Yanbu Journal of Engineering and Science

Volume 20 | Issue 2 Article 1

2023

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Recommended Citation
Alghamdi, Ahmed A. (2023), Appraisal of community awareness of water conservation and the importance of greywater as one of the solutions to reduce water wastage in the Kingdom of Saudi Arabia, *Yanbu Journal of Engineering and Science*: Vol. 20: Iss. 2, 1-9.
DOI: https://doi.org/10.53370/001c.92148
Available at: https://yjes.researchcommons.org/yjes/vol20/iss2/1

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Alghamdi AA. Appraisal of community awareness of water conservation and the importance of greywater as one of the solutions to reduce water wastage in the Kingdom of Saudi Arabia. *YJES*. 2023;20(2):1-9. doi:10.53370/001c.92148

Research article

Appraisal of Community Awareness of Water Conservation and the Importance of Greywater as One of the Solutions to Reduce Water Wastage in the Kingdom of Saudi Arabia

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Keywords: Greywater, awareness, surveys, water conservation, Wastewater, Saudi Arabia citizens

https://doi.org/10.53370/001c.92148

Yanbu Journal of Engineering and Science

Vol. 20, Issue 2, 2023 Submitted: 27 JAN 2023 Revised: 28 MAR 2023 Accepted: 04 APR 2023

The Kingdom of Saudi Arabia depends mainly on desalinating seawater for its potable water needs due to the scarcity of natural water resources such as rainwater, rivers and lakes. With the high cost involved in the water desalination process and the state bearing a high percentage of these costs, it becomes a great necessity for the general community to be aware of the importance of water conservation. Reusing grey water in agriculture, industry, or even for potable water production has become an acceptable solution in many countries. Greywater reclamation and reuse have long been considered a favored strategy to overcome severe water scarcity in arid countries such as Saudi Arabia.

However, the success of greywater reuse is highly dependent on end users accepting its consumption. This study aims to measure Saudi society's awareness of the importance of water conservation and their knowledge and acceptance of the use of greywater. A comprehensive questionnaire was developed and distributed to 733 participants, of different age groups and qualifications, from different regions in the Kingdom of Saudi Arabia. The results reveal that there is a clear lack of knowledge about water scarcity in Saudi Arabia as well as the potential use of greywater among the participants. According to the results, the majority of participants welcome the use of greywater for domestic purposes if it is economical. Finally, the paper recommends that more efforts be made to create awareness about the importance of greywater in the country and water conservation. Due to the lack of detailed research on greywater reuse and the extent to which Saudi society accepts this idea, this research becomes relevant in the present context.

1. INTRODUCTION

The scarcity of water sources is construed as one of the serious challenges for many countries in the world today as well as in the near future. The depletion of some of their natural resources, including groundwater, low river water levels, and/or lack of rainwater lead to the shortage of water in many of the countries.[1] This paper engages with the issue of scarcity of water in The Kingdom of Saudi Arabia (KSA). KSA is one of the largest producers of desalinated water in the world and the country is expected to desalinate nearly 30 billion m^3/day of water in 2040.[2] It is one of the countries that depend on the desalination of seawater for essential uses of water for humans, animals, and vegetation. It has been reported that the KSA will face a serious challenge in water scarcity in the coming years. These shortages have many causes, including man-made, excessive consumption of raw water, population growth, and lack of rainfall in many areas. Therefore, the rapid population growth in the KSA requires the construction of more desalination plants to meet the current and future demands of water. This will cause an increase in financial investment for the construction of new desalination plants along with an increase in energy consumption and environmental pollution.[1] This paper explores the ways in which greywater could remedy the scarcity of water sources in the KSA.

Greywater is a type of domestic wastewater that is generated in households and office buildings. It is obtained from different streams such as sinks, showers, baths, washing machines, or dishwashers without contamination from the water from toilets. As greywater contains fewer pathogens than domestic wastewater, it is generally safer to handle and easier to treat and reuse onsite for toilet flushing, landscape or crop irrigation, and other non-potable uses.[3] The most commonly described application for greywater reuse is toilet/urinal flushing, which can reduce water demand by up to 30%. However, greywater has been considered for many other applications, including vehicle washing, fire protection, and boiler feed water.[4] Greywater reuse was studied by various groups recently in different localities.[5-7]

Table 1. Source of wastewater and its type[8]

No.	Source of wastewater	Types of Sources of wastewater	Quantity/day/person
1	Toilets	black water	3 L
2	Bathing	greywater	20-30 L
3	Kitchen	greywater	5-10 L
4	Washing Clothes	greywater	15-20 L
5	Animals	greywater	10-15 L

Water used in hand washing and bathing generates around 50-60% of total greywater and is considered to be the least contaminated type. Common chemical contaminants include soap, shampoo, hair dye, toothpaste, and cleaning products. It also has some facial contamination (and the associated bacteria and viruses) through body washing.[8] According to state and local authorities, 140 liters of water per day is consumed by one person for cleaning and washing - greywater. Table 1 lists each greywater source's expected volume in liters.

