

Public Perception of Water Conservation, Reclamation and Greywater Use in the United Arab Emirates

Munjed A. Maraqa^{1 +} and Kilani Ghoudi²

¹ Department of Civil and Environmental Engineering, UAE University, Al Ain, United Arab Emirates

² Department of Statistics, UAE University, Al Ain, United Arab Emirates

Abstract. The United Arab Emirates (UAE) lies in a region with an extremely high baseline water stress. Efforts to reduce water consumption in the country are greatly needed. One way to do so is by expanding the usefulness of treated sewage effluent and by reusing greywater. However, public support is considered a major hurdle in the implementation of water reuse initiatives. Without effective public participation in the process, development and adoption of strategies pertinent to water reuse may not succeed. In this study, a public survey (n= 1079) was conducted to ascertain the views of UAE nationals regarding water availability and their acceptance of water reuse. The survey form was formulated based on the stated preference approach. Results show that the majority of respondents believe there may be a water shortage in the country in future. There is also a strong believe for a need to conserve water by both reducing tap water consumption and improving awareness. A large fraction of respondents are comfortable to use treated sewage effluent for outdoor activities that do not involve physical contact. However, less than half of the respondents are willing to consider using a greywater system at their home, with the main motivation to do so would be to save water resources. Positive perceptions of using greywater appear to be inversely associated with the level of physical contact, with car wash and toilet flushing ranked the highest, while the use of greywater for washing clothes or for bathing/showering ranked the least preferred option.

Keywords: water reuse, public survey, water management.

1. Introduction

Substantial economic and population expansion in the UAE have caused a dramatic increase in water consumption despite the low natural availability of water in the country. Usage of water on a per capita basis in the country is among the highest in the world. For example, water consumption in Abu Dhabi Emirate ranges from 170 to 200 Lpcd in flats and from 270 to 1,760 Lpcd in villas [1]. The World Resources Institute classified the UAE as a country with an extremely high baseline water stress [2]. Water resources in the country are anticipated to be more stressed in future due to substantial economic and population expansion coupled with desert greening and agricultural activities. To meet its water demand, the UAE is heavily relying on the production of desalinated water nowadays, with lesser dependence on the rapidly-depleted groundwater. The desalination capacity in the UAE in 2010 was the highest in the Gulf Cooperation Countries at 1776 million m³/year [3].

To overcome some of the encountered challenges in meeting the country's water demand, the Abu Dhabi Urban Planning Council [4] recommended undertaking an audit of all possible water resources. Recycling and reuse of treated wastewater or greywater is considered a potential alternative in the absence of substantial surface water supplies and limited rainfall in the country. Several studies showed that reuse of alternative water resources is a viable solution for water demand reduction in water scarce countries [5], [6].

⁺ Corresponding author.
E-mail address: m.maraqa@uaeu.ac.ae

The water policy in the UAE has been largely based on increasing supply rather than managing demand. Efforts to reduce water consumption in the country are greatly needed not only to save resources, but also to reduce pressure on treatment plants and reduce the associated environmental impacts. However, the ability of gaining public support for any water reuse initiative is a critical aspect for success. Without effective public participation in the process, development and adoption of strategies pertinent to water reuse may not succeed. The purpose of this study was to explore public acceptance of water reuse in the UAE.

2. Methodology

The UAE consists of 7 emirates: Abu Dhabi, Dubai, Sharjah, Ajman, Fujairah, Ras Al Khaima, and Umm Al Qaiwain. The country is characterized by a tropical dry weather, with relatively high temperatures throughout the year, especially in summer. The estimated population of the UAE in 2013 was about 6.3 million, with almost 40% of the population is located in the Emirate of Abu Dhabi [7]. Meanwhile, a large fraction of the residents (75%) are expatriates [8]. Thus, the UAE nationals are estimated to be between 2-3 million. The country is considered one of the richest in the world with a gross domestic product (GDP) of US \$375 billion [7].

In order to assess public perception towards some water management aspects, a preliminary survey form was distributed to a limited number of UAE residents to assure the questions are understandable and free of technical jargons. Based on this, the survey form was modified and was then distributed to a statistically sufficient number of residents. Forms were collected during the period of 2011-2015. Equation (1) gives the minimum number of survey forms that are required for a given confidence level with a normal distribution response of a large population size [9].

$$N = (z^2 s^2) / e^2 \quad (1)$$

where, N is the minimum sample size; z is the z-value of a given confidence level (for 95% confidence level it is 1.96); s is the coefficient of variation (assumed as 0.5) and e is the tolerance level (assumed as 5%). Based on Eq. (1), the minimum sample size was found to be 384. A total of 1079 filled survey forms were collected from all emirates in the UAE, which far exceeds the minimum number required to achieve a 95% confidence level. Form distribution was carried out using a paper-administered method. The survey targeted only UAE nationals who are 18 years or older.

