A pilot study into public attitudes and perceptions towards greywater reuse in a low cost housing development in Durban, South Africa

B. F. Bakare, S. Mtsweni and S. Rathilal

ABSTRACT

The benefits of greywater reuse have been identified to include the protection of water resources, recovery of nutrients for agriculture, savings in fresh water usage, reduction in volumes of wastewater discharged into wastewater treatment works, groundwater recharge and sustainable water resource management. An understanding of public attitude and perceptions towards the reuse of greywater will help to facilitate a positive reaction to the promotion of such concepts. The study involved administering of structured questionnaires to residents within the community through field visits. The questionnaire addressed issues related to attitudes towards the reuse of greywater, perceived advantages related to the reuse of greywater and concerns related to public health issues regarding the reuse of greywater. A total number of 346 questionnaires were administered and respondents were aged from less than 19 to over 60 years. Of the respondents, 55% were female and 45% male. The findings revealed a complex and shifting relationship between attitudes towards and perception of the reuse of greywater. This paper thus presents the findings and assesses certain aspects of greywater reuse.

Key words | attitudes, greywater, perceptions, recycling, reuse, water resources

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INTRODUCTION

In South Africa, where there is a growing pressure on water resources, the challenge has always been to balance between the supply and demand for freshwater. This has been triggered by low rainfalls and high evaporation rates faced in most parts of the country. Various efforts have been made, and some are still in progress, to identify new means of meeting the increasing water demands within South Africa and across the globe. Many research studies are being conducted to provide solutions on ways of reducing the growing pressure on the available freshwater resources by increasing the efficiency of water usage and to expand the usefulness of alternative sources of water which were previously considered unusable (Allen *et al.* 2010). Among these alternative sources of water previously considered unusable is greywater. Greywater is simply referred to as the wastewater generated from household uses like bathing, laundry and washing of dishes without input from toilets. It is an immense resource that could find significant applications in regions of water scarcity (Allen *et al.* 2010). The advantages of greywater reuse either on-site or nearby are that it has the potential to reduce the demand of new water supply, reduce the energy and carbon footprint of water services and meet a wide range of social and economic needs (Allen *et al.* 2010).

Greywater makes up about 60–70% of the domestic wastewater volume in most developed countries (Friedler 2004). The generation of greywater is directly related to the consumption of water in a household and is dependent on a number of factors including the level of service provision, tolerance of residents to pollution and the communities' level of awareness of health and environmental risks (Carden *et al.* 2006). According to Carden *et al.* (2006), it

doi: 10.2166/wrd.2015.076

could be assumed that greywater accounts for virtually all water usage in non-sewered areas except for that which is used for drinking purposes, that which is used consumptively in cooking, and the water that remains on the surfaces of washed articles. Japan, the USA and Australia maintain the highest profile in greywater reuse worldwide, although Jordan, Israel, Canada, the UK, Germany and Sweden are also involved in active research and applications (Al-Jayyousi 2003). It has been established that in an individual household, the reuse of greywater could support the amount of water needed for toilet washing and outdoor uses such as garden watering (Karpiscak *et al.* 1990).

Many research studies conducted to evaluate the volume of greywater generated in various households have indicated that if the volume of greywater generated in households is either treated before reuse or reused directly for toilet flushing and gardening, it has the potential to significantly reduce domestic water consumption, since toilet flushing and gardening can respectively represent 30 and 40% of daily water needs (Jefferson *et al.* 2004; Toze 2005; Madungwe & Sakuringwa 2007; Allen *et al.* 2010). However, public acceptance towards establishing water reuse projects has been a major challenge and it is in this view that recent studies now consider public acceptance and perceptions of water reuse as one of the key successes of any water reuse project (Po *et al.* 2003). According to Po *et al.* (2005), several factors affect public attitudes towards any reuse schemes which can be issues related to perceive risks, political issues and degree of human contact. Human exposure to water reuse plays a major role to public acceptance towards any water reuse projects because the idea of reusing water in which they perceive to be unsafe or unhealthy is usually a challenge (Brown & Davies 2007). According to Dolnicar *et al.* (2011), the willingness to reuse water which involves low human contact such as watering of gardens is generally acceptable by individuals compared to other uses with high likelihoods of personal contact.

