



Public attitude for acceptance of grey water reuse in Istanbul and the impact of informing potential consumers

M.N. Taher*, J. Awayes, S. Cavkas, B. Beler-Baykal

Department of Environmental Engineering, Istanbul Technical University, 34469 Ayazaga, Istanbul, Turkey, emails: mustafan@gmail.com (M.N. Taher), jafar.awayes@gmail.com (J. Awayes), simaycavkas@yahoo.com (S. Cavkas), baykalb@itu.edu.tr (B. Beler-Baykal)

Received 1 April 2019; Accepted 29 September 2019

ABSTRACT

Utilization of grey water as an alternative source of water is a recent useful option to serve environmental sustainability, especially in water stressed and water scarce areas. Public acceptance is one of the key determinants of the success of grey water reuse. Surveys were conducted in the Turkish megacity Istanbul to investigate awareness and attitude of the public, and the impact of supplying information upon acceptance of grey water reuse. The major focus of the paper is placed on sources of grey water, possible final uses and economic considerations. The results revealed that the reuse of grey water as flush water was accepted the most with 79% which increased to 92%. The highest impact upon positive opinion was with acceptance on the reuse of grey water from washing machines with 93% change in approval after supplying information. The results reveal that informing public and awareness raising regarding grey water and its management are major factors for improving the level of acceptance.

Keywords: Grey water management; Reuse; Public opinion/acceptance; Public surveys; Sustainability

1. Introduction

Water is one of the critical elements that maintains and sustains the life of mankind. However, it faces the risk of pollution and running out. Integrating wastewater into water management and reclamation can be utilized as a possible tool to combat with water stress and scarcity. Water quality and scarcity are considered as major issues of our time that is impacted by the dramatic increase of world population which is estimated to reach 9.0 billion by 2050 [1]. The increasing concern about these issues obligates both academicians and the public sector to find alternative resources that could alleviate water scarcity and deterioration of quality.

Segregation of domestic wastewater at the source is one of the best options for recycling and reuse of valuable materials embedded in domestic wastewater. Grey water is

the stream which will result from such segregation regardless of the type of separation used either two components or three components. Containing all but toilet wastewater, grey water will consist of wastewater from different washing functions in the households such as bath tubs, showers, wash basins, laundries, kitchen sinks and dishwashers. Grey water constitutes 75% by volume and can cover the entire flush water demand typically making up 25% of daily domestic water use, in addition to various other end uses. As it contains lesser amounts of pollutants, 3% nitrogen, 10% phosphorus and around 40% organic matter in conventional domestic wastewater, reclamation and reuse of this renewable alternative source presents an obvious benefit [2]. Recycling greywater can help mitigate the increasing demand for pristine water from natural resources. Although different types of grey water may show a variability in terms

* Corresponding author.

of constituents [3], non-potable reuse of greywater has been commonly recognized for various end uses including toilet flushing, municipal uses such as firefighting and street cleaning, landscaping, irrigation, etc. [4–12] in various locations of the world.

Although treating grey water for reuse as an alternative water source to almost any high-quality demanding end use is technically possible, positive public opinion and acceptance by consumers is one of the key elements in the success for full-scale practice [13]. Furthermore, positive opinion and acceptance necessitates awareness in the subject matter and must be based on sound information about grey water and its management.

Papers devoted to public acceptance surveys focusing wastewater reclamation and reuse were mainly conducted to assess opinion regarding the reuse of conventional domestic wastewater, however without stream segregation [14–16]. Although work upon technical and even economic aspects of grey water reclamation and reuse exist in appreciable numbers, papers devoted to upon public opinion are very limited [13,17].

This work was undertaken to investigate awareness and attitude of the public towards reusing grey water for various end uses with specific emphasis on the impact of supplying information upon acceptance. The paper will report the results of the survey conducted in the Turkish megacity Istanbul, focusing on present awareness and willingness of participants to use reclaimed grey water along with changes in their perception and level of acceptance after being informed about the subject matter. The major focus of the paper is placed on sources of grey water, possible final uses and economic considerations.

