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Potential Reuse of Grey water form Mosques for Toilet Flushing and Garden Irrigation in Saudi Arabia

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ABSTRACT

Water samples were collected from the grey water used for ablution in ten mosques in the Riyadh city. Such water were analyzed to identify its physical and chemical characteristics such as amount of suspended matter ; turbidity, ; EC_w; pH and their content of boron and (Ca^{2+}, Mg^{2+},Na^+, K^+, NH_4^+, HCO_3^-, CO_3^{2-}, Cl^-, SO_4^{2-} and NO_3^-). In addition to the number of pathogenic microbes; total bacterial counts and colon bacteria E. Coli. As well as the chemical oxygen demand (COD). On the other hand the SAR, SAR_{adj}, and alkalinity, RSC, were calculated in order to determine its suitability for garden irrigation. A system was fixed to treat the grey water from a mosque at Riyadh city. In this system the Grey water must passed systematically through four sand filters to remove the suspended materials then passed through an activated charcoal filter to remove color and some organic and

inorganic anions and finally the water passed through an ultraviolet unit to killed and remove the pathogenic microbes and other impurities. Results confirmed that the water resulting from the ablution characterized by ionic balance between the concentrations of Ca^{2+}, Mg^{2+} and Na^{+}. The relatively higher contents of Ca^{2+} + Mg^{2+}in such water along with its lower Na^{+} content reflected on decreasing the SAR values to be less than 10. Also all the values of EC_w, RSC and boron concentrations of such water are within the permissible limits for irrigation water. Moreover such water does not contain any of the heavy metals which determine its uses. On the contrary, the untreated grey water contained total bacterial counts of (1.7×10^8 -17 $\times10^8$ cells/100 ml water). The treated water (e.g. sand and /or carbon filters followed by simple sterilization) resulted in removing the pathogenic bacteria and gained very good water near to the tab water in its properties.

Keywords: water reuse, wastewater management, grey water, toilet flushing

1. INTRODUCTION

The estimated production of desalination plants exceeded 3.5 million m^3 per day which represents 60% of total urban water in the

year of 2010. Such a high amount of water consumption produces a huge amount of sewage water which needs to be treated. Lowering the amount of urban water demand could achieved by a combination of different measures such as increasing the efficiency of water supply systems (mainly reducing the pipe losses), installation of water conserved appliances (showers) and reusing some of that water (greywater). Experience of several countries indicates that greywater can be a cost effective alternative source of coming from baths, showers, washing machines and bath ram sinks, comprising 60 -70% of the total water demand. Greywater is the term given to all used water discharged from a house includes shower, bath, hand basin, kitchen sink, dishwasher, washing machine and laundry tub water except for toilet water. In addition the re-use of greywater for garden irrigation or in flushing system should be encouraged in urban and rural households as it utilizes a valuable on-site resource, conserves precious drinking water and reduces the load on wastewater disposal systems. In the literature greywater has been used to conserve water and to promote sustainable development without compromising public health and environment. (Prathapar *et al.* 2005) concluded in their

study at Oman that building industry can be persuaded to install grey water treatment system in new apartment complexes and public buildings. An Australian experience shows that reuse of greywater of toilet flushing and garden irrigation saved up to 50% (Jeppesen 1996). While the saving in Mallorca Island, Spain reached to 23% (March *et al.* 2004).

This research suggests the development of a plumbing system designed to collect, filter and disinfect water consumed in ablution to be used subsequently for the above purposes. The objective of this study is to assess the greywater recycling system and to investigate the effect of the treatment on microbial and chemical quality of the recycled water.