Several studies investigating public attitudes towards water reuse have been conducted over the past decade. The study conducted by Bruvold (1988) indicated that the acceptance of water reuse for non-potable uses that involved low human contact such as irrigation was high compared to uses with close human contact such as swimming and drinking. In a large scale study conducted in Australia investigating public attitudes and perceptions towards water reuse, Hurlimann & Dolnicar (2010) found that 92% of the respondents were willing to use recycled water for garden watering but only 36% were willing to use recycled water for drinking purposes. In one study on community receptivity to greywater reuse in northern Sydney, Australia, conducted by Brown & Davies (2007), 95% of respondents indicated that they were willing to make use of greywater for watering of gardens. Positive perceptions were directly the inverse of the level of physical contact with the water. The concerns raised as key reasons for the lack of acceptance of greywater reuse were about health, water pricing signals, and a belief that using recycled water represented a decrease in the standard of living. According to Domenech & Sauri (2010), in Barcelona, Spain the factors determining the level of public acceptance of greywater reuse include: perceived health risk, perceived cost, operation regime, and environmental awareness. It was found in this study that the reuse of greywater was seen as relatively safe, 84% of the respondents to the survey perceived health threats associated with the use of greywater to be low or very low. In South Africa there is still a need to investigate public acceptance towards the reuse of greywater and also create awareness towards the importance and underlying opportunities related to the reuse of large volumes of greywater generated in many low cost housing developments spread across the country. This paper investigates public attitudes and perceptions towards certain aspects of greywater reuse through field visits and administering of structured questionnaires. The overall aim of the study is to provide insight into public acceptance and perception towards the reuse of greywater in a South African context.

METHODOLOGICAL APPROACH

The study was approved by the Research Ethics Committee at the Faculty of Engineering of both Mangosuthu University of Technology and Durban University of Technology. The ethical guidelines and principles provided by both University and the South African guidelines for Good Clinical Practice in Human Participants (Department of Health

2000) were used in conducting the pilot study. All participants involved in the survey were informed of the objectives of the study in their home language (IsiZulu) and signed the informed consent. The survey was conducted anonymously. Based on the information provided by the community councillor from the 2014 demographic statistics, there were approximately 3,500 dwellings in the community. In order to provide a statistical representation of the community, the determination of the number of households required to conduct this study was based on the statistical calculator for sample estimation presented by Christova-Boal *et al.* (1996). The calculation indicated that the required number of households for this study should be a minimum of 346. Data were collected by means of structured questionnaires during home visits to all randomly selected households. The questionnaire used was a modification of what was used in a previously conducted study by Adewumi *et al.* (2010). Data were obtained from owners of each dwelling with a response rate of 100%. The study was conducted in Umhlabeni informal settlement within Umlazi Township located in the South Western part of Durban. This area is a low income peri-urban settlement which comprises mainly informal dwellings and is densely populated. No problems were encountered during the administering of the questionnaire and people were willing to participate.

The questionnaire comprised sections on demographics, attitude towards the reuse of greywater, concerns related to public health issues, as well as a section that related to perceived advantages of greywater reuse. Data were analysed to compute descriptive statistics, mainly averages, standard deviations, correlations and frequency distribution. The types of data collected were ranked in order of responses from the participants which consisted of a five scale ordinal level: strongly disagree, disagree, not sure, agree, strongly agree. Responses were grouped in an ordinal scale and analysed to provide insight on the community attitude, perception, and concerns towards the reuse of greywater.

RESULTS

The pilot study provided feedback on the actual questionnaire structure and contents itself, which revealed the relationship between public attitudes and perception towards greywater reuse within the community in which the study was conducted.

Demographic characteristics of the respondents

Table 1 presents the demographic characteristics of the 346 respondents that participated in the study. As summarised in the table, there was a larger number of female than male respondents and most of the respondents were between the ages of 20 and 29 years (40% of the respondents).