2. Materials and methods

This preliminary survey of 30 questions was run in Istanbul, Turkey, with 227 participants on a face to face basis to be able to supply information and to directly answer any questions that they may pose. The survey was directed toward assessing the opinion of participants about their present awareness regarding recycling/reuse of grey water, their willingness to install grey water separation systems and the acceptance of using treated grey water in

their daily life. The major focus of the paper is placed on sources of grey water, possible final uses, and economic considerations. In addition to the six questions of demographic nature, questions were directed towards their former awareness regarding grey water and its management, their willingness to pay extra for grey water separation systems, their acceptance toward sources of grey water from households and final end uses related to household use, agricultural irrigation of food stuff, industrial plants, and irrigation of green areas.

After finishing the entire questionnaire, participants were supplied with a standard piece of information on grey water about origin and contents of grey water, its impact on the environment and that in developed countries reclaimed grey water is used as a safe source of water which meets the health and safety standards. 17 of the questions were repeated for the second time to assess the effect of supplying information. Meanwhile, questions from the participants were answered.

The assessment was mainly based on counts and percentages of possible choices. Changes in attitudes were calculated based on the difference between counts of selected choices as indicated in the first (before) and the second (after) runs.

3. Results and discussion

Table 1 summarizing the demographic data indicates that out of 227 participants, 46% was female and 54% was male. The majority of the survey sample was from young population with ages below 34 years with 76%. 91% of the participants were people who received a university degree or equivalent and about 3% who were still working to get a university degree. The highest ranked occupation was engineering with 33%, followed by educational professionals, self-employed and administrative staff. Occupations with less than 5% were classified as other. Most of the participants with 93% live in urban areas, while only 7% live in rural areas and 46% of the entire participants have a connection to rural life. Hence the sample was mainly young people with high education levels living in urban areas.

To start with, participants were asked to rank their awareness regarding the reuse of the wastewater on a scale from

Table 1
Demographic data of the survey sample

| Demographic data | No. | % | Demographic data | No. | % | Demographic data | No. | % |
|--------------------------|-----|----|-----------------------|-----|----|--------------------------|-----|----|
| Gender | | | Educational level | | | Connection to rural area | | |
| Female | 104 | 46 | Less than high school | 3 | 1 | Yes | 104 | 46 |
| Male | 123 | 54 | High school | 18 | 8 | No | 123 | 54 |
| Occupation | | | 2-years degree | | | Age | | |
| Engineering | 75 | 33 | Undergraduate | 145 | 64 | <18 | 11 | 5 |
| Educational professional | 43 | 19 | Master | 36 | 16 | 18–24 | 93 | 41 |
| Owner/self-employed | 30 | 13 | PhD | 14 | 6 | 25–34 | 68 | 30 |
| Administrative work | | | Urban/rural | | | 35–54 | | |
| Other | 57 | 25 | Urban area | 211 | 93 | >55 | 10 | 4 |
| | | | Rural area | 16 | 7 | | | |

1 to 5. 19% were not familiar at all to the reuse of wastewater, and the majority was moderately familiar with a typical scale of 3.

Fig. 1 presents awareness about water-related terms, which revealed that the participants were familiar with the terms potable water and wastewater by 88% and 90%, respectively, however, recognized the term non-potable water with a smaller percentage. Regarding grey water, 47% never heard of this term before and 24% heard about it but they were not sure of the meaning indicating that there is a lack of knowledge about this segregated wastewater stream and its reuse as an alternative water source.

The results regarding acceptance towards using reclaimed grey water are presented in Figs. 2–4 and the changes in attitude after being informed are shown in Table 2.

The participants were asked about their opinion regarding segregation and reuse of grey water focusing upon the use of two simultaneous water supply streams (potable and non-potable water), possible benefits of reuse of grey water, and its impact upon the environment and water resources, both before and after sharing information. Fig. 2 shows that providing information improved public opinion by 21%–28%. Table 2 shows further that providing information increased acceptances between 33% and 61%.

