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Social Investigation of Greywater Reuse in Baghdad

Prof.Dr.Dheyaa Wajid Abbood[1*] Dr.Ayad Sliybi Mustafa[2] Seroor Atallah Khaleefa Ali[3]

[1]Prof.Dr.Dheyaa Wajid Abbood Civil Engineering /Mustansiriya University Baghdad/ Iraq
[2]Dr.Ayad Sliybi Mustafa Serror Civil Engineering /Anber University Baghdad/ Iraq
[3]Seroor Atallah Khaleefa Ali Environmental Engineering /Mustansiriya University / Iraq
*Ema il: Dr.Dheyaa@gmail.com , ayad_eng2001@yahoo.com

Abstract
Both the 1991 Gulf War and the 2003 Iraq War have affected and used the water resources. Most of the water in Baghdad comes from Tigris river. Baghdadis need abundant water supplies to live and survive in the desert environment. The wars and economic sanctions have left the people in a state of drought, with the water largely contaminated and few resources available to clean it. Baghdad has arid climate with extremes of heat and cold, temperatures also vary greatly with time, the mean January temperature is 7°C and the mean July temperature is 35°C.High temperatures in the capital city of Baghdad, which lies in the central part of the country, is 51° C have been recorded. Analyses were conducted from 2005 to 2010 and the results for percent of electricity consumption by end use shows that 10 percent is for evaporative cooling. In addition to water policies of Turkey ,Syria and Iran which affects strongly the water availability in Iraq, the lack of water for irrigation is the major reason of failure of agricultural policy in Iraq . Water shortage in Baghdad occurs. More than one out of three Baghdadi's people lack access to safe drinking water, and more than one out of six lack adequate sanitation. Wide attention are required for starting national water conservation programs .In arid areas of Baghdad, water conservation and reuse are issues that receive a great deal of public attention in the last decade. The search for ways to responsibly use and reuse water is vital to the sustainability of the water supply and thus the future of these regions Treated gray water in houses can be reused for toilet flushing, outdoor irrigation and spraying water evaporation cooling of selected apartments building located in Baghdad. Treated wastewater also can be used for irrigation and streets cleaning by municipal institutes. Several experiments in Baghdad have been achieved for small scale to reuse graywater for toilet flushing, irrigation, outside house cleaning and evaporative cooling. The basic goal of this project proposal is to apply the graywater for wide range as solution of water crises in Baghdad. Baghdad's Water demand is estimated to 3.2 Millions m^3/day, the quantity of produced water is (66%) of the required needs.
-The Average daily use is about 18% lower than the annual daily average in Winter, while it is 38% higher than the annual daily average ,that cause wide variation in water demand during the year.
- For selected communities the maximum daily use is about 205% of the average daily use.
- Although electrical energy have decreased significantly during the past decade, Increased use of evaporative cooling make residential water use was continued to rise approximately 5% per year.
Keywords: water resource management ,greywater reuse, Baghdad

1-Introduction

Water is a strategically limited natural resource, and currently Iraq is in the grip of an extended drought period. We need to look for alternative water sources and work towards achieving high level of sustainability. A greywater amount that is generated will vary depending on the number of people, their age, their water usage pattern and time. Experience in several arid and semi-arid countries indicates that greywater can be a cost-effective alternative source of water. However, until recently, lack of data on this aspect has been a barrier to arriving at such a conclusion (Prathapar et al., 2005). Prathapar et al. (2005) pointed out several factors constraining treated greywater reuse such as quantity, quality, financial, legal, social and institutional constraints. Quality of greywater varies depending on the source and use of greywater, geographical location, social habits, demographics and level of occupancy (Al-Jayyousi, 2003; Jefferson et al.,1999).Greywater has been used to promote sustainable development and resource conservation without compromising public health and environmental quality (Prathapar et al., 2005). Japan, the US and Australia maintain the highest profile in greywater reuse (Ottoson and Stenstrom 2003).

Greywater may be reused for groundwater recharge, irrigation, plant growth, washing of vehicles and windows, fire protection, boiler feed water and concrete production. In addition, grey wastewater could

be used to develop and preserve wetlands (Jamrah et al., 2006; Eriksson et al., 2002; Nolde, 1999).Greywater may be polluted, and as a result may cause health risks, and it contains certain environmental pollutants. This would mandate the identification of characteristics of greywater and the treatment of greywater prior to reuse. It should be noted that the characteristics of greywater depend on the quality of fresh water, the distribution network and the activity and habits of the residents (Prathapar et al., 2005). Greywater reuse is a major issue in terms of the number of persons involved. It appears that greywater reuse is more possible in older houses and lower-income areas. In the same time, greywater reuse system can be constructed in new houses. However, the survey results also suggest that if greywater reuse is proposed to not be a public health issue, and if permitting requirements are relaxed, greywater reuse might increase substantially.

The objective of this study is to collect enough information about greywater in the Baghdad city and to judge if this greywater can be employed as part of the overall sustainable management of the limited water resources. As a result, this study is an attempt to :-

(1)- Evaluate the daily, maximum daily and hourly water consumption in Baghdad

(2) - Estimate the quantities of greywater generated in typical Baghdadian households

(3) - Investigate the quality of the different greywater sources generated from Baghdad city to assess the risks of greywater use .

(4) -Investigate the public acceptance towards greywater reuse.