Respondents' attitudes towards the reuse of greywater

In order to ascertain the attitudes of respondents towards the reuse of greywater for specific applications as identified to be appropriate for the community in which the study was conducted, respondents' attitudes were assessed by asking five questions on how comfortable and willing respondents were to use greywater for the identified applications within the community. Responses available for selection were: strongly disagree, disagree, not sure, agree, and strongly agree. The results are shown in Table 2. As can be seen, there was a higher percentage (>70%) of respondents that were willing to reuse greywater for either toilet flushing or for garden purposes. This result indicates that people residing in the community where the study was conducted did not have any issues related to the reuse of greywater for the identified application found appropriate for the community. It is also interesting to see from this study that a greater percentage of respondents (approximately 71%) were willing to use greywater from other buildings for the identified applications (toilet flushing/garden purpose). A positive attribute of this study is that 65% of respondents were willing to use greywater not because there was a drought or water scarcity, and 80% of

Table 1 | Demographic characteristics of the respondents

Age	Percentage	Gender	Percentage
Under 19	7		
20–29	40	Male	45
30–39	22	Female	55
40–49	19		
50–59	9		

Table 2 | Percentage of respondents willing to use greywater for the identified reuse applications

Items	Response				
	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
I am willing to use greywater for toilet flushing	6.1	10.1	8.1	28.3	47
I am willing to use greywater for garden purposes	5.8	12.5	11.6	32.5	37.7
I am willing to use greywater from other building for toilet flushing or for garden purposes	9.9	7.8	11.6	34.9	35.8
I am only prepared to use greywater for either of the identified applications only during drought or water scarcity	19.9	4.6	9.8	36.7	28.8
I am willing to have a dual water distribution system installed where I currently reside	4.9	4.9	10.1	31.8	48.3

the respondents were also willing to have a dual water distribution system installed where they reside.

The main factors identified to being associated with higher levels of public acceptance of greywater reuse in the community in which this study was conducted were age and gender. Chi-square tests were undertaken to assess whether there was a significant association in agreement with the respondents' attitudes towards the reuse of greywater between different age groups and gender. The result indicated that there was a significant association ($P < 0.05$) for all the questions posed. The influence of respondent age and gender on their attitudes towards the reuse of greywater is presented in Figures 1 and 2, respectively. As can be seen in Figure 1, the percentage of respondents within the age bracket of 20–29 years showed greater willingness towards the reuse of greywater compared to the other age groups considered in this study. Statistical analysis performed using univariate analysis of variance with a post-hoc Scheffe test to compare the mean values of respondent in terms of attitudes that are in agreement with the reuse of greywater for the different age groups indicated that there was a significant difference ($P = 0.03$) between the age bracket of 20–29 years and the other age groups considered in this study. This could be attributed to the fact that this age group is well informed, educated, or has a better knowledge/understanding

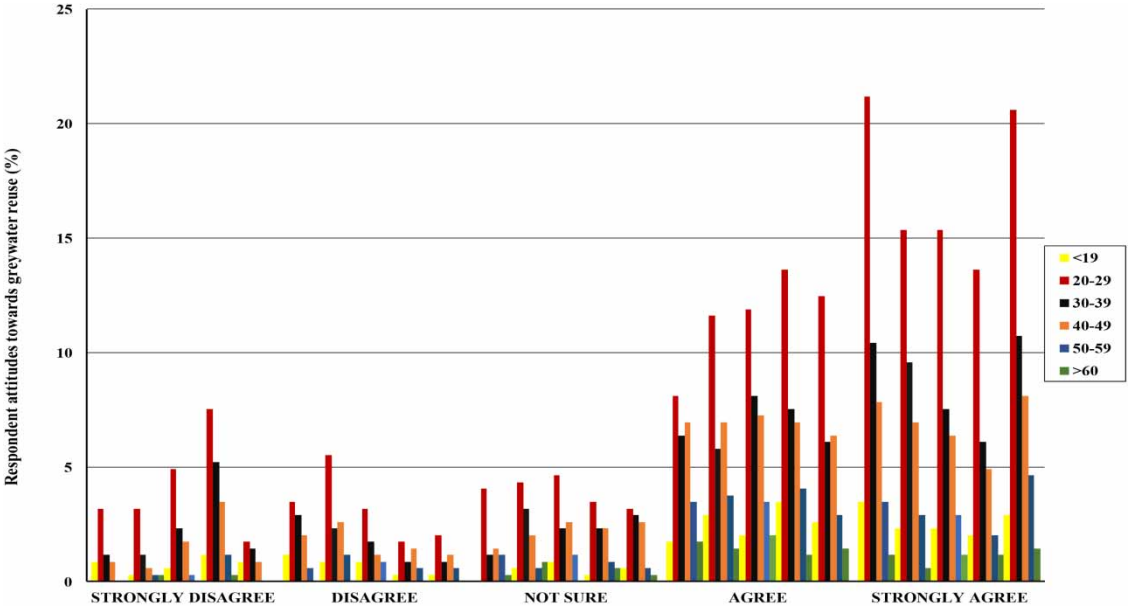

Figure 1 | Influence of respondent age on attitudes towards greywater reuse.