Greywater is proven to be the less polluted water compared to domestic wastewater It was previously reported that approximately one-third of the total household water consumption can be reduced by reusing greywater for flushing purposes.[9] A research project funded by the International Development Research Center (IDRC) – was carried out by the Royal Scientific Society of Jordan (RSS) with the aim of investigating the feasibility of adopting innovative unconventional wastewater management policies for small communities in the country. A major activity of the project was to develop some effective wastewater treatment and recovery methods for greywater use in agriculture.[10]

Recently the focus on the reuse of sewage effluent has increased significantly. At the end of 1991, an environmental and process audit of the major sewerage treatment plant in the Australian Capital Territory recommended encouraging and developing the reuse of sewage effluent.[11] Another study also investigated the socio-demographic variables influencing public perceptions of reusing grey and mixed wastewater for non-domestic uses (Nuhu el al., 2020). Data were collected from 624 households in the Dammam Metropolitan Area, Saudi Arabia, using a structured questionnaire. The data were analyzed using descriptive and inferential statistics. The results from logistic regression indicate that the likelihood of a household to accept reusing treated mixed wastewater is influenced by gender with an odds ratio (OR) of 2.71–2.18, residential location (OR = 1.32–1.03), age (OR = 1.22–0.18) and educational level (OR = 1.33–0.98), with a tendency for more acceptance of treated grey wastewater than mixed wastewater.[12] Nowadays, very few reuse guidelines are particularly made for greywater recycling. The World Health Organization (WHO) is currently in a process of revising the last edition of its guidelines for reclaimed water reuse, and will in the future includes guidelines for grey water reuse.[13,14]

The Kingdom of Saudi Arabia faces severe water problems, and at the same time needs new water policies to achieve sustainable development in its harsh environment.[1] A study was conducted with the intention of assessing the degree of people's acceptance of greywater reuse in Saudi Arabia.[15] There were reports on the reuse of wastewater in Saudi Arabia recently mainly focusing on city or neighborhoods in a city[12,16,17]

This paper focuses on measuring societal awareness of greywater reuse and the extent of comprehension of the danger of the increase in per capita consumption in Saudi Arabia, which may result in a huge economic burden on the government. This research also concentrates on measuring the extent of society's acceptance of greywater recycling and its use domestically or in public places. Due to the lack of published research related to measuring awareness and knowledge among Saudi citizens, this research paper contributes to guiding government agencies for future water scarcity planning. All developmental projects and greywater reuse would not be successful without the participation of all layers of people in society.

2. METHODOLOGY

In this study, a questionnaire was distributed to different regions of the Kingdom and to participants with different age groups and qualifications. The research was focused on two categories:

A. Measuring societal awareness of the importance of water conservation and the extent of understanding of the Kingdom's efforts to confront water scarcity in the future.

B. Measuring the community's awareness of the concept of greywater and its ability as one of the solutions to reduce the wastage of water in daily uses.

A total of 733 participants from different cities in the Kingdom participated in answering the questionnaire, as shown in Table 2. It is important to note that the questionnaire was sent via an electronic link to all participants. This is because an online survey could give easy access to participants and allow them to respond in a timely fashion. All responses were collected and analyzed through the same link. The results of the survey are presented in the following sections.

3. RESULTS AND DISCUSSION

A comprehensive questionnaire was prepared to identify the awareness and behavior of the participants within the objectives of the first category of this research, measuring societal awareness of the importance of water conservation

Table 2. Study participants (gender - age - education level - region)

Gender	Male	702	95.80%		
	Female	31	4.20%		
Age					
65 >	56-65	46-55	36-45	26-35	15-25
69	130	208	192	113	21
9.40%	17.70%	28.4%	26.2%	15.40%	2.90%
Education Level					
PhD & MSc	Bachelor	≥ high school education			
163	409	161			
Region					
Central Region	Western Region	Eastern Region	Southern Region		
184	166	214	169		

and the extent of understanding of the Kingdom's efforts to meet water scarcity in the future. Accordingly, these questions have been classified into:

1. Measuring the awareness of citizens of the importance of rationalizing water, the danger of facing the threat of water scarcity, and the construction of desalination plants on the environment:

As shown in Figure 1, 53% have expressed their concern and awareness of the importance of water conservation; the danger of not rationalizing water consumption; and future challenges in the event of an increase in the number of desalination plants on the environment, economic cost, or environmental pollution. The results also showed that 26% of the participants expressed that they often care about these issues and have awareness. On the other hand, 16% of the participants responded that they do not have the knowledge about the aforementioned facts or even understanding and awareness, and 5% showed a lack of interest or even keenness.

2. Measuring citizen's awareness of the challenges facing the Kingdom and the efforts it is making in providing drinking water, and whether there is a media failure to educate citizens:

As shown in Figure 2, the results showed that it is clear that 41% of the participants have knowledge of the Kingdom's efforts, planning and the challenges it faces. They also believe that there is a media failure in educating the community about the importance of this national issue. On the other hand, 28% of the participants believe that they have some interest and knowledge and believe that the role of the media is still minor and weak. 23% showed their lack of knowledge and awareness of the matter, and 8% of the participants were not interested and did not show any importance to the matter.

3. Knowing the water consumption, if it is within its normal limits. Knowing the cost of water consumption on a monthly basis by individuals and families:

Figure 3 shows that 33% of the participants confrmed their follow-up to their monthly consumption of water as well as the cost of the monthly bill. They are also keen to share with their family members and inform them about it so that they feel the importance of rationalizing water and thus the value of the bill. They also see that their monthly consumption of water is within normal limits. On the other hand, 29% indicated that, to a lesser extent, they monitor their monthly consumption and the value of their bills, and that their families do not show high interest in water conservation or even the cost of the monthly bill. It is also clear from the aforementioned figure that 29% do not know the amount of their consumption or even their monthly bill, while 12% of the participants said that they are not interested and do not have any concerns.

