Journal of Environmental Science and Engineering A 9 Jan.-Feb. (2020) 28-32
doi:10.17265/2162-5298/2020.01.004

Greywater Management in Bahraini Schools, Jaw School—Case Study

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Abstract: The greywater management by treating and reusing is an important issue to provide a new source of water that will not cost as much as using clean water. In general, the water demand in the world is increasing with the increased population, thus it can lead to a water crisis. To reduce the effect of this problem, greywater treatment system can be applied. The greywater in schools is gone to waste every single day, so to provide a logical, cheap and effective solution to manage this problem is to treat and reuse greywater in irrigation, since it does not necessarily need clean water. The aim of this manuscript is to manage and reuse the greywater to reduce the water crises, design an economical greywater system that will act as an investment to the school, and decrease the pressure on sewage system. The paper also aims to identify the wastewater characteristics generated from schools. Therefore, three samples of greywater from water basins and three samples from the kitchen were collected to test and analysis. The analysed parameters are BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), pH, SO_4, TDSs (Total Dissolved Solids), Cl, turbidity, Ca, Mg, NO_3 and TH (Total Hardness). The results showed that, the samples collected from the basins are in the accepted range, however the samples of the kitchen have a higher concentration in SO_4, BOD, turbidity and nitrate, therefore the greywater generated from the kitchen has been excluded from the greywater system. In terms of the cost, the results indicated that the payback cost could be returned in three years.

Key words: Greywater, management, schools.

1. Introduction

Growth of urban water consumption has been greatly increased, which is influenced by population growth, rapid urbanization, climate change and higher standards of living. This leads to increase of the total global urban water consumption. Efficient use of water is commitment and responsibility of everyone. From here, there should be a useful way to rationalization of water. There are many alternative water sources, such as wastewater treatment, rainwater tanks and storm water. Wastewater contains black and greywater. Black water includes wastewater generated from toilets that includes solids, while greywater includes wastewater generated from showers, baths, spas, hand basins, laundry tubs, washing machines, dishwashers and kitchen sinks. Greywater can contain some soap, salts, hair and bacteria, but the amount of these contents is very few. Since kingdom of Bahrain has low average of rain and storm water as well as increasing of population which increase the consumption of water also for psychological reasons, greywater treatment has been chosen. The greywater can be reused in flushing because toilet flushing is a frequently cited greywater application. If treated greywater is used in toilet flushing full purification is not required. Treated greywater is different from recycled water, which requires high treatment of wastewater from a centralized treatment facility. There are numerous case studies of installed greywater systems within individual family dwellings, multiple housing dwellings, multi-storey office buildings, individual (multi-room) hotel buildings and schools. The high volume of greywater generation in residential buildings, which accounts for approximately 50%-80% of daily water consumption, is usually greater than the requirement for toilet flushing

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(20%-36%). In contrast, the greywater produced in commercial, retail and other non-residential buildings (from hand basins, which use 21% of daily water consumption) is substantially less than the demand for toilet flushing (43%-65%).

The most commonly described application for greywater reuse is toilet/urinal flushing which can reduce water demand within dwelling by up to 30% [1]. However, greywater has been considered for many other applications including irrigation of lawns at cemeteries, golf courses and college campuses [2] vehicle washing, fire protection, boiler feed water, concrete production [3] and preservation of wetlands [4]. The water quality requirements for each application are geospecific but normally contain criteria based on organic, solids and microbiological content of the water [5]. The practices in re-use of greywater are growing up in many countries. Some of those countries have evaluated the re-use of greywater where practiced. Furthermore, they researched in the technical methods followed in the re-use and the resulting effects on health and environment.

This study has been designed, for a school Jaw in kingdom of Bahrain, which contains five buildings; each building consists of three floors except one building (two stories). The design of greywater treatment system starts with separating pipelines of greywater from black water, then, collecting the greywater in a collection tank to be treated, finally, reusing it in the same buildings for irrigation and toilet flushing. The main objectives of this study are to: decrease the water demand/use, reduce the pressure on wastewater collection systems and wastewater treatment plant, ecologically sustainable development and minimize the annual utility water bills.