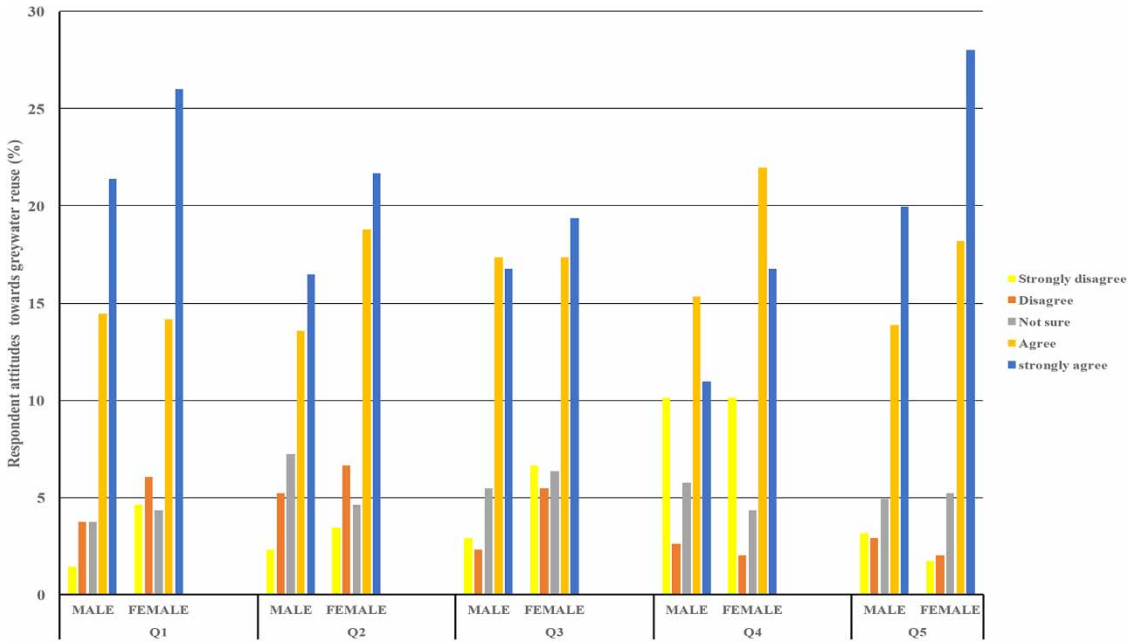

Figure 2 | Influence of respondent gender on attitudes towards greywater reuse.

of the importance of water reclamation and reuse, thus they are keen to see changes in the current practice within their community.

It was also observed that the female respondents showed more willingness towards the reuse of greywater, as presented in Figure 2. Statistical analysis using the t-test was conducted to establish if there exist any significant differences in responses in terms of gender in this study; it was found that there was significant difference ($P < 0.05$) between the female and male respondents.

Respondents' concerns on health implications associated with the reuse of greywater

Another important factor that influences public acceptance towards the reuse of greywater is often related to public health issues from using the water. Respondents were asked three main questions to access their concerns on health implications associated with the reuse of greywater. Responses available for selection were: strongly disagree, disagree, not sure, agree, and strongly agree. This was done because health concerns associated with the reuse of greywater has often been one of the major factors that have affected public willingness to accept the reuse of greywater for various applications. Table 3 shows the percentage of respondents who have concerns on the health impacts associated with the reuse of greywater.