4. USING TECHNOLOGY TO RATIONALIZE WATER CONSUMPTION

Figure 4 showed the results of the following theme: the use of the best modern water conservation methods such as installing a water flow regulator in bathrooms, kitchens, and homes with gardens. Participants' responses showed that 33% confirmed that they installed these guides in an intermittent or non-permanent manner to reduce water consumption in their homes. It was also found that 25% of the participants stated that they install these guides from time to time to reduce water consumption. Moreover, the results also showed that 25% of the participants do not use any guides in their homes or on a rare or permanent basis, while 17% of the participants showed a lack of interest in such an issue.

As mentioned earlier, the second category of this research is to measure the community's awareness of the concept of greywater and its ability as one of the solutions to reduce water wastage in daily use. It also measures the acceptance of such a method by the community. From this standpoint, four questions were used to draw the participants' views. These questions were categorized under four axes:

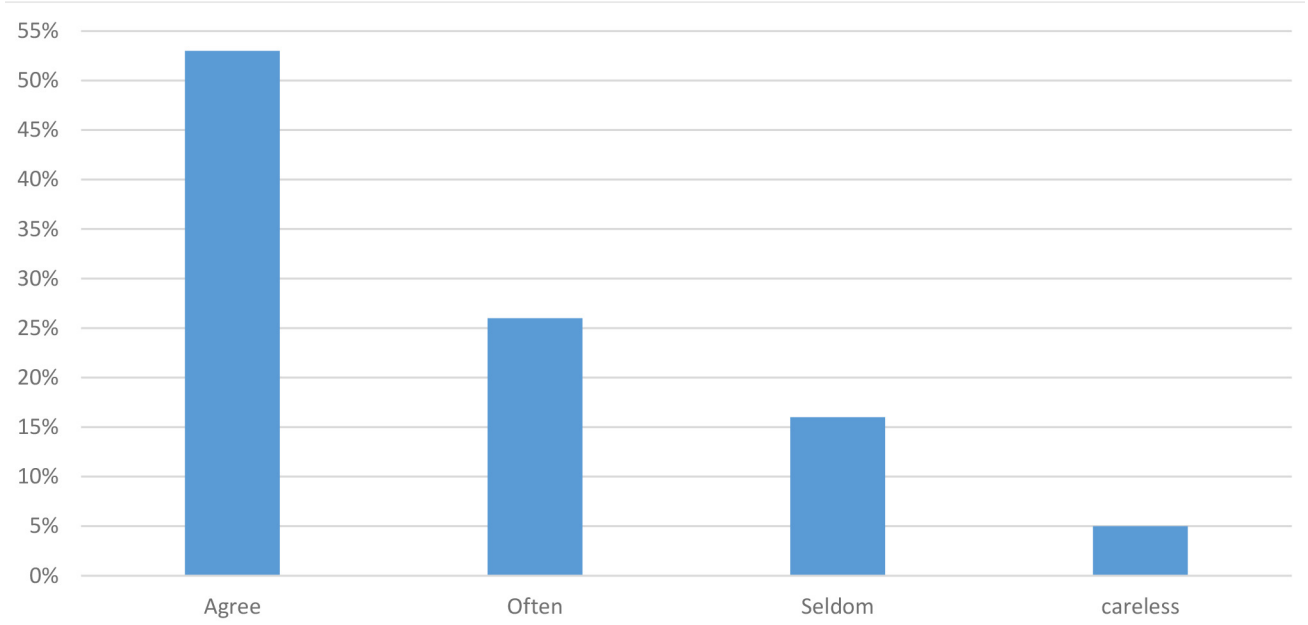

Fig. 1. Measuring the awareness of citizens of the importance of rationalizing water