One major interest of this investigation is the reuse of domestic greywater for irrigation around homes. The greywater reuse practice is becoming increasingly common in many households around the world, but there are no in-depth studies that provide a clear understanding of how the greywater reuse impacts on soil, plant and human health in the long-term especially in Iraq. This study is first of its kind to be conducted in Iraq seeking views of the community from a range of age groups, professional backgrounds and socio-economic levels on greywater reuse and actions individual homeowners are taking to cope with the current water scarcity. A social survey has been designed and administered to identify quantities and qualities of fresh water consumption and greywater generated in different regions in the two sides of Baghdad city (Rusafa and kerkh). The number of households covered by the survey in Baghdad was ***575***, and the total number of residents participating in the survey was ***3218***, over a period of ***21*** weeks. ***Sixty-one*** greywater samples were collected form households during the period ***August to December 2010*** to represent the different sources of greywater. The participants for this study accessed the survey questionnaire by mail (***394*** respondent) or as a hard copy (***181*** respondent) that was hand delivered to their homes. ***A total of 575*** participants from different socio-economic background, aged over ***18*** years were responded. Regardless of their age and gender, water quality is the most important aspect of water for the participants, and the availability of water without restriction is the least important aspect. About ***67%*** of the participants are affected by the current water scarcity in some way and believed that greywater recycling can potentially overcome some of the water scarcity being faced by homeowners. In order to combat the water scarcity, they suggested to recycle more greywater at domestic level.The cost of plumbing and health risks to people, plants and soil are the two most important issues that need attention. Overall, people are environmentally conscious and are interested in saving water provided there is proper encouragement given by government, local councils and other authorities that regulate water supplies and reuse. Results of the study showed that quality data for ***61 samples*** indicated that greywater treatment is necessary to reuse.

Public acceptance survey indicated that ***31%*** of people oppose greywater reuse concept . Therefore, for widespread reuse of greywater in Baghdad homeowners need some reliable and practical information for its safe and sustainable reuse. In addition to, financial incentives from Baghdad governments may help more people to accept any project of reuse of greywater. Whether and how Government and municipal water providers should encourage greywater reuse are issues that should be addressed.

2-Methods

Baghdad has been divided into two sides , Kerkh and Rusafa side according to geographic site and six sections in each side have been selected to study contrary to income class. The latter approach would have the advantage that particular geographic circumstances might be taken into account. Of course, a minimum of empirical data would still be needed: the mean amount of freshwater and greywater per income class. This survey was targeted at houseowners with different socio-economic backgrounds spread across the Baghdad region (Rusafa and Kerkh). The target group for the survey included people

over 18 years of age and those who are interested in sharing their thoughts on water issues in general and greywater reuse in particular. A questionnaire in the form of a social survey was designed to identify the water consumption and the quantity of greywater generated in typical Baghdadian households. The survey was administered in Baghdad over a period of ***21 weeks***. The number of households covered by the survey in Baghdad was ***575***, and the total number of residents participating in the survey was ***3218***. Survey questionnaire was made available to the survey participants in both email line and hard copy forms, thus allowing them to respond to the questionnaire with or without an access to the internet. The questionnaire included questions dealing with the number of occupants in a given household, water bill, frequency of bathing, hand washing, teeth brushing, ablution andhair washing, frequency cloth washing and type of laundry machines, floor area of the house, existence of garden and frequency of garden watering. An estimate of the total household water consumption was obtained from last household quarterly water bill for the first quarter of the year 2010.There were a total of ***20 questions*** in the survey and out of those questions ***15 questions*** were to be responded by all participants while the rest by those who interest and expert in water supply and management. The survey questionnaire can be divided into three parts. The first part (Q 1-5) was about characterizing the participants in terms of their gender, age group, the type of dwelling they are living in and the number of people living in the household. The second part (Q 6–13 and 19) is focussed on the participant's views on water issues, water saving practices they are using, water scarcity in Baghdad, the extent to which they are impacted by the scarcity and their willingness to reuse greywater. The survey also included an open-ended question (Q 20) that was responded by all the participants for their views on water recycling, greywater reuse and water conservation issues, challenges and opportunities,(Appendix A).Some assumptions were made for calculating the amount of greywater generation .Greywater generation was estimated from the sum of sink, shower and laundry. Black water generation was calculated from the difference between the total household water consumption and the sum of greywater generation, garden water consumption and water used for cooking and drinking. The data collected was analyzed for total daily per capita greywater generation, daily per capita fresh water consumption, and daily per capita black water generation. A statistical analysis was carried out on the collected data to examine the variability, correlation, distribution and statistical inference. Greywater samples in this study were collected from different households in Baghdad city.

Samples were collected from shower, sink and laundry in various locations of the study to represent different sources of greywater generation. Samples were collected in sterile bottles from households and were analyzed for pH, Dissolved Oxygen (DO), Electrical Conductivity (EC), alkalinity, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD5), chlorides (Cl^-), calcium (Ca), sodium (Na), magnesium (Mg), potassium (K), lead (Pb), Total Coliform (TC), Total Fecal coliform (TF), Total Solids (TS), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and nitrate ($NO3^-$). All analyses were carried out according to the Standard Methods for the Examination of Water and Wastewater (APHA, 2005). Sampling bottles were kept in an ice box below 4 ^{O}C during transportation to the laboratory and were rapidly analyzed, except for Ca, Na, Mg, K and Pb, where samples were preserved in nitric acid and stored at 4^{O}C.

A survey questionnaire was also designed and administered in the selected cities over a period of months from August to December to gauge public reaction towards greywater reuse. The survey basically aimed at measuring opinion of the public towards acceptance and/or opposition of greywater reuse, and find out reasons behind the public opinion.

2-1 Mailings and Response Rates

Surveys were mailed to family residences in the different areas in Baghdad .This sampling methodology resulted in each home owner having an equal chance of receiving a questionnaire. Just under 1800 surveys were mailed, only some 394 responses returned. Response rates vary from ***(68 %)*** in Rusafa to ***(42%)*** in Kerkh. The survey was conducted to the survey participants over a period of ***146 day***. Except two responses, all the survey responses were received from participants living in Baghdad . ***575 participants*** filled out the survey questionnaire. Majority of participants ***(63.8%)*** used the mailing version of the questionnaire and about ***(36.2%)*** of them used the hardcopy version of the survey questionnaire.