Contrary to what was expected, this study has indicated that public concerns related to health implications associated with the reuse of greywater for the identified applications were minimal. It was found that a higher percentage of respondents (>60%) disagree that the reuse of

Table 3 | Percentage of respondents' concerns on health implications associated with the reuse of greywater

	Response				
Items	**Strongly agree**	**Disagree**	**Not sure**	**Agree**	**Strongly agree**
Can the use of greywater for toilet flushing impact negatively on public health	38.4	25.7	16.8	14.3	4.3
Can the use of greywater for garden purpose impact negatively on public health	42.2	27.7	15	10.1	4.9
Is using greywater for toilet flushing or for garden purposes disgusting	45.2	24.9	10.1	9.8	10

greywater could negatively impact on public health compared to less than 20% of the respondents that agree that the reuse of greywater can negatively impact public health.

Chi-square tests were also undertaken to assess whether there was a significant association in agreement with the respondents' concerns on health implications associated with the reuse of greywater between different age groups and gender. The results indicated that there was a significant association ($P < 0.05$) for all the questions posed. The influence of respondent age and gender on concerns related to health issues associated with the reuse of greywater is presented in Figures 3 and 4, respectively. As can be seen in Figure 3, respondents within the ages of 20–29 years showed a greater percentage in disagreement of the fact that the reuse of greywater for the identified applications in this study could have adverse effects on public health.

Statistical analysis performed using univariate analysis of variance with a post-hoc Scheffe test to compare the mean values of respondent in terms of public health concerns that are in disagreement that the reuse of greywater could pose adverse effects on public health for the different age groups for every single statement indicated that there was a significant difference ($P < 0.05$) between the age bracket of 20–29 years and the other age groups considered in this study. It was also observed that the female respondents are in more disagreement that the reuse of greywater could pose adverse effects to public health compared to the males, as presented in Figure 4. Statistical analysis using the t-test was conducted to establish if the differences were significant in responses in terms of gender in this study; it was found that there was significant difference ($P < 0.05$) between the female and male respondents. The overall assessment of this aspect of the study indicates that a greater percentage of the respondents do not agree that the reuse of greywater could have any adverse effects on public health. This is a good indication of public awareness and willingness to accept the reuse of greywater within the community.

Respondents' perceived advantages of greywater reuse

Two questions were posed which were aimed at determining whether the respondents had any perceived advantage of greywater reuse for the identified application in this study. It was found that a greater percentage of the respondents (>75%) agreed that the reuse of greywater for the identified applications considered in this study would have a positive impact on the environment and would help in saving