2. Literature Review

The practices in re-use of greywater are growing up in many countries. Some of those countries have evaluated the re-use of greywater where practiced. Furthermore, they researched in the technical methods followed in the re-use and the resulting effects on health and environment. The following are some of the legislation and practices relating to the reuse of greywater in a number of countries. Despite the proliferation of re-use the greywater in some parts of the United States, there are no national policies for the re-use of greywater, as each state holds the responsibility of legislation of the water and sewage systems in it. Some states have developed legislation that allows the reuse of greywater under certain conditions. There are studies that spread in Australia in 1994 and 1997 [6, 7] about the possibility of re-use of greywater. This study indicates re-use of greywater. This study shows the ability of providing water clearly, if they work under conditions, but so far no information is available showing the extent of the re-use of greywater in Australia. The re-use of greywater is widespread in Japan. It includes simple systems scattered in homes relying on water from hand washing sink flow directly from boiled private toilet tank and there are more complex systems used in office buildings. Re-use of greywater in Tokyo mandatory in buildings with an area of more than 30,000 m^2 consumes more than 100 m^3 of water per day [8].

Having a look at the above studies one can say that there is a need to evaluate the quality of greywater in the schools to be treated and reused.

3. Methodology

Grey water has a specific characteristic and differs from the conventional wastewater (black water), which almost contains no pathogens and a little ammonia nitrogen. There are another sources of water which are devoid of solids and not classified as a conventional wastewater such as rainwater, but greywater is classified as a unique source of water and must be used different from portable water and rainwater.

To evaluate the quality of greywater generated from the basins and kitchen of the Jaw school, three

samples of greywater were collected from the basins and three from the kitchen using a glass tube, which was washed and disinfected. The six samples were tested and analysed.

4. Developing a Grey Water System

To create a high efficiency greywater treatment system with well-functioning and safety precautions, a full understanding of greywater properties and design process is required. Systems of greywater can range from the simple systems to the complicated systems; it depends on the building, which the treatment process will be created for. Here are steps to follow in developing greywater systems.

4.1 Conservation

Conservation is the most important step to begin with thinking about it. It is always the most environmental and economical way to gain benefits. Many places require lower amount of water than what is actually consumed, and there are a lot of easy ways to greatly reduce the amount of used water.

• Consultation about water conservation in the building is very useful and important before planning the system of greywater; this will be by scheduling water conservation and visiting Electricity and Water Authority website, which helps in evaluating and assessing the water use and identifying ways that reduce it.

• If ability of installation greywater system is not available, there are some other ways for the benefit and exploitation of greywater re-use such as collecting shower water or any washing water from wash basins in a bucket and with heating it, it will be saved for watering the plants.

(a) Selection of the Suitable Place Was began

This research was choose for economic and environmental reasons, by separating the greywater from the black water, then, collecting the greywater in a single tank and purifying it from impurities and odors for re-using it. First step was selection of the best place to experience this idea. Therefore, the inquiries of the specialists and study of the existing statistics at the government ministries about water consumption per capita in different places done.

(b) Selection Reasons

After contemplation of the possibility of applying the study on different places in many aspects such as:

• Large free area around it (enough space to install the treatment plant).

• Provide appropriate number of consumers, which increases the amount of greywater to return the cost as possible as can in few years.

• It has more than a source of greywater such as hand basins, showers place and kitchens sink.

(c) School Details

The selected place was a school constructed in Jaw by Ministry of Work. The school consists of:

Kinder garden building (two floors), primary building (three floors), multi-purposes building (three floors), intermediate building (three floors) and secondary building (three floors).

(d) Grey Water Tests

The second step in this research after choosing the building is taking samples of greywater then applying the recommended tests on it. Since the building is not constructed yet, different samples is collected from random schools. Based on similar use of water, approximately similar properties of greywater had obtained (see Figs. 1 and 2).

Fig. 1 Collecting greywater samples.

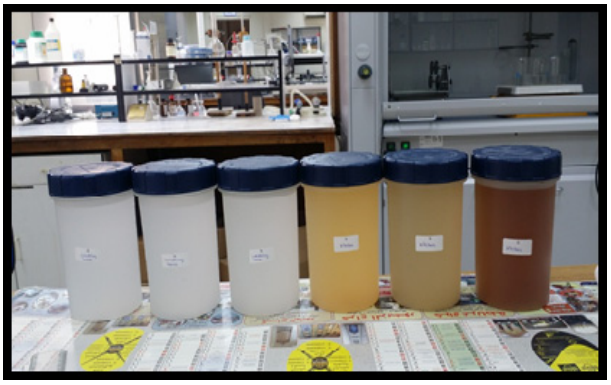

Fig. 2 Samples of greywater.