Out of ***500*** hard copies of survey questionnaire distributed in Rusafa side and the other in the Kerkh side of Baghdad, ***(36.2%)*** completed questionnaire were returned. The survey responses in the study were received from ***181*** in Baghdad,**(Figure(1)).**

2-2 Data analysis

The survey data collected during the study from ***August to December 2010*** were analyzed to obtain key trends and inter-relationship of responses to different survey questions in tabular and graphical forms. The responses for the open-ended question were manually analyzed and grouped into a number of themes to develop insights into issues, difficulties and challenges the community is facing in relation to greywater reuse and practical actions that can be taken to secure water supplies and achieve sustainability of water resources in urban landscapes. An electronic copy of the survey questionnaire was sent to the professionals, Engineers and water system provider (Ammant Baghdad) to participate in the survey. This was mainly aimed at collecting views from professionals in different fields of expertise.

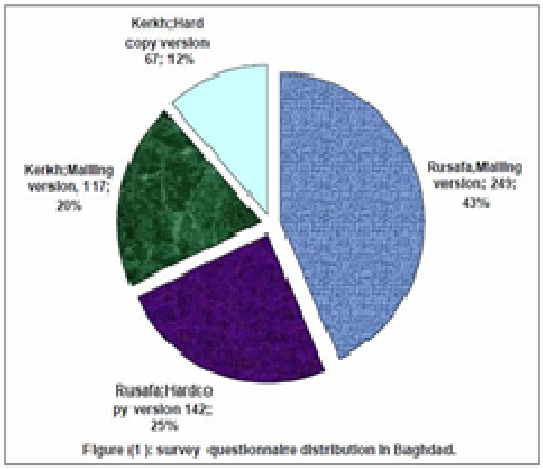


Figure (1): survey -questionnaire distribution in Baghdad.

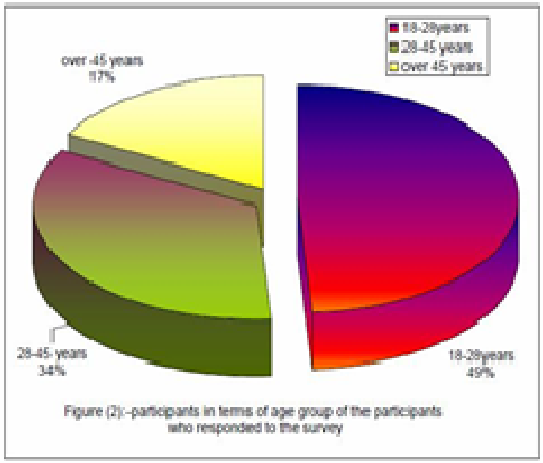


Figure (2):-participants in terms of age group of the participants who responded to the survey

3- Results

3-1 the survey process

Community concern, response and support towards issues that affect the region may be influenced by age, gender and other factors. In this study, we found that the participation of people in the survey tends to decline with the age **(Figure (2)).** In terms of age group of the participants who responded to the survey, the highest number of responses was received from participants aged between ***18 and 28 year*** and the lowest number of responses was ***over 45 years*** of age. Females responded more than males in ***18-28***, ***28-45*** age groups. Overall ***49%*** of the survey responders in this study were aged between ***18 and 28***. These differences between service areas are likely due to different socio-demographic characteristics. All this suggests factors that may increase the likelihood of greywater reuse:

- Older houses.

- Lower income levels.
- Building under construction.

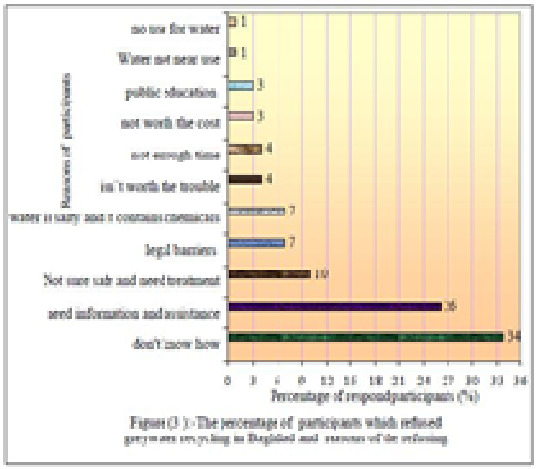
These factors appear consistent with assumptions about what motivates some people to reuse greywater. Motivations presumably include:

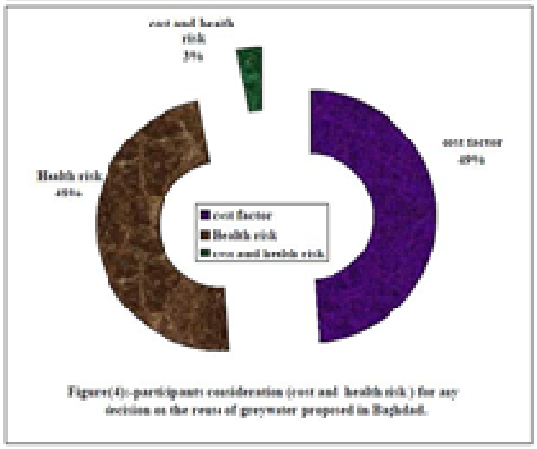
Ÿ Environmental sensitivity.
Ÿ Water conservation ethic.
Ÿ Desire to reduce one's water bill.

All respondents in different regions in Baghdad indicated they do not know what is greywater and certainly do not reuse any greywater. Reasons offered for this are explained in **Figure(3).**The top reason offered for not reusing greywater is "don't know how." Another important reason is "need information and assistance." This suggests that if the legal barriers were lowered and public education and incentives offered, greywater reuse might increase considerably.