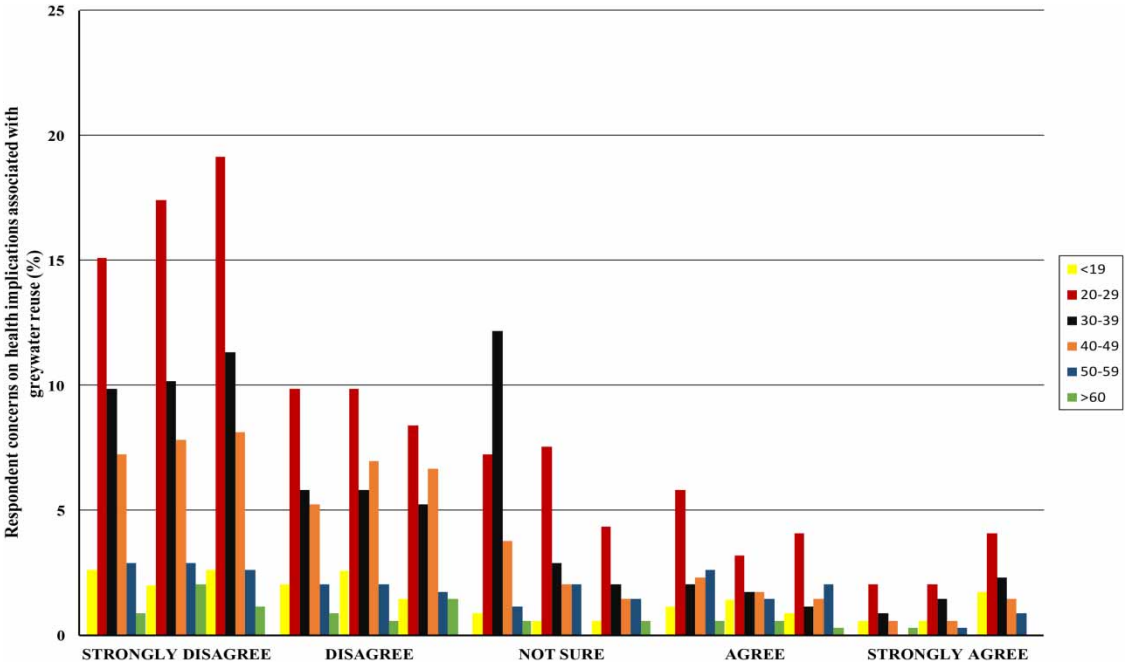

Figure 3 | Respondent concerns on health implications in relation to age.

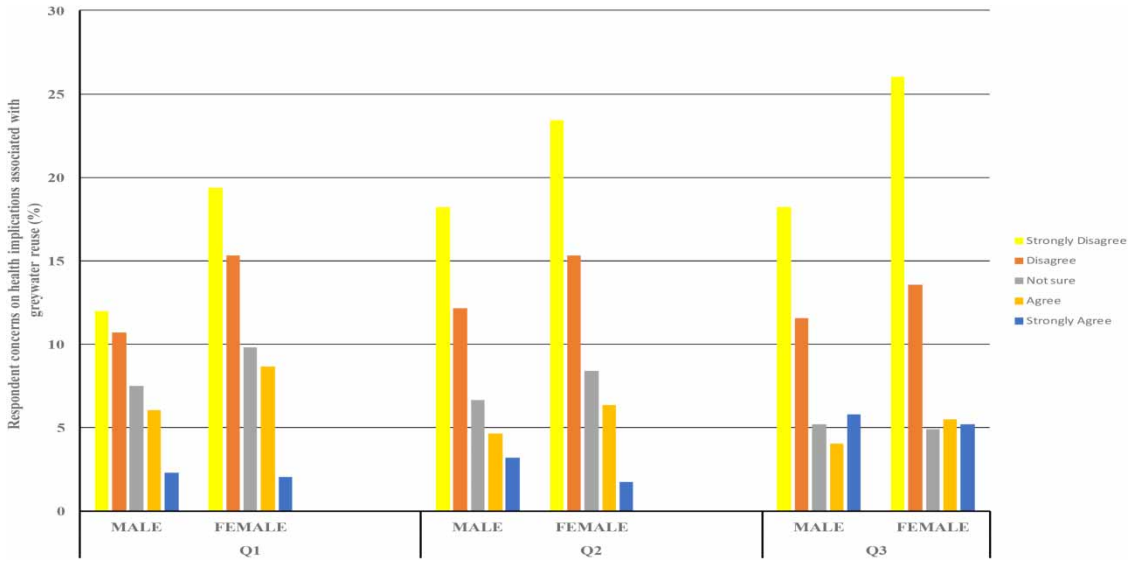

Figure 4 | Respondent concerns on health implications in relation to gender.

freshwater as well as reducing large volumes of wastewater discharged into wastewater treatment works which could be reused. The findings are shown in Table 4.

It was found that there was significant association in agreement with the respondents' perceived advantages for the reuse of greywater between different age groups and gender in the community in which this study was conducted using the Chi-square test (at $P < 0.05$). Statistical analysis conducted using univariate analysis of variance with a post-hoc Scheffe test to compare the mean values of respondent in relation to their perceived advantages towards the reuse of greywater for the different age groups showed that the respondents within the age bracket of 20–29 years demonstrated a higher percentage compared to the other age brackets considered in this study, as presented in Figure 5. This finding is consistent with the other aspects of this study and therefore supports the facts that this particular age group (20–29 years) is well informed, educated, or has a better knowledge/understanding of the importance of water reclamation and reuse, and is keen to see changes in the current practice within their community.

It was also observed that the female respondents, compared to the males, had a higher perception that the reuse of greywater could have an advantage in reducing water demand within the community and would have a positive impact on the environment, as presented in Figure 6. Statistical analysis using the t-test was conducted to establish if the differences were significant in responses in terms of gender; it was found that there was significant difference ($P < 0.05$) between the female and male respondents.