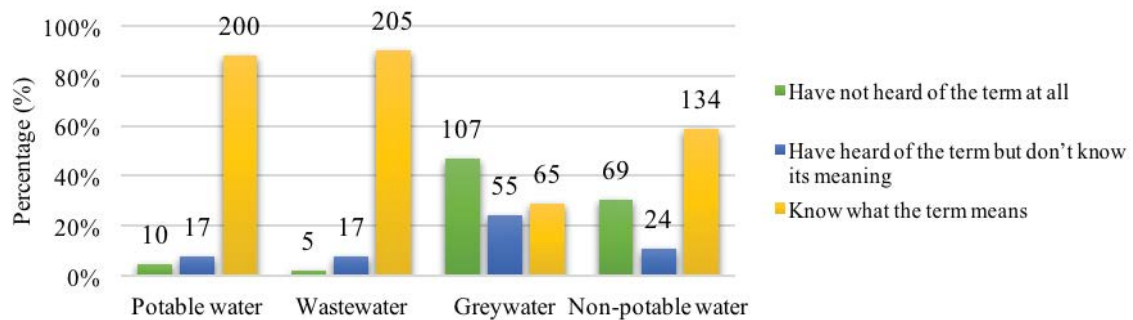


Fig. 1. Awareness regarding water-related terms.

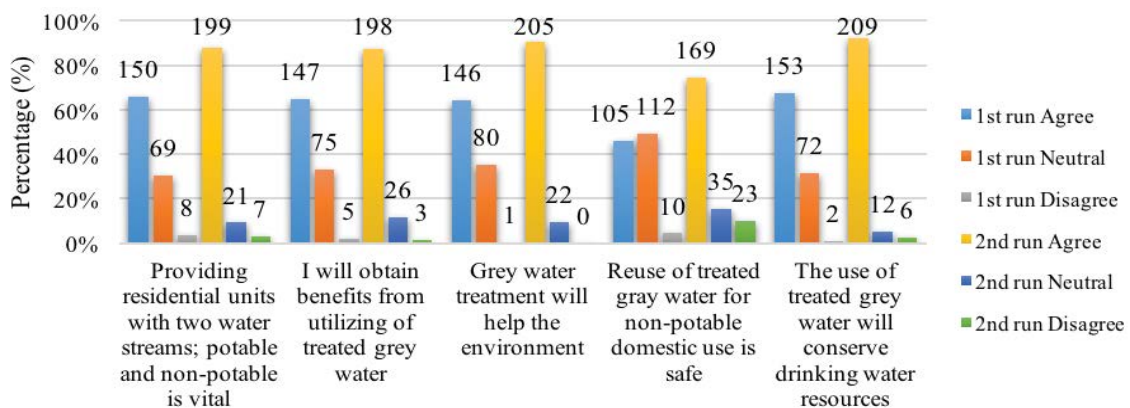


Fig. 2. Opinion about grey water and reuse.

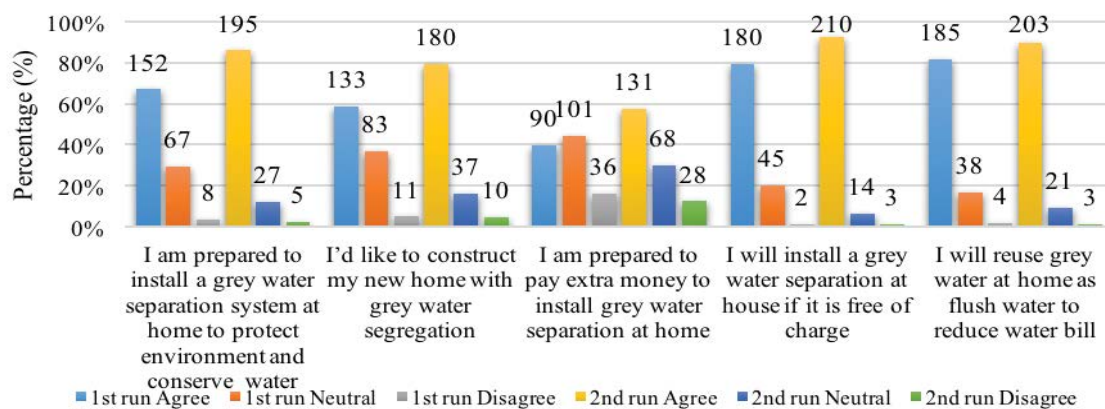


Fig. 3. Willingness to pay for installing grey water separation systems.