Several of the reasons offered are similar, by design. The specific reasons can be grouped into five categories. For example, "don't know how" and "need information and assistance" both indicated the respondent needs help. These two categories account for ***(63%)*** of all reasons given. "Not sure safe and need treatment "and" water is salty and it contains chemicals" suggests health or environmental concerns. These account for (***18%).***

Similarly, "isn't worth the trouble", "not enough time" and "not worth the cost" all indicate a similar lack of motivation. These three reasons account for ***(11%)*** of all responses. Legal, and permitting issues account for ***(7%)*** of responses. "Water not near use" and "no use for water" indicates reuse is not practical, and account for ***(1%)*** of responses.





There was some interesting trend in terms of participants' views as to how they will cope with future scarcity. In all age groups, a ***54%*** of participants voted to reuse greywater and use less water, as a means of securing future water supplies. The trend for the number of votes received for 'use less water' strategy declined with the increase of age, while the votes for 'increase the price of water' strategy increased with the increase of age. This indicates that a blanket approach to water conservation strategy may not be very

effective across the community.
Nearly ***65%*** of the participants think that the reuse of greywater by houseowners can help in sustaining Baghdad's future water supplies, and about ***63%*** of the participants viewed that the greywater reuse will reduce the amount of portable water usage and improve the local environment. ***Forty-nine percent*** of participants thought the cost associated with the reuse was a very important consideration for them, while ***(48%)*** of participants considered health risk to be very important for any decision on the reuse of greywater. On the other hand, for one in thirty (***3%***) participants, health risk and cost weren't very important at all,(***Figures (4)***). One of the prime concerns of the survey participants was impacts of greywater on soil quality and environment surrounding greywater reuse sites if greywater recycling for irrigation.

Many participants who responded to the survey were environmentally conscious and wanted to reuse greywater to cope with the water scarcity, but they often lacked information on how to reuse greywater and were concerned about its long-term effects on soil and plants. Some participants were particularly concerned about accumulation of salts and phosphorous in soil and likely impact on Iraq native plants at their home sites. The participant suspected that this was possibly due to the long-term greywater reuse but wasn't sure of the underlying dynamics of nutrient accumulation or other possible changes in soil pH and EC. In general, the cost involved in plumbing and health risks to people, plants and soil are the two important issues that need attention for professional engineers notes. Some form of financial support from government and information packages that explain best practices to avoid risk to human health, soil and plant will be valuable in achieving widespread reuse of greywater in Baghdad region.
Eighty one percent of the survey participants were aware of the current water scarcity in Baghdad , but a relatively small proportion of participants (***19%***) were of the opinion that they were not aware of the scarcity. The percentage of the total number of survey participants who were affected in some way in their summer daily lives by the current water scarcity is ***67%***.Regardless of their gender and age, water quality is the most important aspect of water for the participants, and the availability of water without restriction is the least important aspect of water . These indirectly means that majority of people want access to high quality water in sufficient quantity and are prepared to pay higher prices and can put up with water restrictions. The concerns expressed by the participants in this survey about health risks and long-term impacts on soil and plant are really the signs of lack of useful information required for safe and sustainable greywater reuse. The data from this study indicate that about ***(59%)*** of the total number of participants were not aware of the problems associated with greywater reuse. The study also indicates that, whether someone is reusing or not reusing greywater, there is not much difference in their views on the long-term effects of greywater reuse. This means, there is a general need for greywater reuse education in the community. For the reuse to occur widely, there is need for easily accessible, user friendly information packages to create 'greywater reuse literacy' throughout in the community (includingin schools and universities). One of the interesting findings of this study is that about ***(26%)*** of the total number of survey participants was not aware of the long-term consequences of greywater reuse for irrigation at their home gardens. This means, appropriate educational program on the safe and sustainable reuse of greywater will be critical in achieving widespread reuse around houses.

3-2 Water Conservation in Baghdad

Data related to water quantity was collected during a period of ***21 weeks*** from ***August through December, 2010***. **Figures (5) to (13)** show the statistical summary of the distribution of internal domestic fresh water use in Baghdad. The daily water consumption ranged in Baghdad from ***75 Lpcd to 176 Lpcd with an average of 116 Lpcd*** .The maximum daily consumption ranged in Baghdad from ***124 Lpcd to 327 Lpcd with an average of 180 Lpcd*** . The maximum hourly consumption ranged in Baghdad from ***154 Lpcd to 900 Lpcd with an average of 308 Lpcd*** The results show that greywater generation ranged in Baghdad from ***34 Lpcd to 139 Lpcd with an average of 68 Lpcd***, The results also show that sink constituted the higher percentage of greywater generation, followed by shower and finally laundry.
There should be a direct relationship between the total greywater generation and the fresh water consumption in a given household. Figures (7)and (8) present the average percentage per capita greywater generation versus average percentage per capita total household water consumption in the Baghdad city selected for the study in conventional use and if greywater reuse proposed project are applied. Greywater generation data were estimated throughout this study while household water consumption data were obtained

from the quarterly water bill for the households participating in this study. The figure shows a direct and well established relationship between water consumption and greywater generation. The per capita rate of greywater generation also increases with the increase of total household water consumption.

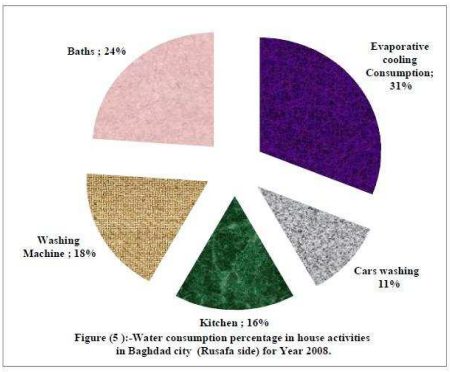


Figure (5):-Water consumption percentage in house activities in Baghdad city (Rusafa side) for Year 2008.