2. MATERIALS AND METHODS

A greywater reuse system was designed for the purification of water consumed in ablution. The system cosseted of: (A) four PVC sand filters (15 cm internal diameter and 1.5 m long each), (B) one activated charcoal filter (20 cm internal diameter and 1.0 m long), (C) ultra violet unite, and (D) tanks for collecting grey water and final

purified water, (E) valves and regulators. In such system the greywater passed systematically through four sand filters to remove the suspended materials then passed through an activated charcoal filter to remove color and some organic and inorganic anions and finally the water passed through an ultraviolet unit to killed and remove the pathogenic microbes and other impurities.. as shown in (Figs.1-2). We used gravel infiltration galleys and filter the grey water through the septic system so the pipe doesn't clog. A greywater reuse system receive the effluent from one big Mosque (Othman bin Affan Mosque), as the out put of water passed through the system was analsized all year round. Due care was in the system to protect public health, protect the environment, meet community aspirations and be less cost-effective. Current on-site treatment systems have generally adopted the technology of the conventional sand filters, activated Charcoal filters and U.V filter for large treatment systems. Different stages of water treatment were analyzed to identify its physical chemical and chemical characteristics such as the amount of suspended matter; turbidity, ECw ; pH and their content of (Ca^{2+}, Mg^{2+},Na^{+}, K^{+}, HCO_3^{-}, CO_3^{2-}, Cl^{-}, and SO_4^{2-}), the number of colon bacteria (E. coli.), COD, TOC and Turbidity were determined according to the

methods described by (Rainwater and Thatcher,1979; Etaon, 1995; Page *et al.,* 1982; APHA, 1985).

3. RESULTS AND DISCUSSION

Data presented in Table (1) show that the concentrations of soluble (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, NH_4^{+}, HCO_3^{-}, CO_3^{2-}, Cl^{-} and SO_4^{2-} in the grey water were relatively similar or higher than tap water. However, by using the system the concentrations of the studied ions became more or less the same as in tap water, especially at the final stage of water purification (after passing the water through the U.V. units). Also all the values of EC_w, RSC and boron concentrations of such water are within the permissible limits for irrigation water. Moreover such water does not contain any of the heavy metals which determine its uses. On the contrary, the untreated grey water contained total bacterial counts of (1.7×10^8 -17×10^8 cells/100 ml water). It's needless to say that such purified water could be successfully re-used for flushing the toilets or in garden irrigation. It's needless to say that such purified water could be successfully re-used for flushing toilets or irrigating all kinds of crops (as grass and palms) which are sensitive and /or resistant to salinity. Furthermore the treated water resulted in removing the

pathogenic bacteria and gained very good water near to the tab water in its properties. The chemical composition of finial treated water was more closed to those of tap water (Table, 1 & 2), with safe microbial content (E.Coli), Fig (3 and 4). On the other hand, the biological analysis of the grey water indicated that the COD, turbidity and TOC were so much higher in the grey water (water consumed in ablution) compared to the tap water. However such parameters were greatly decreased by passing the grey water through the proposed system, (Table 3 & Fig., 5). Therefore, the greywater re-use can be achieved through the use of a simple system consisted of sand filters, activated charcoal, and UV unit. Using this simple system can safe about 30-40 % of fresh water to be used in toilets and irrigate the landscape area under Saudi Arabian conditions. The treated water resulted in removing the pathogenic bacteria and gained very good water near to the tab water in its properties.