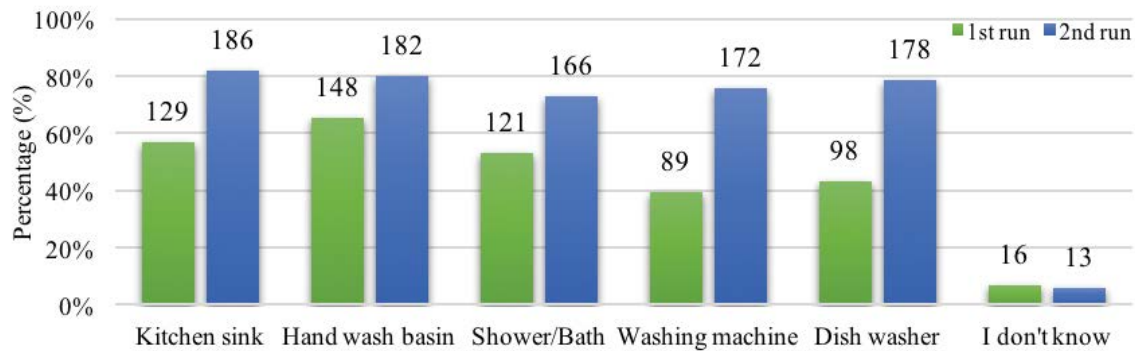


Fig. 4. Sources of greywater for reuse in households.

Table 2
Acceptances and changes in attitudes of participants on the use of reclaimed grey water in their daily lives

| Option | Before information | After Information | % increase | |
|---|---|-------------------|------------|------|
| Opinion about grey water and reuse | Providing residential units with two water streams potable and non-potable is vital | 150 | 199 | 32.7 |
| | I will obtain benefits from utilizing of treated grey water | 147 | 198 | 34.7 |
| | Grey water treatment will help the environment | 146 | 205 | 40.4 |
| | Reuse of treated grey water for non-potable domestic use is safe | 105 | 169 | 61 |
| | The use of treated grey water will conserve drinking water resources | 153 | 209 | 36.6 |
| Willingness to pay for installing grey water separation systems | I am prepared to install a grey water separation system in my home, to protect environment and conserve water | 152 | 195 | 28.3 |
| | I'd like to construct my new home with a grey water segregation | 133 | 180 | 35.3 |
| | I am prepared to pay extra money to install grey water separation at home | 90 | 131 | 45.6 |
| | I will install a grey water separation system in my house if it is free of charge | 180 | 210 | 16.7 |
| | I will reuse grey water at home as flush water to reduce water bill | 185 | 203 | 9.7 |
| Sources of grey water for reuse in household | Kitchen sink | 129 | 186 | 44.2 |
| | Hand wash basin | 148 | 182 | 23 |
| | Shower/Bath | 121 | 166 | 37.2 |
| | Washing machine | 89 | 172 | 93.3 |
| | Dish washer | 98 | 178 | 81.6 |

Fig. 3 presents the willingness of participants regarding the installation of grey water separation systems at their homes. Before sharing information, 67% of the participants said they would like to install this system to protect the environment while about 50% of the participants said they would like to construct their new homes with a gray water separation system. The percentages increased to 86% and 79% after supplying information. Fig. 3 shows further that economics is an important aspect in terms of acceptance, as the survey has shown that the percentage of agreement

increased by almost two-fold, from 40% to 79%, if it was offered for free. Table 2 indicates acceptances increased up to 46%. It is also to be noted that since the installation free of charge originally received a high percentage, the increase in acceptance raised only by 17% although 210 out of 227 indicated approvals.