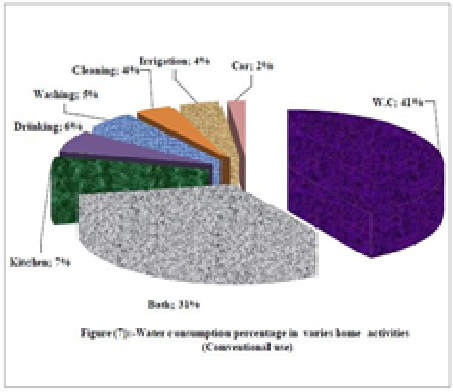


Figure (7):-Water consumption percentage in varies home activities (Conventionall use)

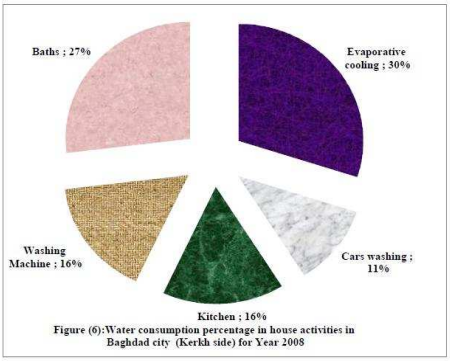


Figure (6):Water consumption percentage in house activities in Baghdad city (Kerkh side) for Year 2008

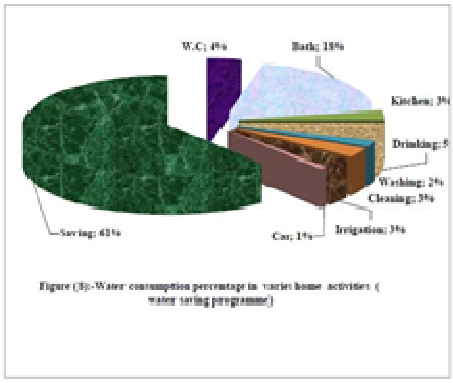


Figure (8):-Water consumption percentage in varies home activities (water saving programme)

3-3 Greywater Characteristics

A total of 61 greywater samples were collected from the different sources of greywater in the households in Baghdad . The greywater samples were analyzed for the different water quality parameters.**Tables (1) to (4)** presents the results of analyses and shows a comparison between physical,chemical and biological quality parameters for greywater generated from the different sources.The table shows that total coliforms and total fecal coliforms were present in all analyzed samples over a five month period(August to December 2010). The levels of total and fecal coliforms found in greywater indicate high contamination and necessitate greywater treatment prior to reuse.

3.3.1 Chemical and physical quality

There is a high amount of variability in the chemical and physical quality of greywater produced by any household, which is due to factors such as the source of household water, the water use efficiency of appliances and fixtures, individual habits and products used in the household (e.g., detergents, shampoos, soaps). The amount of salt (e.g., sodium, calcium, magnesium, potassium and other salt compounds), nutrients, oils, grease, fats, and chemicals in greywater are a direct result of the type of products and foods used within the household. Greywater from laundries and bathrooms will contain some body fats, urine, faeces or blood.

Phosphorus and nitrogen are two nutrients of concern to the environment, as they can cause algae blooms in surface water. These nutrients are also limited in Baghdad soils and necessary for plant growth. The nitrogen and phosphorus in greywater can substitute fertilizer requirements and provide phosphorus and nitrogen to the garden and lawn; however, if too much greywater is used, nitrogen and phosphorus can move off-site into water bodies where they can cause environmental problems.Minimum and maximum pollutants loading measured in Baghdad for sixty one samples for period from August to December 2010 was

tabulated in **Table(1).** Relative Pollution of Grey water and Blackwater in the total wastewater (Black water + Greywater)for 20 samples was explained in **Table (2).**The basic flow rate measured in Baghdadian houses was greywater and approached to 94%, of total water if kitchen waste is included in greywater quantity and 70% when wastewater from kitchen is excluded in greywater **(Table(3)).** .

Table (4) shows minimum and maximum Pollutants Loading measured in gram per day per capita for twenty samples for period from August to December 2010 .A study which aimed at evaluating the amount of greywater generation in the city of Baghdad has been carried out by Dheyaa et al. (2009). The study showed that the water consumption in Baghdad in August averaged 138 Liters per capita per day (120-200 Lpcd);while the water consumption in Baghdad in December averaged 75 Liters per capita per day (58-100 Lpcd).Sink water comes from the sum of hand washing, ablution, tooth brushing and hair washing. The figure indicates that hand washing frequency is higher than ablution followed by tooth brushing and finally hair washing. Additionally, the figure indicates that sink has higher frequency of use followed by shower and finally by laundry. Investigation of the figure indicates that water shortage in Baghdad has affected the water use habits of people.

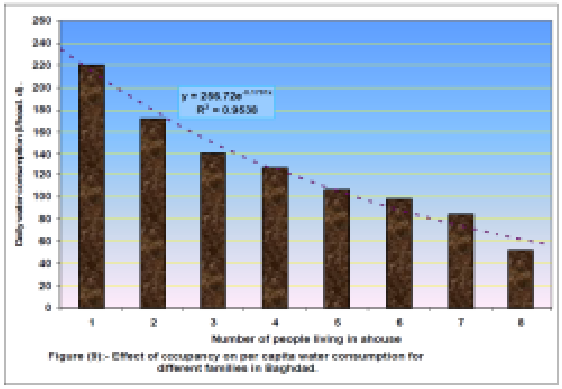


Figure (9):- Effect of occupancy on per capita water consumption for different families in Baghdad.

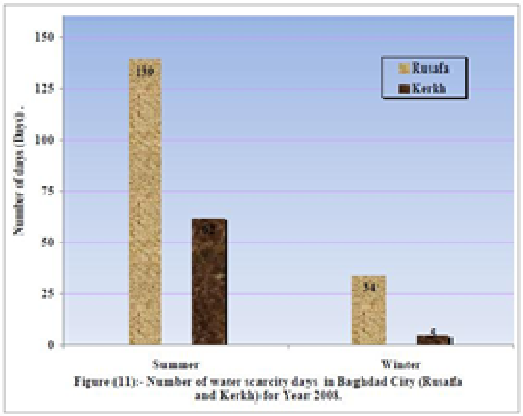


Figure (11):- Number of water scarcity days in Baghdad City (Rusafa and Kerkh)-for Year 2008.