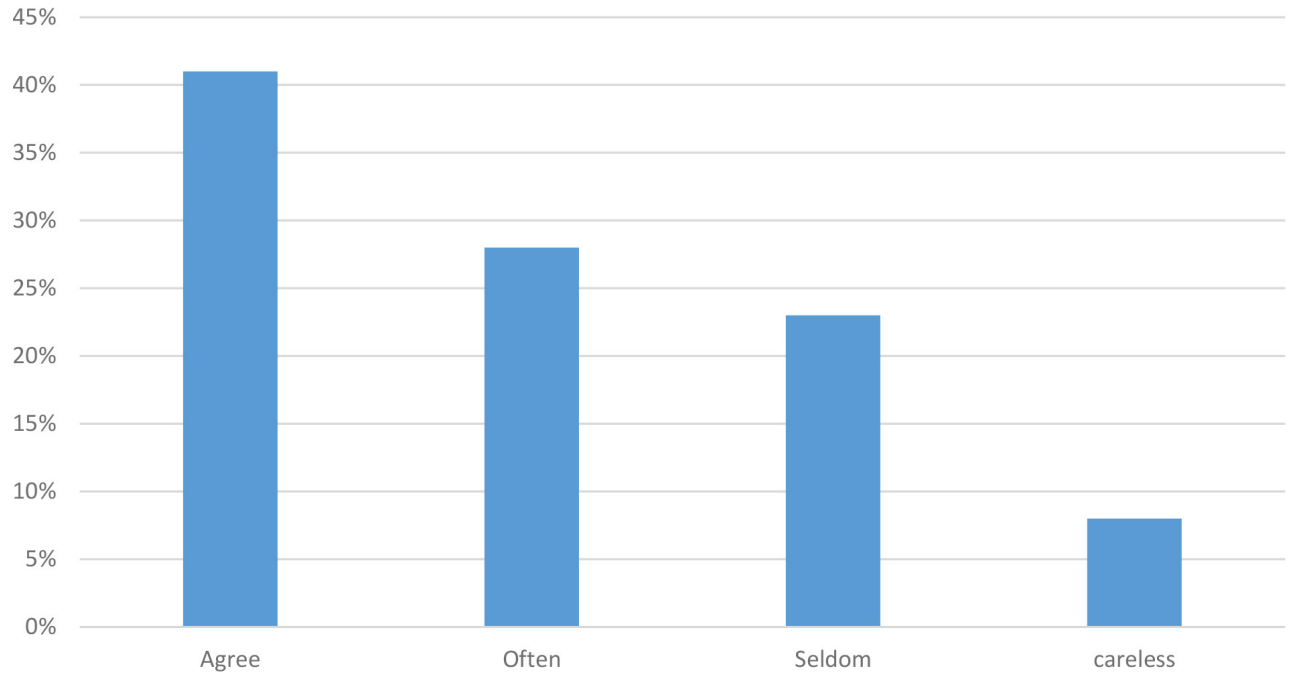

Fig. 2. Measuring citizens' awareness of the challenges facing the Kingdom and the efforts it is making in providing drinking water

1. What grey and black water are, their sources, and the percentage of greywater to the total water consumed?

Figure 5 below captures the extent of weakness in the segment of participants in knowing what grey or black water is and its sources. It also shows the percentage of greywater represented in the total water consumed. The findings show that those who said that they often have this knowledge, but to a lesser extent, constitute 6% of the participants. On the other hand, the percentage of those who do not have any knowledge about greywater reached 35%. Also, 51% of the participants expressed their lack of interest or concern about what greywater is.

2. Measuring the knowledge of the participants about the experiences of countries in reusing greywater and its importance in terms of rationalizing consumption, saving energy, and financial cost.

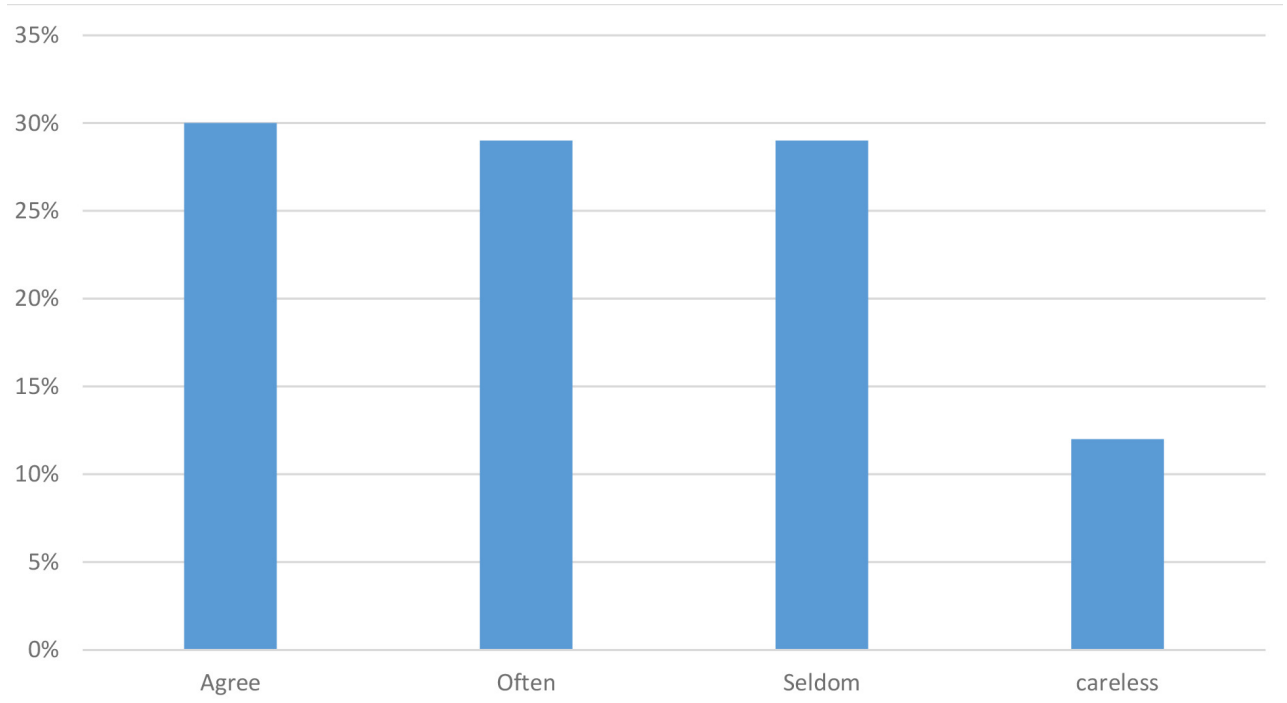

Fig. 3. Knowing the water consumption, if it is within its normal limits. Knowing the cost of water consumption on a monthly basis by individuals and families