Regarding acceptance towards different origins of grey water, at least one of the grey water sources was accepted by a large majority of participants to be reused in households with a range of 39%–65% and 73%–82% before and after

sharing information respectively, as shown in Fig. 4. Table 2 reveals that the highest impact of supplying information was observed in this group where the acceptance raised to 93% for reuse from washing machine and 83% for dish washers. Where to reuse grey water is a critical matter, and it depends on the willingness and perception of the users. Figs. 5–8 present acceptances of using treated grey water in household applications, agricultural and landscape irrigation, and for industrial plants/products, both before and after providing information and Table 3 summarizes the impact of supplying information.

Toilet flushing ranked the highest before and after sharing information receiving the highest acceptance in all with 79% and 92% respectively among choices shown in Fig. 5, and washing cars ranked the second. Although Table 3 indicates that the increase in acceptance for toilet flushing was about 17%, it is to be noted that this practice was accepted even before supplying information by 179 out of 227 participants and increased to 209 participants, which corresponds to 92%, after being informed. The reuse of grey water in swimming pools was the choice which was least accepted by 22% of the participants, and about 42%

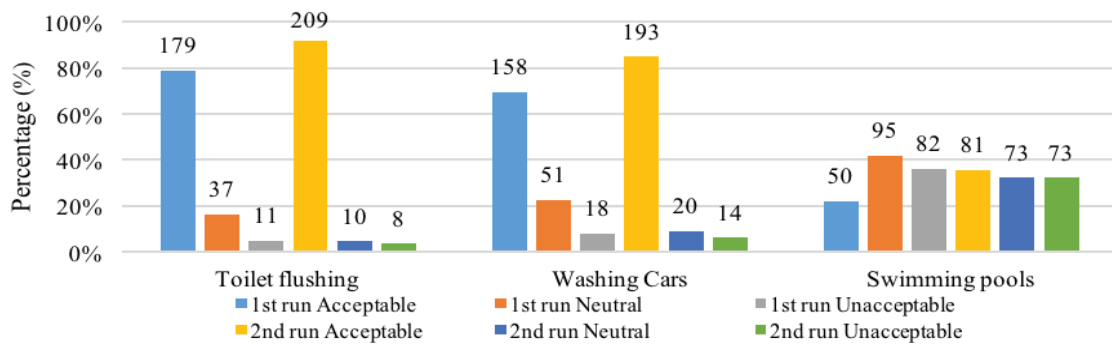


Fig. 5. Impact of supplying information on the acceptance of using treated grey water in household applications.

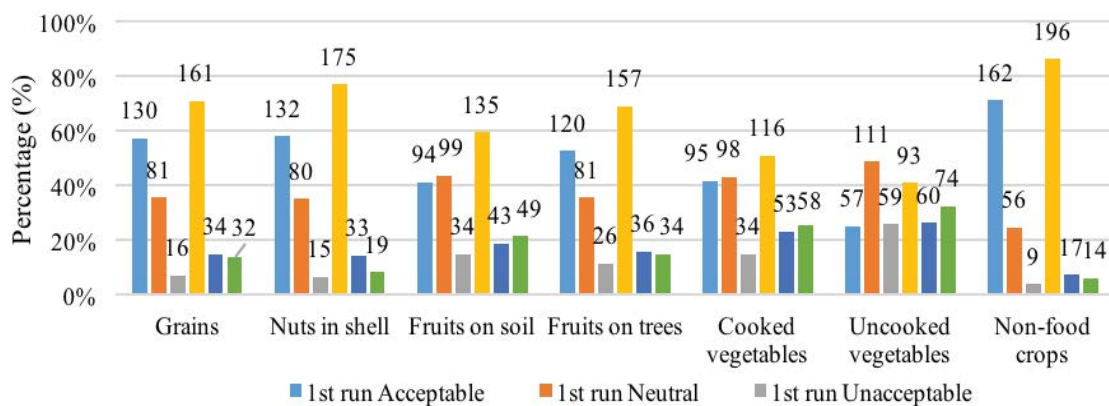


Fig. 6. Impact of supplying information on the acceptance of using treated grey water in agricultural irrigation.