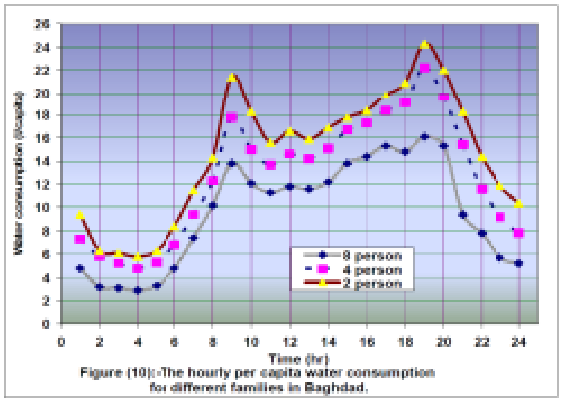


Figure (10):-The hourly per capita water consumption for different families in Baghdad.

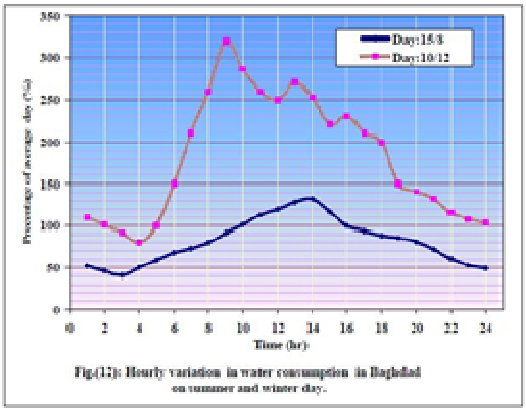


Fig.(12): Hourly variation in water consumption in Baghdad on summer and winter day.

3.3.2 Microbiological quality

The concentrations of human pathogen hazards in greywater vary over a wide range. In the worst cases, concentrations of faecal microorganisms are almost as high as those found in sewage. The reason for this variation is that pathogens depend on the behaviour of people living in or visiting the house, and the control of materials discharged into the greywater.

Microbiological quality depends on the amount of faecal material that enters greywater from activities such as washing nappies or other types of soiled clothing, and the health of the individual living in or visiting the house.

3.4 Greywater volume and source

Greywater generation will vary according to the water saving practices of each individual in the household. On average the volume of water use in the house per day in Baghdad is (**116 L/person/day)** . Approximately **71% (83 L/person/day)** of this water can be captured and recycled from the greywater. Bathroom greywater (bath, basin and shower) contributes approximately (**50%)** of the total greywater volume (**Figure(8))**. Bathroom greywater can be contaminated with hair, soaps, shampoos, hair dyes, toothpaste, lint, nutrients, body fats, oils and cleaning products. It may also contain some faecal contamination (and the associated pathogens) through body washing. Laundry greywater contributes approximately (**30%)** of total greywater volume . Wastewater from the laundry varies in quality from wash water to rinse water to second rinse water. Laundry greywater can be contaminated with lint, oils, grease, laundry detergents, chemicals, soaps, nutrients and other compounds. It may also contain some faecal contamination (and the associated pathogens) through washing contaminated clothes. Greywater generated from the laundry is often the easiest source of greywater to access although it is usually more contaminated than bathroom greywater.
Kitchen wastewater is sometimes considered as a greywater source. If a suitable treatment is not available, kitchen wastewater should not be used due to the amount of contaminants (food particles, oil, grease, etc.) it contains. Fortunately kitchen greywater contributes a relatively small portion of the total available greywater (15%); however, if additional water is needed, an appropriate greywater treatment system can be installed to recycle greywater from the kitchen also.

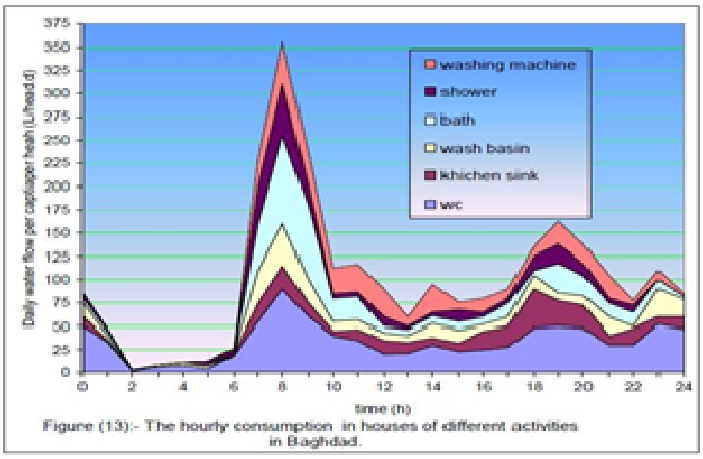


Figure (13):- The hourly consumption in houses of different activities in Baghdad.

3. 5 Public satisfactory

Public is generally a pre-requisite for reuse proposed projects. The results show that the percent of public accepting greywater reuse in Baghdad is far less than the percent of people opposing reuse. The Rusafa side of Baghdad city shows the percent of public accepting reuse is higher than those opposing reuse, while the Kerkh side of Baghdad city shows the percent of public accepting reuse is lower than those opposing reuse. Results indicate that the majority of people in Rusafa and Kerikh oppose greywater reuse projects mainly due to possible health effects, possible bad odors, possible religious concerns and the possibility of flies being present in the vicinity of proposed projects. Investigation of survey shows that the percent of public opposing greywater reuse proposed projects in Rusafa and kerkh are 26% and 39%, respectively because of Its possible effect on human health, 47% and 37%, respectively .Possible bad odors, 18%, and 24%, respectively .Due to religious concerns, 23% and 32, respectively .soil pollution, effects on plants and groundwater pollution, 9% and 5, respectively .The possibility of flies being present in the vicinity of these projects 3% and 2% ,respectively. In a previous study carried out in Baghdad city (questioners including academics, professors and engineers) (Dheyaa,2009), it was shown that 71.8% of people thought that greywater would pose health hazards, 28.2% thought that greywater reuse would not be economically feasible. On the other hand, significant percent of the public support greywater reuse proposed projects.
The reasons for accepting greywater reuse as stated by the public of Kerkh and Rusaifa, about 20% and

26%, respectively would accept reuse of greywater proposed projects because of their benefits in reducing demand on water sources, 25% and 17%, respectively think that greywater reuse may reduce water bills, 15% and 19%, respectively think that greywater reuse may reduce cost of cesspits, 34% and 36%, respectively think that greywater reuse may reduce pressure on wastewater treatment plants and 6% and 2%, respectively think that greywater reuse would increase family income.