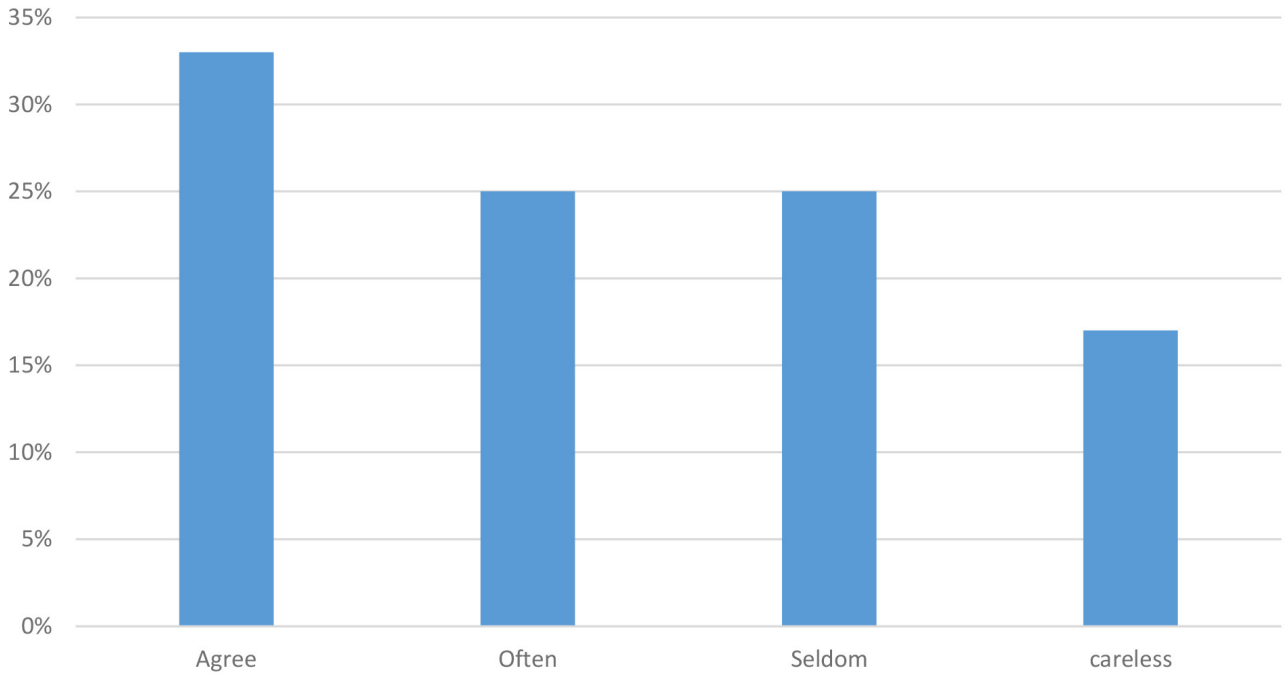

Fig. 4. Using technology to rationalize water consumption.

As shown in Figure 6, a small percentage of participants, 7%, confirmed their knowledge of the importance of greywater recycling alongside its benefits in rationalizing water and energy consumption. While 8% of the participants stated that they have interest and knowledge, the percentage of those who confirmed that they do not have that knowledge and awareness of the importance of recycling greywater was 38%. It was also found that the largest segment of the participants, 47%, have no interest in this issue.

3. Approval of a new design system in homes to separate greywater from wastewater when building houses in the future, even if there is an additional financial cost to be borne by the homeowner.