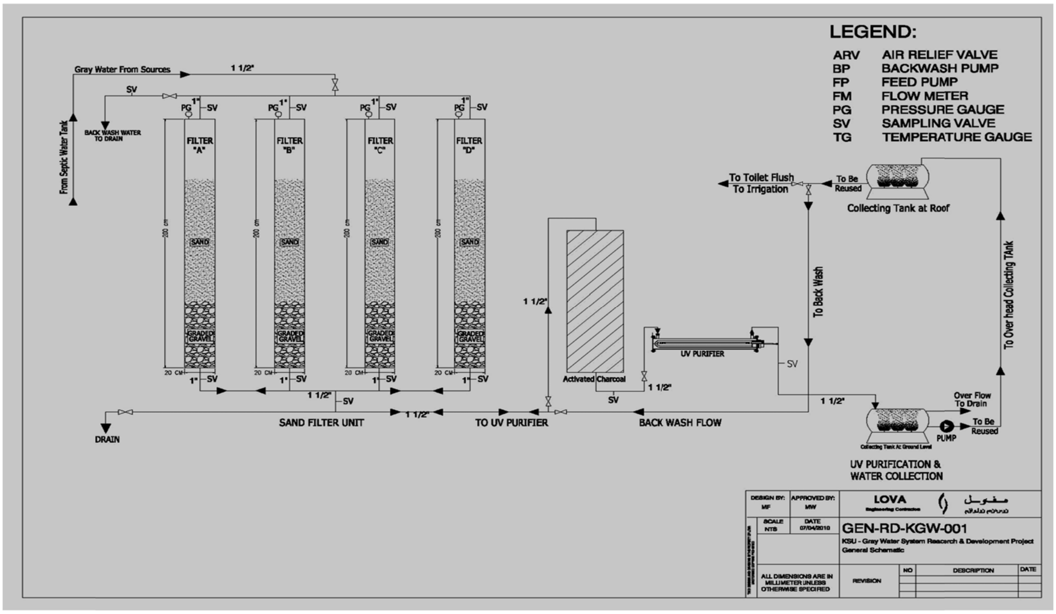

Figure. (1) Schematic diagram for the system that used for treating Gray water.

Figure.(2) Sand and activated charcoal filters.

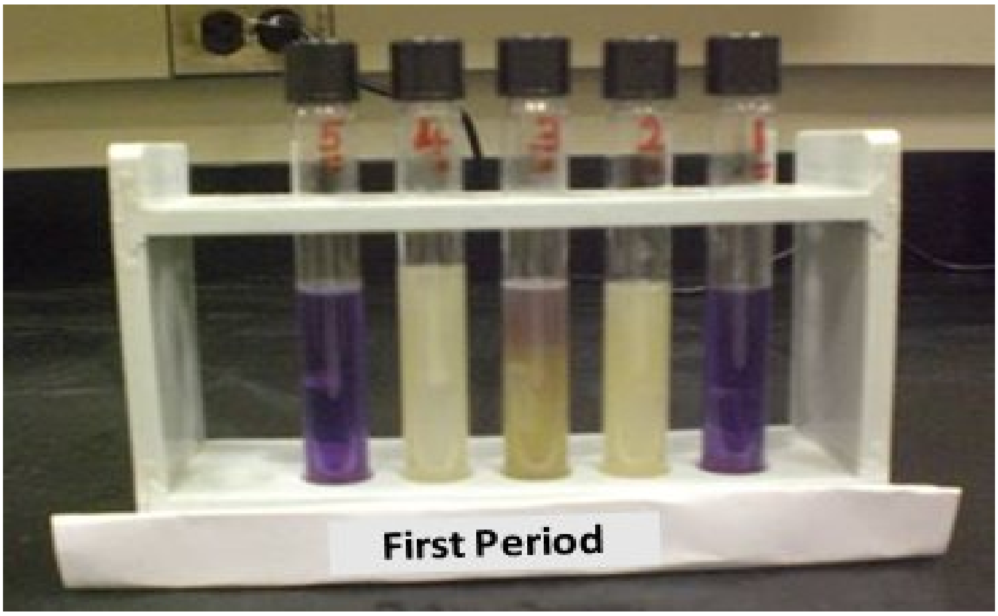

Fig. (3) Colon bacteria (E. coli) in the grey water before and after purification at the 1st period.

Where: (Tube No I contained Tap water; Tube 2 contained grey water , tube 3 water after passing through sand filter , Tube 4 water after passing through Charcoal filter sand Tube 5 water after passing through the U.V unit).