The survey form consisted of four sections. A copy of the form is shown in the Appendix. Section 1 consisted of demographical questions that were used to analyze population sub - groups for attitudinal effects related to residence location, age, and education. Section 2 consisted of questions intended to gauge public perception of overall freshwater resource availability and questions investigating attitudes towards water conservation. Section 3 included questions to ascertain respondent attitude towards recycling treated sewage effluent (TSE) including the risk and benefits of reuse of TSE. Finally, section 4 included questions pertinent to respondent knowledge about greywater, its possible utilization and the factors that would persuade him/her to use greywater.

About 52% of the respondents are from Abu Dhabi Emirate, 13% from Sharjah, 12% from Ras Al Khaima, and the remaining (23%) are from the other four emirates. Almost two-thirds of the respondents are 18 to 25 years old and the second largest group (21%) are 26 to 35 years old. Meanwhile, most of the respondents are educated, with 66% of them have a university degree and 32% completed secondary school.

The form was formulated based on the stated preference approach. In most of the survey questions, respondents were asked to choose one answer from a given list. In other questions, respondents were requested to choose all applicable answers from a given list (questions 10 and 18). In the analysis of the results of the former set of questions, the answers were expressed as a percentage of the total number of respondents who responded to that question. However, in the analysis of the second set of questions, the answers were expressed as a percentage of the total number of responses, which could exceed the sample size. The survey form was furnished in both Arabic and English languages. A platform was developed to ease the entry of data into a spread sheet. Survey results were analyzed using summaries of descriptive statistics.

3. Results

3.1. Perception towards water availability and conservation

When asked if there may be a water shortage in the UAE in future, about 76% answered “Yes”. This percentage is higher than that reported by Wait [10], who found that only 55% of respondents with a Middle East background residing in the UAE (including UAE nationals) expressed concern about the potential of water shortage in the country. Regarding the availability of fresh water in the country, about half of the respondents believe it is scarce, while 35% of the respondents indicated that fresh water is abundantly available, and about 17% selected neither. Again, Wait [10] found a higher percentage of respondents viewing the availability of fresh water in the UAE as either abundant or not scarce. Respondents, who view the availability of fresh water in the country as not scarce, lack awareness and are probably confused with the daily availability of desalinated water. Nonetheless, when asked if there is a need for water conservation, 92% of the respondents answered “Yes”. Respondents were further asked about how to conserve water. The two most selected options were to reduce consumption of tap water and to improve awareness (see Fig. 1), while the least selected option was to increase water price.

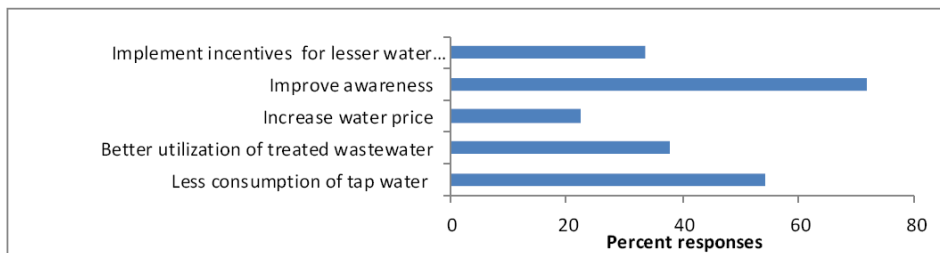


Fig. 1. Options for water conservation

Obviously, respondents do not prefer an increase in water price as a mean for conservation. But increasing water price could lead to conservation. In a previous study [10], 43% of the respondents indicated that they would reduce the amount of water consumed if the water price is doubled. Recently, Abu Dhabi Emirate reduced its subsidies on water by increasing the price of municipal water. The action was taken to encourage residents to use tap water more judiciously and reduce per capita water consumption. However, the price of municipal water remains heavily - subsidized for UAE nationals.

3.2. Perception towards reuse of TSE

TSE is used in the UAE mainly for irrigating amenity areas. It covers about 9% of the total water supply [11]. However, not all TSE is used due to insufficient capacity of the distribution system after treatment. For example, in Abu Dhabi Emirate about 450 million m³/year of TSE is produced, of which about 60% is reused and the rest is discharged into the Arabian Gulf or the desert [12].