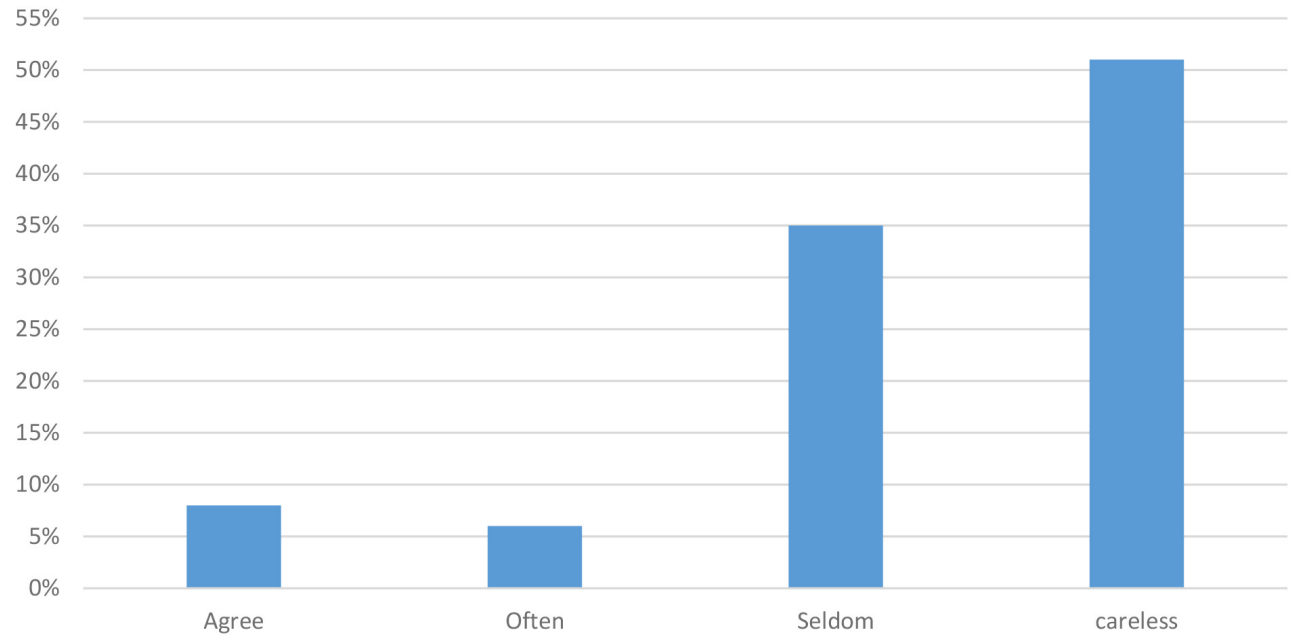

Fig. 5. What grey and black water are, their sources, and the percentage of greywater to the total water consumed.

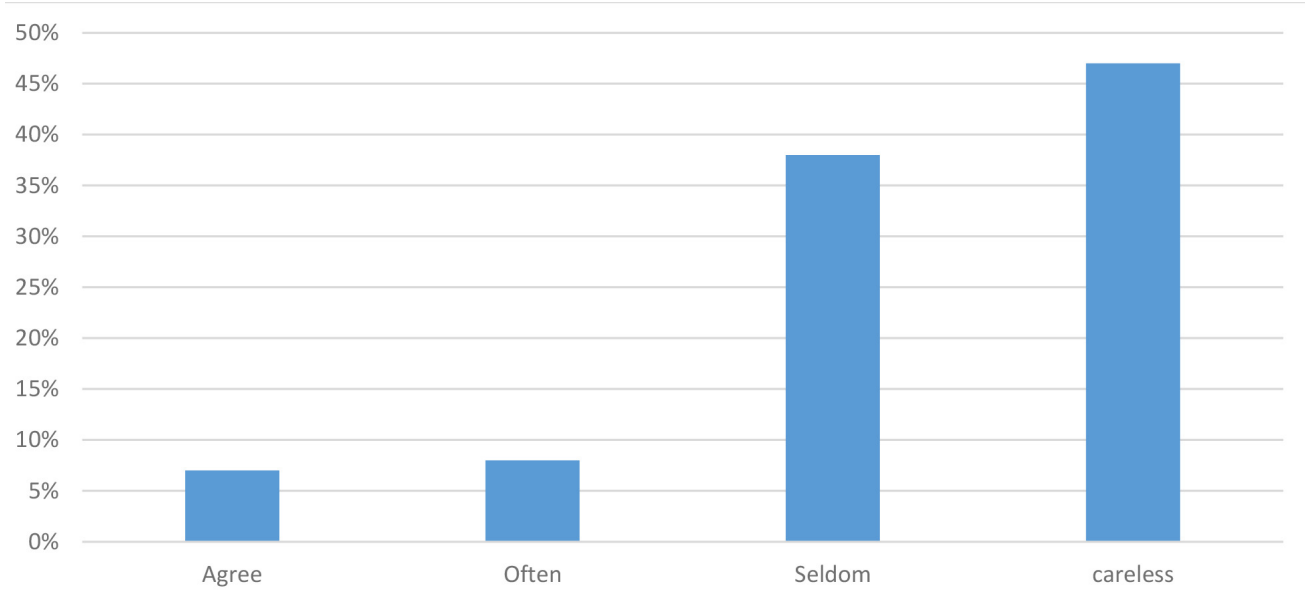

Fig. 6. Measuring the knowledge of the participants about the experiences of countries in reusing grey water and its importance

The majority of respondents (47%) agreed that they do not mind having a new design that helps separate greywater from wastewater. Even if there is a financial cost that may reach 20,000 SR (6000 $), as long as this will help save water and can be used in toilets, bathrooms, or home garden irrigation, for example. About 16% said that they would most likely agree, but without incurring any financial costs. The findings also show that 15% of the participants were against the existence of such a design and 27% expressed their lack of interest in such modifications.

4. Reasons that prevent people from agreeing to the presence of a greywater separation system at home.

Figure 8 shows 38% of the participants refuse or reserve the existence of a new engineering design for separating greywater from wastewater due to a financial cost borne by the owner of the house. Also, 37% of the participants rejected the idea due to their fear of the presence of unpleasant odors or diseases that may be caused by this system. While those who believe that there is no need for the presence of this design constitute 14%, around 11% believe that