4.2 Recommended Tests for the Samples

The following analyzed parameters are suspended solid, COD (Chemical Oxygen Demand), pH, Sulphate (SO_4), TDSs (Total Dissolved Solids), BOD (Biochemical Oxygen Demand), sodium, chloride, fluoride, total hardness, nitrate, magnesium, calcium and turbidity.

5. Results and Discussions

For this research, a calculation was done for intermediate building only as an example and the rest buildings will be approximately same. The quality of tested greywater varies depends on the uses to which the water has been put. The physical and chemical characteristics of greywater generated from three water basins and three kitchens samples shown in Table 1.

In addition, as shown in Table 1 it is obvious that the range of all tests is acceptable except the kitchen samples, which contain high concentration of BOD. So, greywater generated from kitchen was excluded from the greywater system. The greywater containment concentration levels of the parameters SO_4, Cl, BOD and turbidity for the tested samples are shown in Fig. 3.

The concentration levels of the parameters pH, TDS, Ca and Mg for tested greywater samples generated from the water basins are presented in Fig. 4. The concentration levels of the parameters Ni and TH (Total Hardness), for tested greywater samples generated from the water basins are presented in Fig. 5.

Table 1 Physical and chemical characteristics of greywater.

Parameter	COD	pH	SO_4	TDS	Cl	BOD	Turbidity	Ca	Mg	NO_3	TH
Unit	mg/L	--	mg/L	mg/L	mg/L	mg/L	FNU	mg/L	mg/L	mg/L	mg/L
1.WB	33	6.4	0	0.09	16.5	16.54	5.3	2.4	3.4	3	20
2.WB	--	6.1	0	0.1	49.5	16.52	3.7	2.4	1	2.5	10
3.WB	13	6.7	0	0.6	58	16.58	20.2	3.2	0.5	1.7	10
4.Kitch	20	5.4	73.3	0.3	50.5	243.6	90	5.6	1.4	15.1	20
5.Kitch	10	5.1	130	0.7	93.5	244.5	85	4	0	14.2	10
6.Kitch	12	6.4	224	0.6	48	122.3	20.3	2.4	1.4	20.1	12

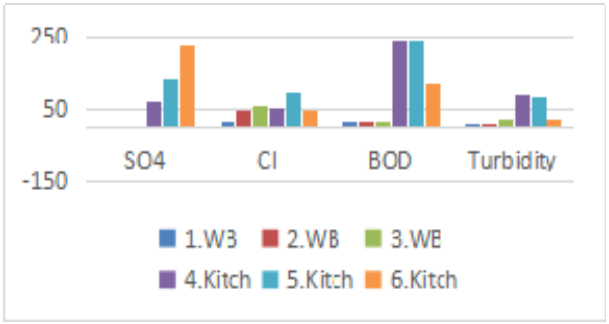

Fig. 3 Concentration levels of the SO_4, Cl, BOD and turbidity.

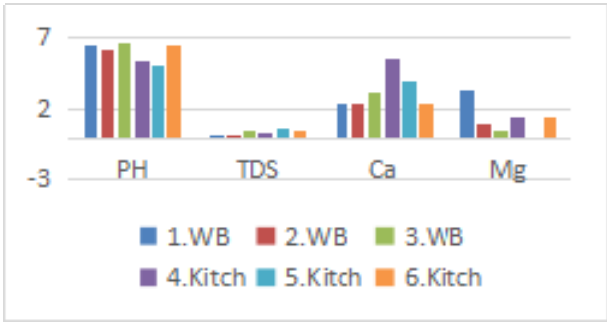

Fig. 4 Concentration levels of the pH, TDS, Ca and Mg.

Fig. 5 Concentration levels of the NO_3 and TH.

6. Conclusions

To conclude, by finishing this study of reusing greywater in Jaw school, a number of results were obtained to constitute many positive aspects. The greywater consumption of the school was 25.08 m^3 per day, which means that the amount of water saved is 2,181.96 m^3 per year. Reducing water demand will help in ecologically sustainable developments, which reduces the impact on nature. This record for Bahrain allows getting lead certificate.

Furthermore, sewage stations in Bahrain face overflow problem, which lead to pressure on treatment systems and high maintenance cost. Instead of constructing a new sewage station, treating and reusing of greywater in all possible places in Bahrain, will reduce the amount of waste water which leads to reducing the pressure on sewage stations.

Finally, the economical profit of applying this system will return to the owner of the project who will save 9,932.748 BD/year (26,222.50 USD).

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