DISCUSSION

A growing increase in water demand and increasing constraints placed on freshwater supply in Southern African

Table 4 | Percentage of respondents with perceived advantages towards greywater reuse

	Response				
Items	**Strongly disagree**	**Disagree**	**Not sure**	**Agree**	**Strongly agree**
I believe that greywater reuse for toilet flushing will positively impact on the environment	5.5	4	10.7	34.4	45.5
Greywater reuse for toilet flushing and garden purposes help save our limited fresh water usage	5.5	2.9	9.5	30.6	51.4

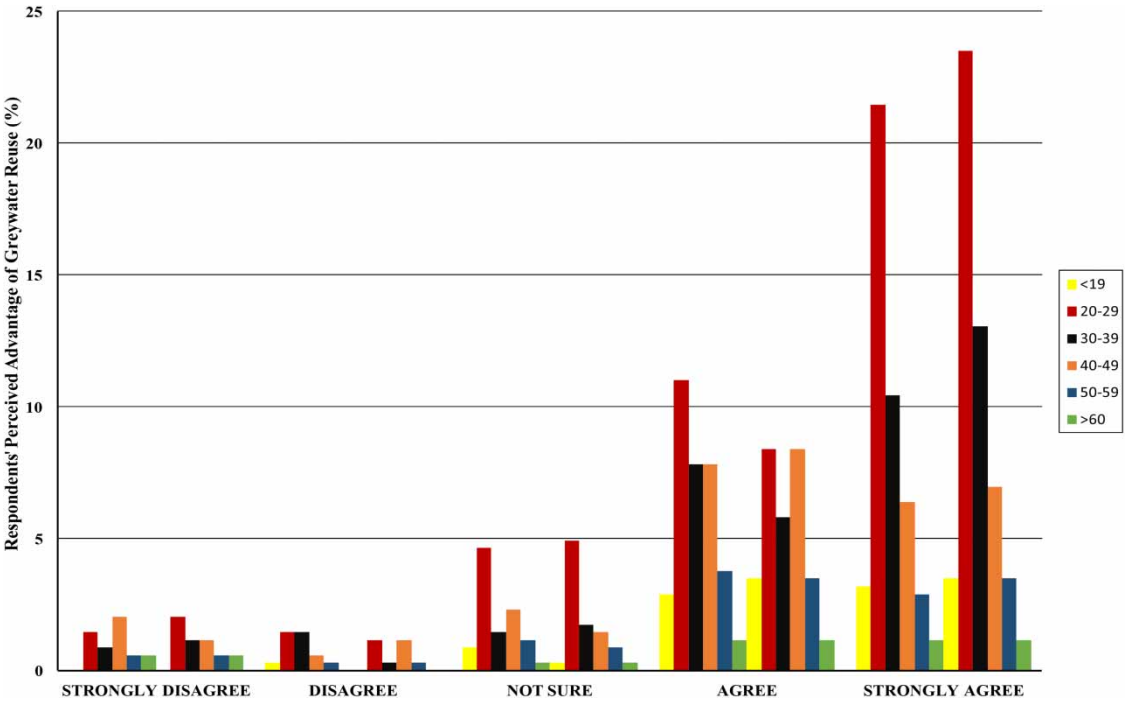

Figure 5 | Respondents' perceived advantage of greywater reuse in relation to age.