Analysis of results of the public acceptance survey showed public reaction toward different uses for greywater . The analysis of results indicates that among the public surveyed in Rusafa and Kerkh, about 56% and 54%, respectively agree to use greywater for toilet flushing, 59%, and 61%, respectively agree to use greywater for irrigation, 65% and 68%, respectively would use greywater for car washing, 2% and 1%, respectively think that greywater can be used for potable purposes after proper treatment, and 7% and 9%, respectively for fire protection. The most acceptable greywater reuse option to the public was garden irrigation and the least acceptable reuse option was for potable purposes. These findings are consistent for Baghdad city , where 59.9% of the public accepted greywater reuse for irrigation , 55.9% for toilet flushing and 67.6% for car washing.

4-Discussion

Regardless of their gender and age, water quality is the most important aspect of water for the survey participants, and the availability of water without restriction is the least important aspect of water. Majority of the survey participants **(81%)** were aware that the region is confronting a severe water scarcity and about **(67%)** were affected by the scarcity in some way in their summer daily lives. In order to combat the water scarcity, they suggested to recycle more greywater at domestic level. People are conscious of the local water and other environmental issues and many of them are willing to do whatever they can possibly to improve the situation. The cost of plumbing and health risks to people, plants and soil are the two the important issues that need attention.When considering the different sources of greywater, the most common source of greywater for reuse was the wastewater from washing machines. The second most common source of greywater was from bathroom, but there is concern that this water may be a risk to human health if reused without proper treatment. The study indicated that some form of financial support and educational program from Iraq government will be valuable in achieving widespread reuse of greywater in Baghdad city especially in government building such as schools, universities, police stations…etc. In general, people are environmentally conscious and interested in saving water provided there is proper encouragement given by government, local councils and other authorities that regulate water supplies and use.This study was carried out to evaluate the potential of greywater generation in Baghdad city . The study employed a questionnaire in the form of a social survey which was administered to **575** households, covering **3218 people**. The study concluded that the average per capita water constitute **70.7 percent** of total water consumption, respectively. Analysis of greywater samples from the different sources in typical households in the city clearly indicated that greywater must be treated prior to reuse.

A survey of the public participating in the study was designed to gauge the public acceptance towards greywater reuse projects. among the public participating in the study in the Baghdad city , the percents of public accepting greywater reuse projects were higher than the percents of those opposing greywater reuse. Most of those opposing greywater reuse listed possible effects on human health, possible bad odors and religious concerns as reasons for their opposition. Most of the public accepting greywater reuse listed benefits in reducing demand on water sources, reduction in water bills and reduction in cost of cesspits as reasons for their acceptance. The most accepted greywater reuse options as stated by the public were toilet flushing, irrigation and car washing.

5- Conclusion

The major results can be summarized as follows:-

Ÿ The daily water consumption in Baghdad ranged from ***75 Lpcd to 176 Lpcd with an average of 116 Lpcd*** .

Ÿ The maximum daily consumption in Baghdad ranged from ***124 Lpcd to 327 Lpcd with an average of***

186 Lpcd .

Ÿ The maximum hourly consumption in Baghdad ranged from ***154 Lpcd to 900 Lpcd with an average of 308 Lpcd***.

Ÿ Greywater generation in Baghdad ranged from ***34 Lpcd to 139 Lpcd with an average of 68 Lpcd***, and that greywater generated constituted ***58% to 72%*** of total consumption.

Ÿ Not all participants for the survey questionnaire in different regions in Baghdad knew about greywater reuse.

Ÿ About ***67%*** of the participants are affected by the current water scarcity in some way.

The percents of public opposing greywater reuse proposed project in the two sides of Baghdad ,Rusafa and kerkh are ***26% and 39%***, respectively because of

Ä Its possible effect on human health, ***47% and 37%***, respectively.

Ä Possible bad odors, ***18%, and 24%***, respectively.

Ä Due to religious concerns, ***23% and 32***, respectively.

Ä Soil pollution, effects on plants and groundwater pollution, ***9% and 5%***, respectively .

The pomssibility of flies being present in the vicinity of these projects ***3% and 2%*** ,respectively.

6-References

Al-Jayyousi, O. 2003. Greywater Reuse: Towards Sustainable Water Management, *Desa lination* (156): 18 l-l 92..

American Public Health Association (APHA). 2005.Standard Methods for the Examination of Water and Wastewater, 19th Edition, Washington DC.

Dheyaa,W.A.(2009) Saving Water and Energy Consumption in Baghdad.

(2009), Baghdad,Water consumption problem in Baghdad symposium ,Baghdad government.

Erikkson, E., Auffarth, K., Henze, M. and Ledin, A. 2002. Characteristics of Grey Wastewater, *Ur ban Wa ter* (4): 85-104.

Jamrah, A., Al-Futaisi, A., Prathapar, S., Ahmed, M. and Al-Harrasi, A. 2008. Evaluating Greywater ReusePotential for Sustainable Water Resources Management in Oman,*Environmenta l Monitoring a nd Assessment*, In Press.