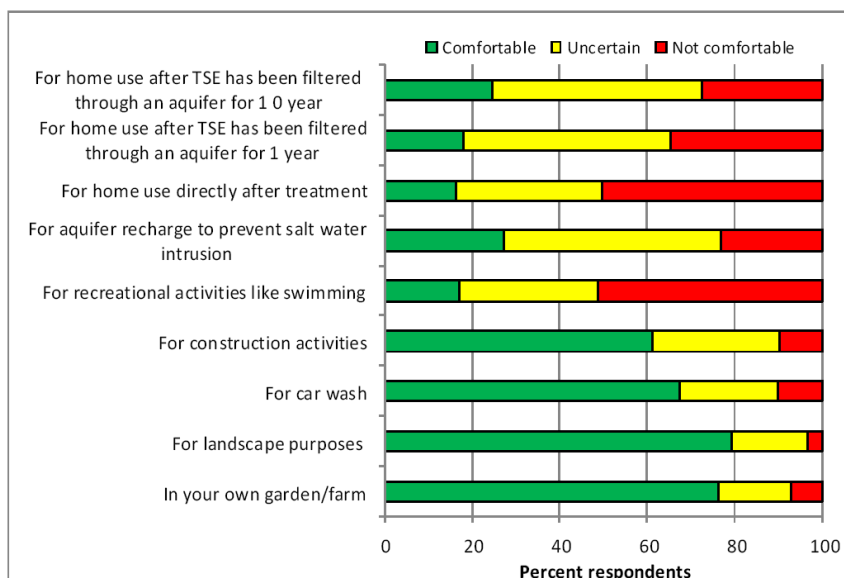


Fig. 2. Response for using TSE for different purposes.

Our survey showed that about 76% of the respondents heard about recycled TSE before taking the survey. As shown in Fig. 2 the level of comfort of using TSE for different purposes varies. Respondents are generally comfortable to use TSE for outdoor activities that do not involve physical contact including gardening, landscaping, car wash, and construction purposes. However, they are uncertain or not comfortable to use TSE for recreational activities or for activities inside the house.

Respondents generally believe that there are benefits of using certified, safe TSE. On a scale from 0 to 10, where 0 indicates not beneficial and 10 indicates extremely beneficial, the average score by all respondents was 6.5 (± 2.2). Nonetheless, respondents believe that there is a moderate risk of using TSE with an average score of 5.3 (± 2.0) on a scale of 10. A moderate risk perception contradicts the fact that respondents have been informed that the water is safe to use, indicating that perception could become more important than reality in adopting reuse of TSE in the UAE. This challenge has been recognized by the World Health Organization [13], which noticed that judgment of an acceptable level of risk in some circumstances is a matter in which society as a whole has a role to play. Meanwhile, the International Water Association [14] indicated that standards should be based on the protection of health and public acceptability.

3.3. Perception towards greywater use

Greywater is untreated residential wastewater that has not come into contact with sewage [15], and typically excludes kitchen wastewater. Greywater is about 50-80% of household generated wastewater [16]. Several countries have incentive programs for installation of greywater systems (see [16] and references cited therein), but such attention has not yet been recognized in the UAE.

In this study, about 70% of the respondents did not hear about greywater before taking the survey. When asked if they would consider using a greywater system at their home, 44% answered “Yes”, 25% answered “No”, and 31% didn’t know. Respondents were then asked about the main reason that motivates them to use a greywater system at home. About 44% of the respondents indicated that it would be done to save water resources (Fig. 3). Other reasons include the possibility of a cost benefit (18%), if it is mandatory (16%), or to reduce generated wastewater (10%). However, about 12% of the respondents indicated that nothing could be done to pursue them to use greywater at home.

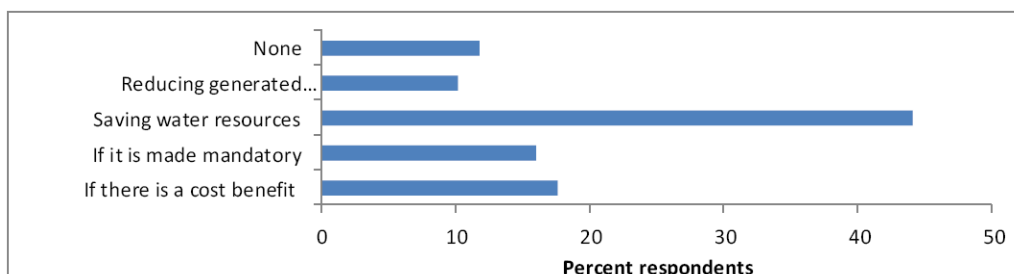


Fig. 3. Reasons to use greywater at home.