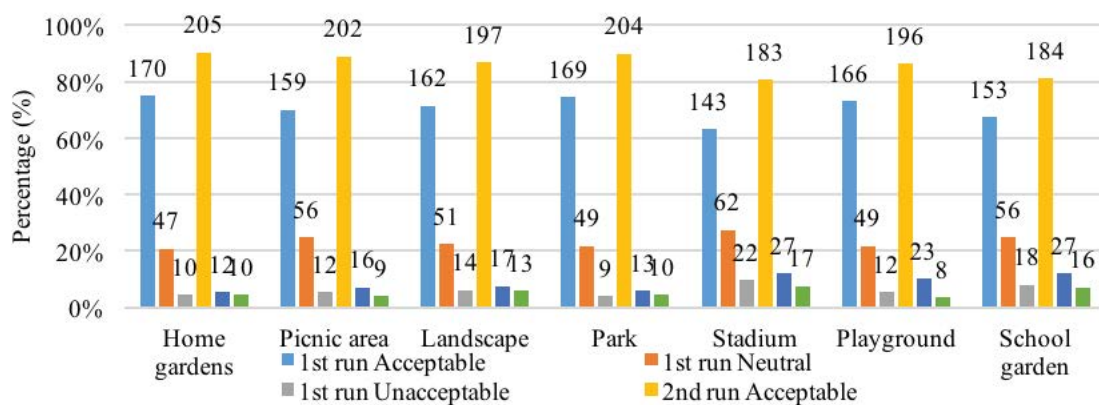


Fig. 7. Impact of supplying information on the acceptance of using treated grey water in landscape irrigation

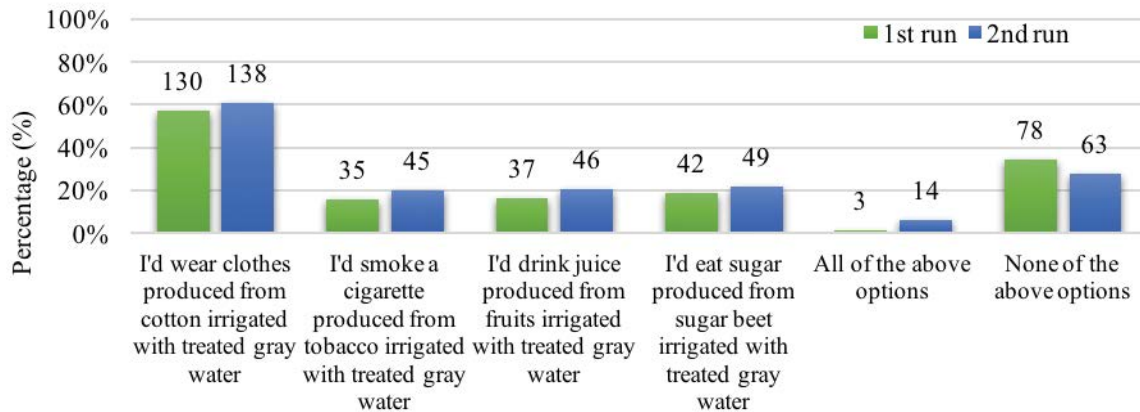


Fig. 8. Using or consuming products irrigated with grey water.

