. TTU was established at the southern part of Jordan in 2005 in the Tafila region, which is one of the

most arid places in Jordan. The region is characterized by low annual rainfall, approximately 250 mm, and high annual potential evapotranspiration, approximately 1450 mm, maximum temperatures during July–August ranging from 28 to 31°C and minimum temperature during December–January ranging from 2 to 6°C. The rapid increase in the number of students, from 2000 to 6000 during the period of 2005 to 2009, accompanied with limited water resources is a driving force to search for alternative irrigation sources to cope with the required extension of green areas within the campus. The amount of GW from all sources in the campus that can be used for watering green area after treatment is about 450 m<sup>3</sup> per month. This amount is expected to increase substantially with the increasing number of students and employees within the recent future.

The system of collecting and reusing GW consist of a sand and gravel filter, water-collection tanks, pumps, fabric filter, pipes, a flushing system to clean the filter, and elevated field tanks (Fig. 1).

### 2.2 System operation

GW is collected by disconnecting the GW resources from the main sewer network and connecting it to the newly established system (Fig. 2). The GW is taken from administration buildings, a lecture hall building, and a student hostel building (source 1, 2, and 3 respectively). The GW flows through pipes to a collection tank, then the water passes through a sand and gravel filter at a fixed height for aeration and to remove the suspended solids to prevent clogging of the distribution system. When the collection tank is filled with water, a pump automatically starts to deliver water to an elevated field tank. Water passes through a fabric filter before entering the pump to protect the system and pump from clogging. The treated GW (450 m<sup>3</sup>/month) is used to irrigate trees and green areas of 8.4 and a 0.5 ha respectively using drip and sprinkler irrigation systems.

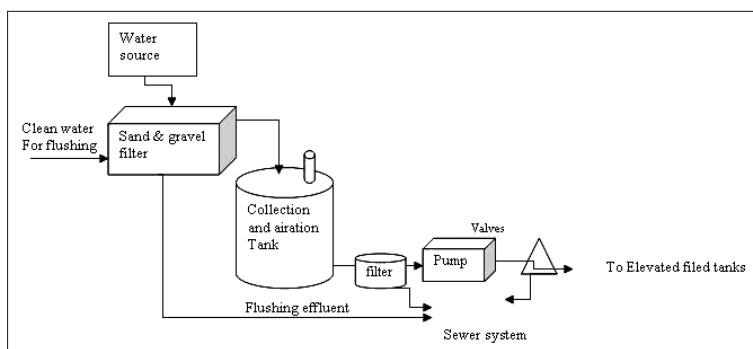


Figure 1. Grey water System in TTU.



Figure 2. Photos of the GW systems at the different GW sources (a, b, and c are GW sources 1, 2, and 3 respectively).

### 3 Results

#### 3.1 Characterization of GW in the Campus:

Water quantity data were collected within a period of 6 months during 2009. Samples from untreated water were taken from the GW sources directly while treated water samples were taken from the elevated tank after the treatment process. Table 1 shows the average values for 6 months before and after treatment for GW characteristic.

Samples were collected in sterile bottles and were analyzed for pH, Electrical Conductivity (EC), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD<sub>5</sub>), Fecal coliform, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Turbidity, and ammonia (NH<sub>3</sub>). All analyses were carried out according to the standard laboratory methods of water and wastewater (APHA, 2005). All tests were conducted at the laboratory of the wastewater treatment plant in Tafila.

From the results, it was noted that sources 2 and 3 had higher PH values than source 1. This could be due to the potential use of the chemical detergents, soap, and shower gel that contains high amounts of caustic soda. This could also be the same reason for the relatively high organic content and turbidity in source 3. No fecal coliform bacteria traces were detected since no toilet waste

is included in the GW. The organic content of the GW samples BOD<sub>5</sub>, ranged from 18 mg/l to 68 mg/l from source 1 and 2, this is lower than typical BOD<sub>5</sub> values for GW. The BOD<sub>5</sub> for source 3 ranged from 250 mg/l to 350 mg/l with an average of 280 mg/l. This value was always higher than in the other sources because of using hand soap and bath detergents, which also affected other parameters such as pH.

After the treatment process there was a significant decrease in all parameters; TSS decreased to 23, 32, and 38 in the GW samples collected from source 1, 2, and 3 respectively. The concentration of NH<sub>3</sub> decreased to almost zero by the efficient aeration. In general, the GW after filtration had a good quality to be used for landscape irrigation.

#### 3.2 Evaluation of the Project:

Before system installation, only about 15% of the lands were available for cultivation in the campus and green areas (grass) were not planted due to its high water requirement. The amount of fresh water used for irrigation was about 30 m<sup>3</sup>/ month.

In 2009 after installing the GW system, all cultivated lands were available for cultivation in the campus and it was planted by trees, ornamental plants, and grass.