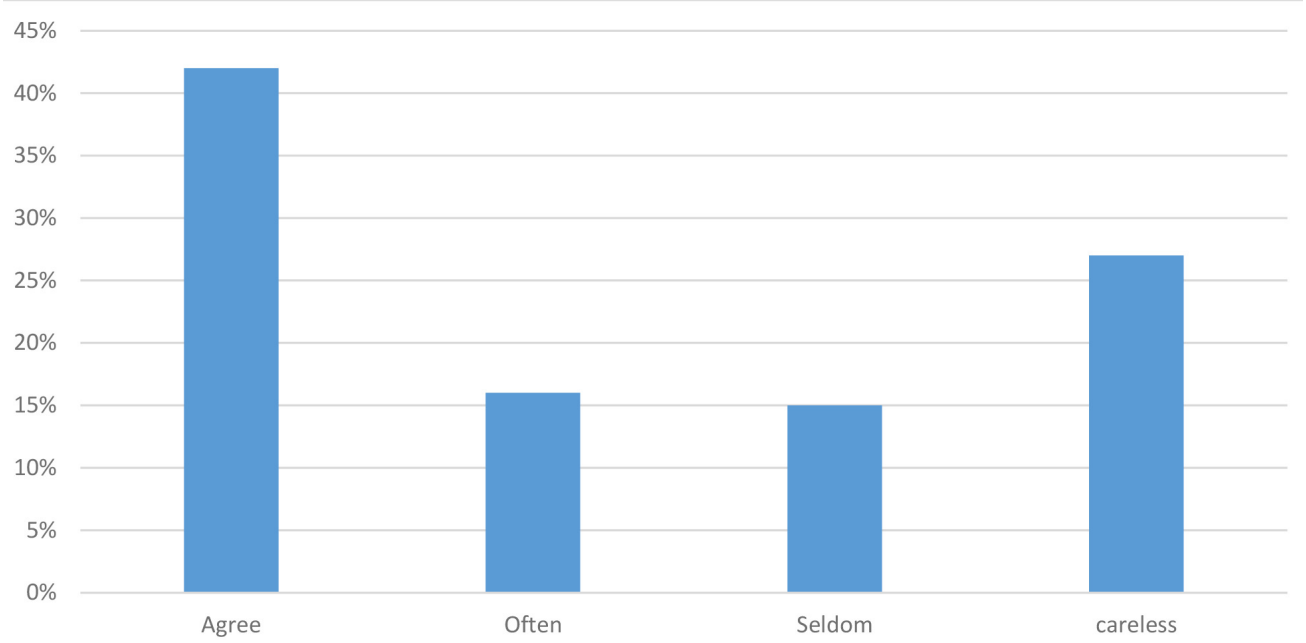

Fig. 7. Approval of a new design system in homes to separate greywater from wastewater when building houses in the future

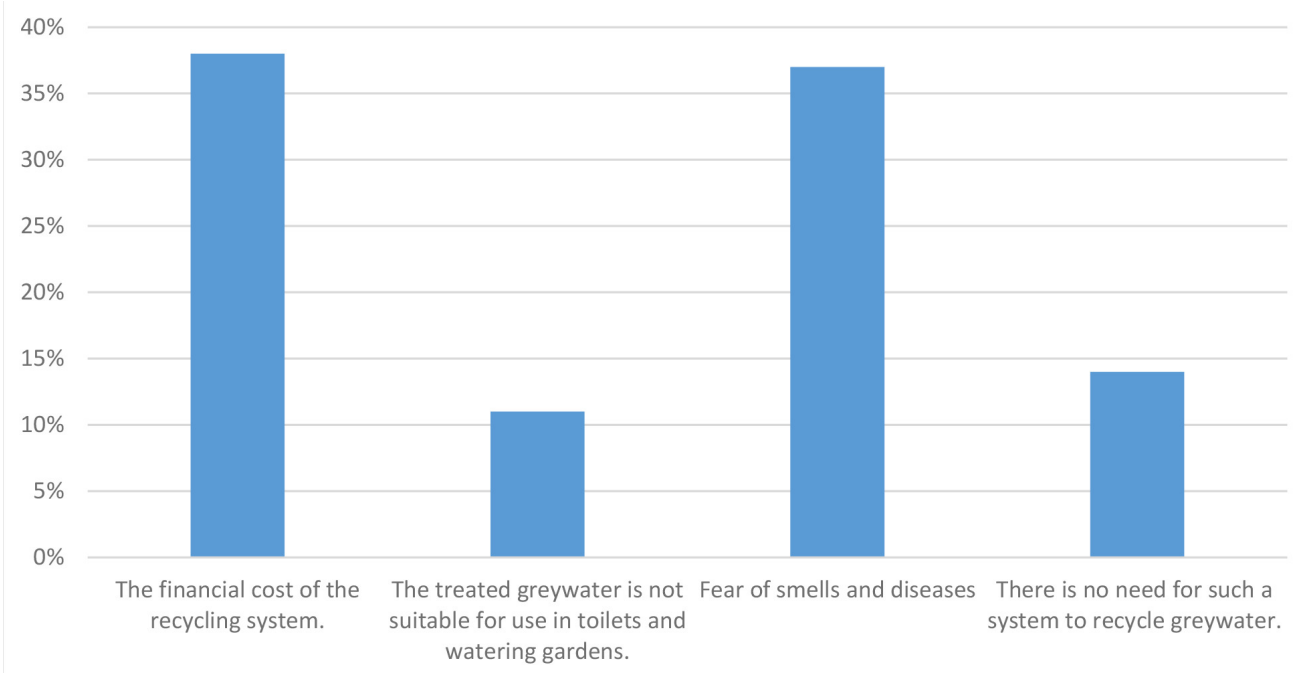

Fig. 8. Reasons that prevent you from agreeing to the presence of a grey water separation system in your home

the treated greywater is not suitable for use in toilets and watering the gardens.