Table 3
 Acceptances and changes in attitudes of participants on final uses of grey water after supplying information

| Final use | Option | Before informing | After informing | % Increase |
|---------------------------|---------------------|------------------|-----------------|------------|
| Household use | Toilet flushing | 179 | 209 | 17 |
| | Car washing | 158 | 193 | 22 |
| | Swimming pools | 50 | 81 | 62 |
| | Cereals/grains | 130 | 161 | 24 |
| | Nuts in shells | 132 | 175 | 33 |
| Irrigation - agricultural | Fruits on soil | 94 | 135 | 44 |
| | Fruits on trees | 120 | 157 | 31 |
| | Cooked vegetables | 95 | 116 | 22 |
| | Uncooked vegetables | 57 | 93 | 63 |
| | Non-food crops | 162 | 196 | 21 |
| | Home gardens | 170 | 205 | 21 |
| Irrigation - landscape | Picnic area | 159 | 202 | 27 |
| | Landscape | 162 | 197 | 22 |
| | Park | 169 | 204 | 21 |
| | Stadium | 143 | 183 | 28 |
| | Playground | 166 | 196 | 18 |
| | School garden | 153 | 184 | 20 |

not sure. The low percentage for swimming pools might be attributed to concerns to come in contact or ingest a treated wastewater stream, which was improved to 35% of all participants after supplying information. This interpretation is in line with similar cases for using reclaimed conventional domestic wastewater [16,18,19].

Before sharing information, regarding using grey water for irrigational purposes, participants were more conservative to accept crops that will be consumed without receiving any treatment, such as uncooked vegetables with 25%. Fruits grown on soil and cooked vegetables received about 40%, while non-food crops were the preferred choice by 71%. After providing information, the percentages for all the choices improved and reached a range of 41%–86%.

In case of irrigating green areas with treated grey water, the percentages in the first run were in a range between 63% and 75%, and in the second run, the acceptance level increased to 80%–90%. The participants' preferences were the

same in both of the first and second runs, indicating the home gardens as the first choice.

In terms of industrial plants, as shown in Fig. 8, 57% of the participants accepted to wear clothes produced from cotton irrigated with treated grey water. This was much lower than the acceptance in an older survey where the acceptance was over 80% and considerably higher than food stuff [12]. It was highly rejected to drink juice or consume sugar produced from plants irrigated with treated grey water; however, total rejection decreased upon supplying information. It was observed in the face to face interviews that psychological concerns comprised a significant obstacle in terms of applying grey water in agricultural irrigation.

Overall, the greatest acceptance as the final use before being informed was with toilet flushing 79% acceptance which still remained as the highest with 92% after sharing information. The lowest was uncooked vegetables with 25% which increased to 41% upon supplying information, Table

3 summarizes acceptances and the changes in attitudes of participants after being informed. Supplying information to the public increases their awareness and motivation in using treated grey water either directly or indirectly. The major responsibility lies with the government/public sector and local councils, as well as NGOs to increase public awareness and to support communities, economically and psychologically.

All in all, for all questions in the survey there was an increase in public acceptance ranging from 17% to 93% showing the positive impact of supplying information to the public in terms of enhancing willingness to reuse grey water. This was specifically obvious for originally rejected items which received low acceptances.

4. Conclusion

Grey water is a renewable and reliable source of water and should be used as an alternative water source. However, successful implementation requires positive public opinion and acceptance. In this survey which was undertaken in Istanbul, it could be observed that awareness regarding grey water and its reuse was limited and supplying information to raise awareness in the subject matter helped appreciably in improving public opinion. The greatest acceptance as the final use was with toilet flushing with 79% acceptance to begin with, which increased to 92%. The lowest was uncooked vegetables with 25% and increased to 41% after sharing information. Economic considerations were observed to play an important role in public acceptance and participants said they would accept to pay for installation of grey water systems with 40% but would accept its installation for free with 79%, both of which have increased to 58% and 93%, respectively, after learning more about grey water management. Grey water reuse is a viable and sustainable option for the future, especially for the regions of the world with water stress/scarcity; however, it is not widely recognized yet and awareness raising will be a critical factor for its widespread acceptance.