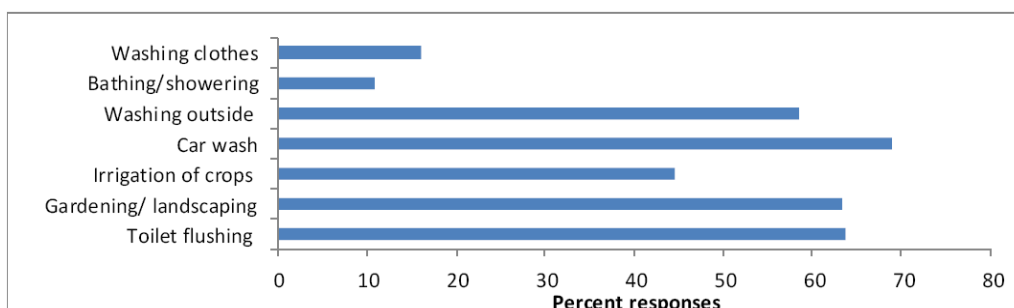


Fig. 4. Acceptable usage of greywater.

Respondents were further asked to select the acceptable usage of greywater from a given list. The highest ranked usage was for car wash, followed by toilet flushing, gardening/landscaping, and washing outside (see Fig. 4). On the other hand, the least acceptable greywater usage is for washing clothes or for bathing/showering. Our results are in agreement with those of Brown and Davies [17]. These authors conducted a study on community receptivity to greywater reuse in northern Sydney, Australia. They found

that positive perceptions were directly the inverse of the level of physical contact with the water, with higher receptivity of using water for toilet flushing than for washing clothes. Several other studies have also shown that health/safety risk is the key factor for the lack of public acceptance of greywater reuse [18], [19]. Others, on the other hand, have indicated that water scarcity is the main determinant of willingness to use greywater [20]. March et al. [21] concluded that social acceptance on the use of greywater can be obtained by raising public awareness.

4. Conclusion

Based on the results of this study it is concluded that the majority of UAE nationals believe there may be a water shortage in the country in future. There is also a strong believe for a need to conserve water by both reducing tap water consumption and improving awareness, but increasing water price was not preferred by many respondents as a mean for water conservation. The level of comfort of using treated sewage effluent for different purposes varies among UAE nationals, but a large fraction are comfortable to use it for outdoor activities that do not involve physical contact such as gardening, landscaping, car wash, and construction activities. However, respondents are generally uncertain or not comfortable to use treated sewage effluent for recreational activities or for activities inside the house. Meanwhile, less than 50% of the UAE nationals are willing to consider using a greywater system at their home, with the main motivation to do so would be to save water resources. Positive perceptions of using greywater appear to be inversely associated with the level of physical contact, with car wash and toilet flushing ranked the highest preferred option, while using greywater for washing clothes or for bathing/showering ranked the least.

5. Acknowledgments

The authors are thankful to the 2011-2015 students in the Water and Wastewater Technology class at the UAEU who collected many of the survey forms.

6. Appendix

A copy of the used survey form is shown below.

Public Survey of Water Management in the UAE: Conservation, Reclamation, and Greywater Use

We would like to know your views about some water management approaches that could be adopted in the UAE, including water conservation, reclamation and greywater use.

Please note that this survey is solely intended for educational and research purposes.

1.	In which emirate do you live? <input type="checkbox"/> Abu Dhabi <input type="checkbox"/> Dubai <input type="checkbox"/> Sharjah <input type="checkbox"/> Ajman <input type="checkbox"/> Umm Al Qaiwain <input type="checkbox"/> Fujaira <input type="checkbox"/> Ras AlKhaima
2.	What is your age group? <input type="checkbox"/> 18-25 <input type="checkbox"/> 26-35 <input type="checkbox"/> 36-45 <input type="checkbox"/> 46-55 <input type="checkbox"/> 56 or older
3.	Nationality: <input type="checkbox"/> National of UAE <input type="checkbox"/> Expatriate (please specify) _____
4.	If you are not a national of the UAE, how long have you been living in the UAE? <input type="checkbox"/> Less than one year <input type="checkbox"/> 1-2 years <input type="checkbox"/> 3-4 years <input type="checkbox"/> More than 5 years
5.	Please mark the highest level of education you have received <input type="checkbox"/> No school <input type="checkbox"/> Primary school <input type="checkbox"/> Secondary school <input type="checkbox"/> University degree
6.	Do you pay for municipal water at your residence? <input type="checkbox"/> Yes <input type="checkbox"/> No
7.	Do you think in the future there may be a water shortage in the UAE? <input type="checkbox"/> Yes <input type="checkbox"/> No
8.	How would you classify the availability of fresh water in the UAE? <input type="checkbox"/> Abundant <input type="checkbox"/> Scarce <input type="checkbox"/> Neither
9.	Do you think there is a need to conserve water usage in the UAE? <input type="checkbox"/> Yes <input type="checkbox"/> No
<i>If your answer to Question 9 is "Yes", then please answer Question 10. Otherwise, skip Question 10.</i>	
10.	In your opinion, which of the followings would be preferred to adopt for water conservation in the