Table 1. Characteristics of GW before and after treatment.

| Source           | PH  | BOD <sub>5</sub><br>mg/l | COD<br>mg/l | NH <sub>3</sub><br>mg/l | Turbidity<br>NTU | TSS<br>mg/l | EC<br>μS/m | TDS<br>mg/l | fecal coli<br>(MPN/100ml) |
|------------------|-----|--------------------------|-------------|-------------------------|------------------|-------------|------------|-------------|---------------------------|
| Before treatment |     |                          |             |                         |                  |             |            |             |                           |
| 1                | 7.8 | 18                       | 164         | 9.8                     | 64               | 280         | 1.33       | 218         | 0                         |
| 2                | 8.6 | 68                       | 190         | 14                      | 55               | 200         | 1.45       | 279         | 0                         |
| 3                | 8.9 | 280                      | 320         | 23                      | 218              | 230         | 2          | 383         | 0                         |
| After treatment  |     |                          |             |                         |                  |             |            |             |                           |
| 1                | 6.9 | 6                        | 80          | 0                       | 18               | 34          | 0.45       | 23          | 0                         |
| 2                | 7.0 | 5                        | 88          | 0                       | 15               | 20          | 0.5        | 32          | 0                         |
| 3                | 7.3 | 90                       | 130         | 3                       | 45               | 20          | 0.88       | 38          | 0                         |

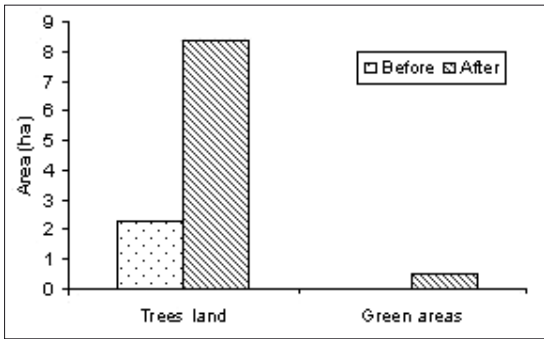


Figure 3. Area of cultivated land before and after the GW treatment system installation.

Figure 3 shows the area of cultivated lands before and after GW treatment. It was shown that the area of trees planted land increased from 2.3 ha to 8.4 ha and a 0.5 ha of grass areas was planted. The quantity of GW used for irrigation is about 450 m<sup>3</sup>/month without any need for using fresh water. The total construction cost of the treatment and irrigation system were about 7250 USD, the monthly cost including operation and maintenance costs was about 400 USD.

More saving by the project by excluding the cost of using fresh water and the cost of exudation of 450 m<sup>3</sup> of GW in case it was not separated from the sewer system before installing our GW system is about 900 USD per month.

#### 4 Conclusion and Recommendations

After 12 months of using the treatment system the area of trees land increased from 2.3 ha to 8.4 ha and a 0.5 ha of green areas were developed throughout the campus area. Meanwhile, there is no need to use fresh water for irrigation purposes. Some odor problem was observed during hot days; therefore an additional simple treatment unit can be added to the system to reach the optimal efficiency during the operation of the whole system. Although the initial cost of the treatment system is relatively high, this cost is approximately covered after 1 year of system operation. Thus, this system seems to be cost-effective. In sum, the use of GW as an alternative

irrigation source is considered an effective method for saving fresh water and increasing green areas at the TTU campus and it can be applied in large scale in other places with separated GW sewer systems.

#### Acknowledgments

The authors would like to thank Prof. Magnus Persson for linguistics help and his valuable suggestions.

#### References

- Al-Jayyousi, O. 1995. An Analysis of Future Water Policies in Jordan Using Decision Support Systems. *International Journal of Water Resources Development*, 11: 315–330.
- Al-Jayyousi, O. 2001. Capacity building for desalination in Jordan: necessary conditions for sustainable water management. *Desalination*, 141: 169–179.
- Al-Jayyousi, O. 2003. Greywater reuse: towards sustainable water management. *Desalination*, 156: 181–192.
- (APHA), A. P. H. A. 2005. Standard Methods for the Examination of Water and Wastewater. *Washington DC*, 19th Edition.
- Eriksson, E., K. Auffarth, M. Henze, and A. Ledin. 2002. Characteristics of grey wastewater. *Urban Water*, 4: 85–104.
- Jamrah, A., A. Al-Futaisi, S. Prathapar, and A. Harrasi. 2008. Evaluating greywater reuse potential for sustainable water resources management in Oman. *Environmental Monitoring and Assessment*, 137: 315–327.
- Jamrah, A., and S. Ayyash. 2008. Greywater Generation and Characterization in Major Cities in Jordan. *Jordan Journal of Civil Engineering*, 2.
- Misra, R. K., J. H. Patel, and V. R. Baxi. 2010. Reuse potential of laundry greywater for irrigation based on growth, water and nutrient use of tomato. *Journal of Hydrology*, 386: 95–102.
- Mustow, S. R., T. Smerdon, C. Pinney, and R. Wagget. 1997. Water conservation-implications of using recycled greywater and stored rainwater in the UK. Building Services Research and Information Association for UK Drinking Water Inspectorate.
- Nazzal, Y. K., M. Mansour, M. Al Najjar, and P. G. McCornick. 2000. Waste water law and standards in Jordan. Presented at Aqua Abu Dhabi 2000 Wastewater Management for a Better Environment, Abu Dhabi. 28 April – 2 May 2000, Projects Committee, Abu Dhabi Municipality, 11 pp.
- Pinto, U., B. L. Maheshwari, and H. S. Grewal. 2010. Effects of greywater irrigation on plant growth, water use and soil properties. *Resources, Conservation and Recycling*, 54: 429–435.