References

- [1] United Nations, World Population Prospects: the 2006 Revision, United Nations Population Division, New York, NY, 2007.
- [2] B. Beler-Baykal, Stream segregation in household use: a review of grey water as an alternative source of water and yellow water as an alternative source of fertilizers, *Water Qual. Exposure Health*, 7 (2015) 27–37.
- [3] E. Eriksson, K. Auffarth, M. Henze, A. Ledin, Characteristics of grey wastewater, *Urban Water*, 4 (2002) 85–104.
- [4] J. Church, M.E. Verbyla, W.H. Lee, A.A. Randall, T.J. Amundsen, D.J. Zastrow, Dishwashing water recycling system and related water quality standards for military use, *Sci. Total Environ.*, 529 (2015) 275–284.
- [5] H. Efe, An Analysis on Grey Water Source Separation as an Alternative for Conventional Wastewater Management Using the Case of Kocaeli Yenikent Neighborhood, M.Sc. Thesis Istanbul Technical University Graduate School of Engineering and Technology, Department of Environmental Engineering, 2017.
- [6] E. Feitelson, J. Chenoweth, Á. Pereira, Introducing Greywater systems into the built environment: an introduction and overview, *Built Environ.*, 42 (2016) 209–211.
- [7] J.Y.C. Leong, K.S. Oh, P.E. Poh, M.N. Chong, Prospects of hybrid rainwater-greywater decentralized system for water recycling and reuse: a review, *J. Cleaner Prod.*, 142 (2017) 3014–3027.
- [8] E. Nolde, Grey water Recycling Systems in Germany - Results, Experiences and Guidelines, *Water Sci. Technol.*, 51 (2005) 203–212.
- [9] K.S. Oh, J.Y.C. Leong, P.E. Poh, M.N. Chong, E.V. Lau, A review of greywater recycling related issues: challenges and future prospects in Malaysia, *J. Cleaner Prod.*, 171 (2018) 17–29.
- [10] R. Snodgrass, Greywater-the reuse of household water: a small step toward sustainable living and adaptation to climate change, *Geo. Int. Environ. L. Rev.*, 22 (2009) 591.
- [11] M. J. Travis, A. Wiel-Shafran, N. Weisbrod, E. Adar, A. Gross, Greywater reuse for irrigation: effect on soil properties, *Sci. Total Environ.*, 408 (2010) 2501–2508.
- [12] M. Halalshah, S. Dalahmeh, M. Sayed, W. Suleiman, M. Shareef, M. Mansour, M. Safi, Grey water characteristics and treatment options for rural areas in Jordan, *Bioresour. Technol.*, 99 (2008) 6635–6641.
- [13] B. Beler Baykal, H. Efe, E. Afacan, E. Arslan, A Preliminary Survey on Public Attitude for the Reuse of Grey Water as an Alternative Source of Water in Turkey, IWA S2Small2017 Conference on Small Water & Wastewater Systems and Resources Oriented Sanitation (SWWS) October 22–26, 2017, Nantes, France.
- [14] N. Buyukkamaci, H.S. Alkan, Public acceptance potential for reuse applications in Turkey, *Resour. Conserv. Recycl.*, 80 (2013) 32–35.
- [15] L. Garcia-Cuerva, E.Z. Berglund, A.R. Binder, Public perceptions of water shortages, conservation behaviors, and support for water reuse in the US, *Resour. Conserv. Recycl.*, 113 (2016) 106–115.
- [16] S. Dolnicar, A.I. Schäfer, Desalinated versus recycled water: public perceptions and profiles of the accepters, *J. Environ. Manage.*, 90 (2009) 888–900.
- [17] M.A. Maraqa, K. Ghoudi, Public Perception of Water Conservation, Reclamation and Greywater Use in the United Arab Emirates. *International Proceedings of Chemical, Biological and Environmental Engineering*, 91 (2015) 24–30.
- [18] J.S. Marks, W.C. Martin, M. Zadoroznyj, Acceptance of water recycling in Australia: national baseline data, *Water*, 33 (2006) 151–157.
- [19] E. Miller, L. Buys, Water-recycling in South-East Queensland, Australia: what do men and women think?, *Rural Society*, 18 (2008) 220–229.