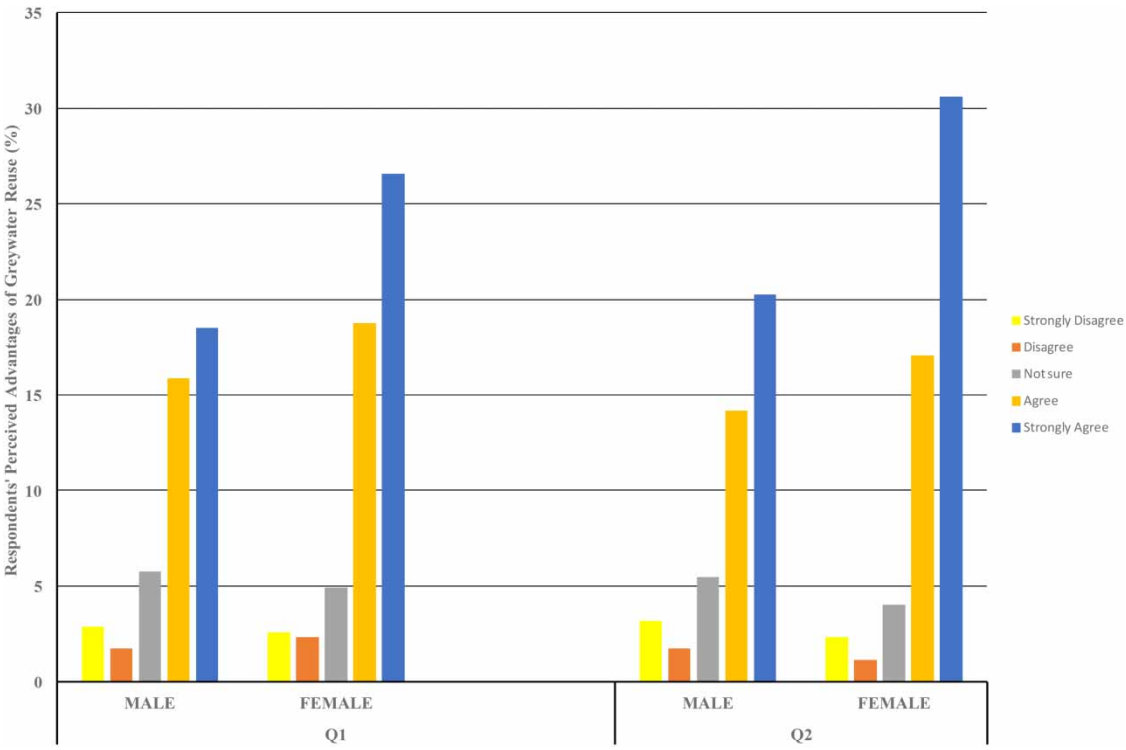

Figure 6 | Respondents' perceived advantage of greywater reuse in relation to gender.

regions is creating a large scale interest in the application of greywater reuse as an alternative measure for water conservation. The success of any reuse proposed project generally depends on public acceptance. This study was undertaken to access the attitudes, health concerns and perception of individuals towards the reuse of greywater. The study was conducted in a community situated in the South Western part of Durban, South Africa. It is observed from this study that the role of the public is a vital component in the development and implementation of any reuse system/application. The major factor affecting the public attitudes and perception towards the reuse of greywater as observed in this study was found to be the need for reuse and their level of education. This pilot study reinforces the findings from previous research that the willingness to reuse greywater which involves low human contact is generally acceptable by individuals compared to other uses with high chances of personal contact (Bruvold 1988; Po *et al.* 2005; Brown & Davies 2007; Dolnicar *et al.* 2011; Hurlimann & Dolnicar 2010), since the greywater reuse options identified in this study were for toilet flushing and for gardening purposes. The findings from the survey conducted showed that the percentage of the public willing to accept the reuse of greywater within the community was far higher than the percentage opposing its reuse. Concerns have often been expressed by the public that the reuse of greywater could pose possible adverse effects to public health. However, in this pilot study it was found that a higher percentage of respondents (>60%) disagree that the reuse of greywater could negatively impact on public health compared to less than 20% of the respondents that agree. An interesting finding of this study was that a greater percentage of the respondents were willing to have a dual water distribution system installed in their current place of residence.

In summary, it is very important to note that the majority of the people residing in the community are receptive to the concept of reusing large volumes of greywater generated for the identified applications. However, more awareness programmes on the benefits of greywater reuse will be required so that the people residing in the community will have the proper knowledge that greywater reuse and other alternate sources of water will soon become a necessity in South Africa.

CONCLUSIONS

The findings of this study have showed that there is a relatively high level of acceptance for the reuse of greywater among the respondents within the community. The relatively high level of support for the reuse of greywater as observed by the respondents in the community where this study was conducted is a key issue for the success of this water conservation concept. The findings from the study conducted thus suggest that the implementation and development of greywater reuse concepts within the community will gain support and this could be a viable option for maximizing the use of freshwater.

ACKNOWLEDGEMENTS

The authors acknowledge the support received from the Research Directorate at Mangosuthu University of Technology Durban South Africa and also appreciate the participants of this study for their time.

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First received 18 June 2015; accepted in revised form 3 September 2015. Available online 21 October 2015