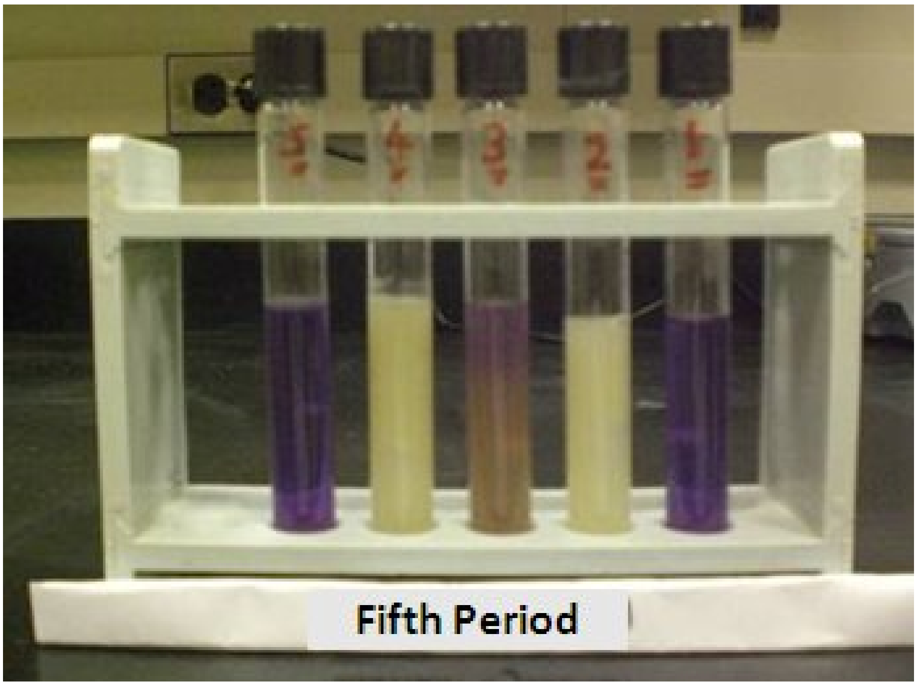

Fig (4) Colon bacteria (E. Coli) in the grey water before and after purification at the 5th period.

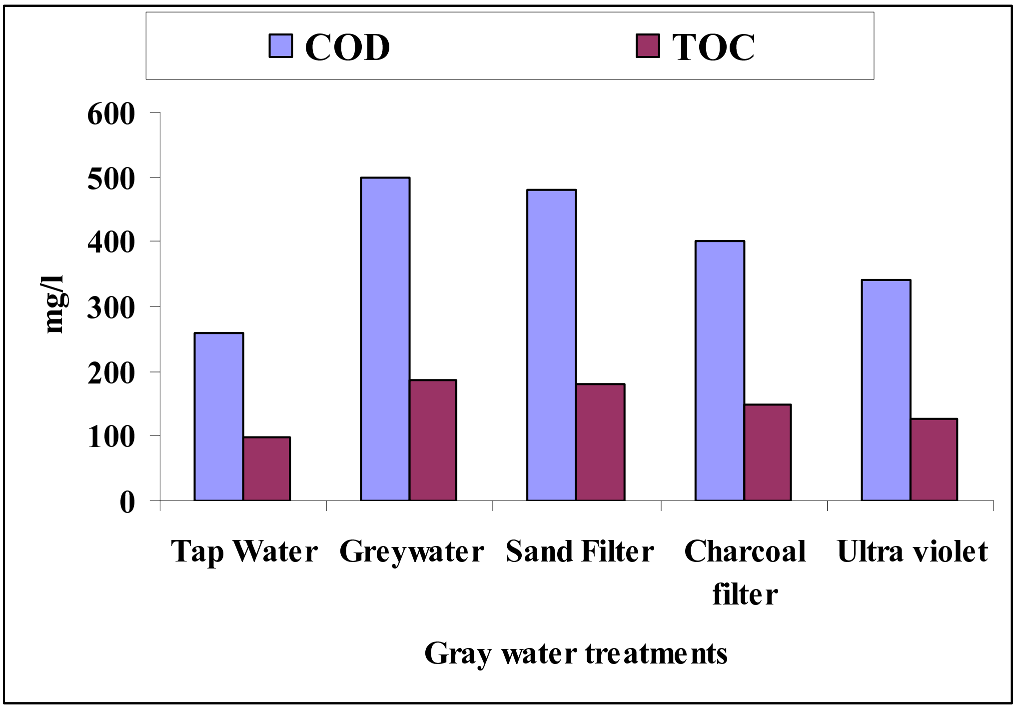

Fig (5) TOC, COD of the grey water before and after purification.