7. References

- [1] Environment Agency-Abu Dhabi. *Abu Dhabi Water Resources Master Plan*. Environment Agency, Abu Dhabi, UAE, 2009.
- [2] F. Gassert, M. Luck, M. Landis, P. Reig, and T. Shiao. *Aqueduct Global Maps 2.1: Constructing Decision-Relevant Global Water Risk Indicators*. Water Resources Institute, 2015.
- [3] M. A. Dawoud and M. M. Al Mulla. Environmental impacts of seawater desalination: Arabian Gulf case study. *Int'l J. Environ. Sustain.*, 2012, **1**: 22-37.
- [4] Abu Dhabi Urban Planning Council. *Al Ain 2030 Urban Structure Framework Plan*. Abu Dhabi Urban Planning Council, UAE, 2009.
- [5] R. K. Chowdhury. Potable water saving by reusing greywater in the Al Ain city. *The 11th IWA Conference on Small Water and Wastewater Systems and Sludge Management*, Harbin, China, 2013.
- [6] B. S. McIntosh, S. Aryal, S. Ashbolt, F. Sheldon, S. Maheepala, T. Gardner, R. Chowdhury, R. Gardiner, M. Hartcher, D. Pagendam, G. Hodgson, M. Hodgen, and L. Pelzer. *Urbanisation and Stormwater Management in South East Queensland – Synthesis and Recommendations*. Urban Water Security Research Alliance, Technical Report No. 106, CSIRO, Australia, 2013.
- [7] UAE Year Book (2013). <http://www.uaeyearbook.com>
- [8] M. A. Maraqa and A. M. O. Mohamed. Key drivers for successful safety management system of construction activities in Abu Dhabi Emirate. *Int. J. Adv. Fire Explosive Environ. Safety Disaster Manage.* 2013, **1**: 1-17.
- [9] R. P. Roses, E. S. Prassas, and W. R. McShane. *Traffic Engineering*. 3rd ed., Pearson Education Inc., New Jersey, 2004.
- [10] I. Wait. Changing perceptions: Water quality and demand in the United Arab Emirates. *13th IWRA World Water Congress*, Montpellier, France, 2008.
- [11] M. M. Al Mulla. UAE state of the water report. In *Proc. the Second Arab Water Forum*, Cairo, Egypt, 2011.
- [12] M. A. Dawoud, O. M. Sallam and M. A. Abdelfattah. Treated wastewater management and reuse in arid regions: Abu Dhabi case study. *The 10th Gulf Water Conference*, Doha, Qatar, 2012.
- [13] WHO. *Guidelines for Drinking-water Quality*. 3rd ed., vol. 1, World Health Organization, Geneva, 2004.
- [14] IWA. *The Bonn Charter for Safe Drinking Water*. IWA, London, 2004.
- [15] WHO. *Overview of Greywater Management: Health Considerations*. World Health Organization, Regional Office for the Eastern Mediterranean, Center for Environmental Health Activities, Amman, 2006.
- [16] L. Allen, J. Christian-Smith, and M. Palaniappan. *Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management*. Pacific Institute, 2010.
- [17] R. R. Brown and P. Davies. Understanding community receptivity to water re-use: Ku-ring-gai Council case study. *Water Sci. Technol.* 2007, **55**: 283-290.
- [18] A. Jamrah, A. Al-Futaisi, S. Prathapar, and A. Al Harrasi. Evaluating greywater reuse potential for sustainable water resources management in Oman. *Environ. Monit. Assess.* 2008, **137**: 315-327.
- [19] L. Domenech and D. Sauri. Socio-technical transitions in water scarcity contexts: Public acceptance of greywater reuse technologies in the Metropolitan Area of Barcelona. *Resour. Conserv. Recy.* 2010, **55**: 53-62.
- [20] O. A. Al-Mashaqbeh, A. M. Ghrair, and S. B. Megdal. Grey water reuse for agricultural purposes in the Jordan Valley: Household survey results in Deir Alla. *Water* 2012, **4**: 580-596.
- [21] J. G. March, M. Gual, and F. Orozco. Experiences on greywater re-use for toilet flushing in a hotel (Mallorca Island, Spain). *Desalination* 2004, **164**: 241-247.