5. Relation between the level of education and the extent of awareness of the importance of water conservation

The questionnaire also examines the relationship between awareness of the importance of water conservation and participants' level of education. Surprisingly, results showed, as in Figure 9, that there is no link between the level of education and awareness of the importance of water and its rationalization. The awareness rate of the participants who hold Ph.D. and M. Sc. degrees is about 21%. In contrast, it was found that the awareness rate of the participants who hold a bachelor's degree is 55%. The awareness rate of the participants who have a secondary certificate is 24%, which is higher than those holding Ph.D. & M. Sc degrees.

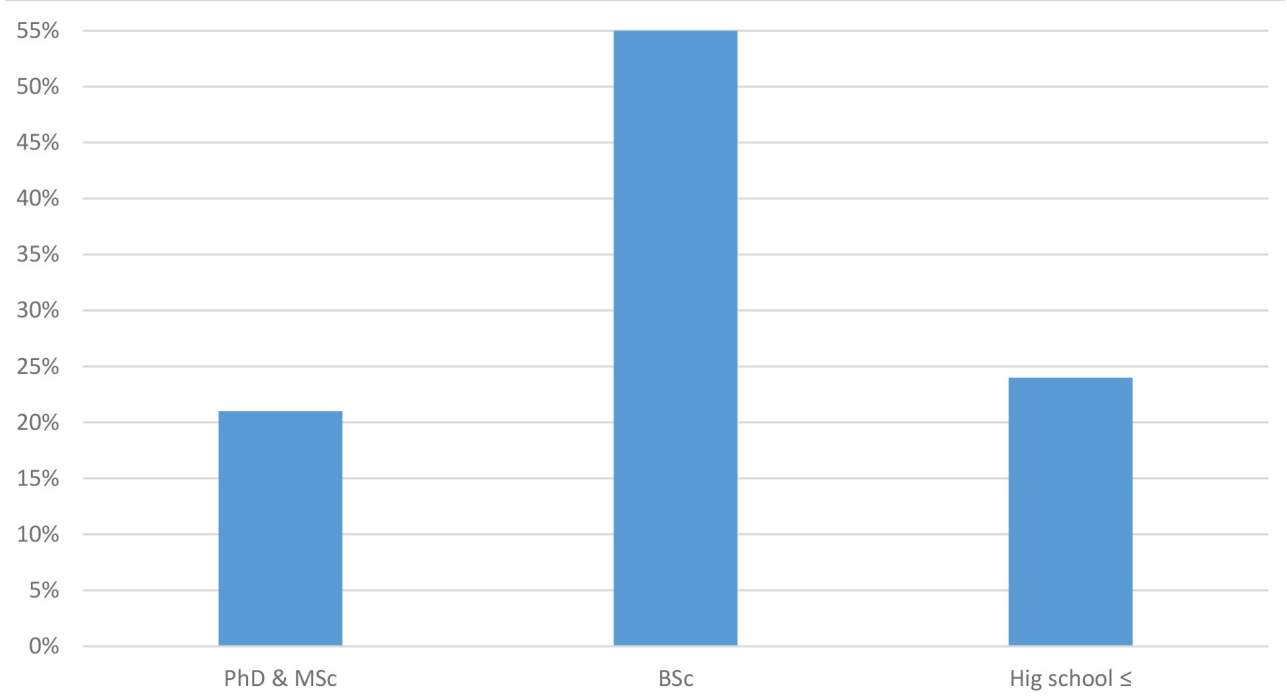

Fig. 9. Relation between level of education and the extent of awareness of the importance of water conservation

5. CONCLUSIONS AND RECOMMENDATIONS

Through the responses of the participants from a survey conducted in the Kingdom of Saudi Arabia, it becomes clear that there is a need to increase society's awareness and participation in the importance of conserving water and reducing its consumption. This could be realized by reducing the use of traditional methods and increasing the use of technology and modern methods that contribute to rationalizing water, especially in a desert country that has minimal water resources. This study shows the absence of the role of family members in contributing to water conservation. This might be due to the lifestyle and structure of Saudi families in which a father usually takes care of all the financial expenses and he does not share them with others. The study also showed that there is a significant number of participants who do not know about greywater and its uses as a solution to rationalize and reduce water wastage. It is important to raise the awareness of the participants about such an issue. This is because with the introduction of value-added taxes on wastewater treatment by the Saudi government the water bill is no longer the same as before. Overall, the results of this study can be summarized in several points:

- 63% of Saudi families do not know how much the monthly consumption of water is and have no interest in knowing.
- 49% of the participants are not interested in expanding the construction of desalination plants and what may cause environmental pollution (this is not clear).
- 50% of the participants in this research welcomed the use of new engineering designs in homes that can separate grey water from wastewater. On the other hand, about 58% refused to pay any financial fees for any engineering design that contributes to separating grey water from wastewater.
- None of the participants reused greywater in their houses.
- 80% of the participants do not know what greywater is.

Based on the results of this study, the following recommendation are put forward:

- It is imperative to raise the awareness of the Saudi community about the importance of water conservation through awareness campaigns, water conservation programs, programs in various media outlets, regular seminars, and lectures.
- New houses during construction should be required to build a greywater reuse system by the law.
- It is important to apply the installation and design of the greywater separation system, as a first initiative, in markets, car washing shops, hotels, and mosques.

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