Table (1) Chemical properties of the grey water before and after purification.

Treatments	Soluble Cations ($meq.l^{-1}$)				Soluble anions ($meq.l^{-1}$)		
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
First Period							
Tap Water	4.00	2.3	2.69	0.108	1.95	4	2.30
Greywater	4.75	2.7	3.85	0.183	3.00	4.5	2.40
Sand Filter	4.60	2.1	2.69	1.35	1.95	4.1	2.40
Charcoal filter	2.95	5.3	2.69	1.40	3.00	4.75	2.70
Ultra violet	4.00	2.3	2.69	0.115	1.80	3.9	2.40
Second Period							
Tap Water	4.00	2.00	2.61	0.01	2.10	4.00	3.15
Greywater	4.55	1.85	2.76	0.13	2.60	4.45	2.87
Sand Filter	4.45	1.65	2.84	0.13	4.00	4.30	3.20
Charcoal filter	4.50	1.98	3.33	0.24	2.10	4.30	3.11
Ultra violet	4.50	2.00	2.61	0.18	2.10	4.05	2.62
Fifth Period							
Tap Water	4.00	2.35	2.69	0.115	2.10	5.00	2.54
Greywater	5.00	2.45	3.58	0.128	3.25	5.25	2.54
Sand Filter	4.75	2.55	2.92	0.141	3.00	4.45	3.66
Charcoal filter	4.75	2	2.69	0.531	2.75	4.68	2.80
Ultra violet	4.15	2.35	2.69	0.503	1.85	4.50	2.50

Table (2) some chemical parameters of the grey water before and after purification.

Treatments	EC dSm^{-1}	pH	T.Hardnes mg $(CaCO_3)/L$	RSC	TDS mgl^{-1}	NO_3 mgl^{-1}	B mgl^{-1}
First Period							
Tap Water	0.836	7.90	315.0	-4.35	535.04	1.87	0.5
Greywater	0.976	7.38	372.5	-4.45	624.64	2.1	0.7
Sand Filter	0.821	7.82	335.0	-4.75	525.44	2	0.6
Charcoal filter	1.076	7.12	412.5	-5.25	688.64	1.9	0.55
Ultra violet	0.802	7.95	315.0	-4.5	513.28	1.88	0.55
Second Period							
Tap Water	0.805	8.05	300.0	-3.90	515.20	1.88	0.54
Greywater	0.878	7.48	320.0	-3.80	561.92	2.20	0.72
Sand Filter	1.000	7.17	305.0	-2.10	640.00	2.00	0.66
Charcoal filter	0.821	7.24	324.0	-4.38	525.44	1.90	0.62
Ultra violet	0.724	7.72	325.0	-4.40	463.36	1.88	0.55
Fifth Period							
Tap Water	0.836	8.10	317.5	-4.25	535.04	1.90	0.54
Greywater	0.923	7.97	372.5	-4.20	590.72	2.20	0.70
Sand Filter	1.050	7.30	365.0	-4.30	672.00	2.00	0.67
Charcoal filter	1.100	7.46	337.5	-4.00	704.00	1.90	0.60
Ultra violet	0.980	7.92	325.0	-4.65	627.20	1.90	0.60

Table (3) some biological parameters of the grey water before and after purification.

Treatments	COD mg O_2 /L	Turbidity NTU	TOC mg C/L
First Period			
Tap Water	260	0.09	97.50
Greywater	500	0.95	187.50
Sand Filter	480	0.47	180.00
Charcoal filter	400	0.46	150.00
Ultra violet	340	0.12	127.50
Second Period			
Tap Water	300	0.08	112.50
Greywater	500	0.99	187.50
Sand Filter	480	0.5	180.00
Charcoal filter	450	0.46	168.80
Ultra violet	340	0.12	127.50
Fifth Period			
Tap Water	280	0.08	105.00
Greywater	520	0.99	195.00
Sand Filter	480	0.5	180.00
Charcoal filter	320	0.46	120.00
Ultra violet	340	0.12	127.50

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