Nolde, E.1999. Greywater Reuse Systems for Toilet Flushing in Multi-storey Buildings – over Ten Years Experience in Berlin, *Urban Wa ter* (1): 275-284.

Ottoson, J. and Stenstrom, T. 2003. Faecal Contamination of Greywater and Associated Microbial, *Risks Wa ter Resea rch* (37): 645–655.

Prathapar, S., Jamrah, A., Ahmed, M., Al Adawi, S., Al Sidairi S. and Al Harassi, A. 2005. Overcoming Constraints in Treated Greywater Reuse in Oman,*Desa lination* (186): 177-186.

Table (1): Quantity of Pollutants Loading (minimum and maximum value) Measured in mg per liter for sixty one samples for period from August to December 2010.

Parameter	August	September	October	November	December
BOD5 (mg/l)	158-187	119-169	105-164	91-158	89-132
COD(mg/l)	287-390	267-313	123-240	144-180	156-230
p	8.6-9.5	7.7-7.9	7.9-8.3	7.6-8.2	7.4-7.8
Suspended Solid(mg/l)	88-137	42-76	37-65	36-45	39-76
Total Solid(mg/l)	345-546	322-418	296-396	287-354	234-344
Total Phosphorus(mg/l)	7	8	7-	9-	9
Presumptive Faecal	2.50E+05	8.00E+05	8.00E+03	6.00E+03	5.00E +03
Coliforms	0	0	0	0	0
Nitrate N(mg/l)	0.0	0	0.0	0.008	0
Nitrite N(mg/l)	2	3	3	2	2
Turbidity NTU	44-78	34-62	28-47	29-43	23-46
Lead(mg/l)	4	1	7	1	1
Zinc(mg/l)	6	7	4	5	8
Copper(mg/l)	9	1	10	1	1

Table (2): Relative Pollution of Grey water and Blackwater in the total wastewater (Black water + Grey water),(number of samples are 20 samples)

Waste water type	chemical oxygen demand COD	biochemical oxygen demand BOD_5	Nitrogen N	Phosphor P	Effluent Flow Rate Q
lack water	62%	42%	90%	48%	6%
Grey water	38%	58%	10%	52%	94%

Table (3): Quantity of Pollutants Loading (minimum and maximum value) Measured and Relative Pollution in Greywater and Blackwater(Twenty samples for period from August to December 2010)

Analysis	Greywater	Blackwater	Grey+Black	Grey water	Black
BOD_5 (mg/L)	179-213	141-167	320-380	56%	44 %
COD (mg/L)	196-232	294-348	490-580	40 %	60 %
Phos.(mg/L)	7-11	5-8	12-19	58 %	42 %
N (mg/L)	3-4	26-34	29-38	9 %	91 %
TSS (mg/L)	287-325	208-235	495-560	58 %	41 %
ent (L/d. per capita)	67-121	13-39	80-160	70%	30%

Table (4): Quantity of Pollutants Loading (minimum and maximum value) Measured in gram per day per capita for Twenty samples for period from August to December 2010.

Analysis	**Greywater**	**Blackwater**	**Grey+Black**
BOD_5 (g/d per capita)	**24-37**	**18-39**	**42-76**
COD (g/d per capita)	**49-57**	**67-81**	**115-128**
TSS. (g/d per capita)	**34-52**	**36-41**	**72-93**
Phos. (g/d per capita)	**2.3-3.2**	**1.5-1.8**	**3.8-5**

Appendix A

Proposed Project : Water conservation in Baghdad using treated gray water for irrigation

Public Questionnaire

This questionnaire is designed to gather all the information necessary for Greywater Recycling System for a specific application. Please complete this questionnaire to help us to find effective, feasible and applicable solution of water crises in Baghdad.

Application form No.:

Date: / / 2010

Name: _____Age: _____Gender _____

Address: _____

City: _____: _____ _____ _____

General Building Information:

Building type:_____Office _____Residential building __ University_____

Government building _____Hotel _____Other:_____

Number of floors: _____. Area of building : _____m^2 .

Number of people occupying the building: _____ Potable

water source: _____Public _ Private

Sewage disposal system: _____Public _____Private

Greywater Information:

Source of greywater:
_____L Showers
_____L , Bathtubs
_____ L , Lavatories
_____L , Laundries
_____L ,
_____L ,
evaporative cooling _____L.

If laundry is included, how many l washing machines?
_____water ,

Do you accept grey water reuse system in your house ? _____Yes , _____No

If No ,the reason for not reusing greywater is

Ÿ Don't know how. _____.

Ÿ Need information and assistance. _____

Ÿ The legal barriers ._____

Ÿ Not sure safe and need treatment_____

Ÿ water is salty and it contains chemicals_____

Ÿ Health or environmental concerns. _____

Ÿ Isn't worth the trouble_____

Ÿ not enough time _____
Ÿ not worth the cost _____
Ÿ Water not near use_____
Ÿ No use for water ._____
If greywater systems are proposed, are you opposing greywater reuse because of
Ÿ Its possible effect on human health._____
Ÿ Possible bad odors._____
Ÿ Due to religious concerns._____
Ÿ Soil pollution, effects on plants and groundwater pollution._____
Ÿ The possibility of flies._____
If greywater systems are proposed, are you accepting greywater reuse because of
ü Their benefits in reducing demand on water sources._____
ü Reduce water bills._____
ü Reduce cost of cesspits._____
ü Reduce pressure on wastewater treatment plants. _____
ü Increase family income._____
Do you agree to use greywater for
F Toilet flushing,_____
F Irrigation_____
F Car washing_____
F Potable purposes after proper treatment _____
F Fire protection. _____
Greywater Usage Information: Planned use for greywater: _____liter for Toilet flushing _____liter for Irrigation Total number of toilets: _____ Number of toilets per floor: _____
If irrigation is planned, what is the area of the green space to be watered? _____m^2
Additional Comments :