

ISSUES AND CHALLENGES OF GREYWATER REUSE FOR IRRIGATION IN AUSTRALIA – A CASE STUDY OF WESTERN SYDNEY REGION

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Abstract

In this study, using Western Sydney region as a case study, we report on outcomes of a detailed survey about people's views on general water issues and their motivation, practices and concerns (particularly soil and human health) related to greywater reuse for irrigation of lawns and garden beds by people. The participants for this study accessed the survey questionnaire on-line or as a hard copy that was hand delivered to their homes. A total of 275 participants from different socio-economic background, aged over 18 years, from 125 suburbs in Western Sydney took part in the survey.

Regardless of their age and gender, water quality is the most important aspect of water for the participants, and the availability of water without restriction is the least important aspect. About 43% of the participants are affected by the current water scarcity in some way and believed that rainwater harvesting and greywater recycling can potentially overcome some of the water scarcity being faced by homeowners. In order to combat the water scarcity, they suggested firstly to harvest as much rainwater as possible, and secondly to recycle more greywater at domestic level.

Among the survey participants, 49% of them have reused greywater regularly or some time during the last few years. The most common source of the greywater they reused was from laundry washing machine, and the most common method of transferring the water from the source to the irrigated area was through a pipeline. The cost of plumbing and health risks to people, plants and soil are the two most important issues that need attention. Overall, people are environmentally conscious and are interested in saving water provided there is proper encouragement given by government, local councils and other authorities that regulate water supplies and reuse. The study indicated that for widespread reuse of greywater, homeowners need some reliable and practical information for its safe and sustainable reuse. The study also pointed out that financial incentives from the state and federal governments may help more reuse of greywater.

Introduction

Water is a strategically limited natural resource, and currently Australia is in the grip of an extended drought period. Water shortage in Australia is mainly due to lack of rainfall and high evaporation (Eriksson *et al.*, 2002), and the situation is made worse by climate change effects and changes in the El Nino-Southern Oscillation pattern (Jefferson *et al.*, 1999). To cope with the current and future water scarcity in Australia, we need to look for alternative water sources and work towards achieving high level of sustainability. One such alternative is the reuse of domestic greywater for irrigation around homes. The greywater reuse practice is becoming increasingly common in many households around the country, but there are no in-depth studies that provide a clear understanding of how the greywater reuse impacts on soil, plant and human health in the long-term.

There have been several studies conducted in Australia and overseas to understand community views on general water issues and effluent reuse, but there is only limited research to date specifically focussing on greywater reuse issues (Christova-Boal *et al.*, 1996, Almeida *et al.*, 1999, Eriksson *et al.*, 2003). This study is first of its kind to be conducted in Western Sydney seeking views of the community from a range of age groups, professional backgrounds and socio-economic levels on greywater reuse and actions individual homeowners are taking to cope with the current water scarcity.

Methodology

This survey was targeted at homeowners with different socio-economic backgrounds spread across the Western Sydney region. The target group for the survey included people over 18 years of age and those who are interested in sharing their thoughts on water issues in general and greywater reuse in particular.

Survey questionnaire was made available to the survey participants in both on-line (<http://www.geocities.com/greywateron-line>) and hard copy forms, thus allowing them to respond to the questionnaire with or without an access to the internet. There were a total of 20 questions in the survey and out of those questions 15 questions were to be responded by all participants while the rest by those who have reused greywater in the past.

The survey questionnaire can be divided into three parts. The first part (Q 1-5) was about characterizing the participants in terms of their gender, age group, the type of dwelling they are living in and the number of people living in the household. The second part (Q 6–13 and 19) is focussed on the participant's views on water issues, water saving practices they are using, water scarcity in Western Sydney, the extent to which they are impacted by the scarcity and their willingness to reuse greywater. The third part of the survey (Q 14-18) collected information from the people who are actually reusing greywater for their garden. In this part, the participants were asked about the history of their greywater reuse, sources of greywater, frequency of reuse and method of reuse. The survey also included an open-ended question (Q 20) that was responded by all the participants for their views on water recycling, greywater reuse and water conservation issues, challenges and opportunities.

Data analysis

The survey data collected during the study were entered into an Excel™ worksheet and were analysed using the Pivot-Table tool to obtain key trends and inter-relationship of responses to different survey questions in tabular and graphical forms. The responses for the open-ended question were manually analysed and grouped into a number of themes to develop insights into issues, difficulties and challenges the community is facing in relation to greywater reuse and practical actions that can be taken to secure water supplies and achieve sustainability of water resources in urban landscapes.

Recruitment of Survey Participants

The participants for the survey were recruited mainly through four methods:

- (i) Accessing internal mailing lists of organizations,
- (ii) Publishing the questionnaire link on vUWS (virtual University Of Western Sydney) discussion board,
- (iii) Letter box delivery of survey questionnaire, and
- (iv) Advertising about the survey in local newspapers.

Accessing internal mailing lists of organizations

An electronic copy of the survey questionnaire was sent to the Western Sydney Regional Organization of Councils (WSROC) and 10 local city councils in Western Sydney for advertising the study in their intra-network and requesting people to participate in the survey. This was mainly aimed at collecting views from professionals in different fields of expertise. The survey was also announced in the daily staff newsletter (e-Update) of the University of Western Sydney (UWS) delivered to staff (>4000) across all six campuses of the University.

Publishing the link on vUWS discussion board

A pop up announcement and an on-line survey link were published on vUWS discussion board across six campuses for a period of two weeks. The announcement on vUWS appeared every time a student or staff logs onto their e-Learning account. In this case, our target was to seek views of students and staff who are from different educational backgrounds.

Letter box delivery of survey questionnaire

A total of 500 hard copies of the survey questionnaire, with reply paid, self-addressed envelopes, were delivered randomly to homes in 20 suburbs across Western Sydney. The selection of the suburbs was done such that they are well spread across the region. The individual homes for the survey were selected randomly while driving through the suburbs.

Advertising in the local newspapers

With the help of the Media Unit at UWS, several local newspapers were sent a press release about the study. As a result of the press release, a number of local newspapers, viz., The Liverpool Champion, The South Western Rural Advertiser, The Hawkesbury Independent and The Mt. Druitt Standard published a news story about the study and provided the web link for accessing the survey questionnaire.

Pilot Survey and Human Ethics Clearance

A draft of the survey questionnaire was developed after several iterations. The next step in implementing the survey questionnaire was to run a pilot survey using 10 hard copies. Through the pilot survey, we assessed how different people responded to the draft survey questionnaire and any difficulty in accessing the questionnaire through the web page. As a result of the pilot survey, some questions were revised for improving the clarity of questions and some new ones were added to ensure that all relevant data/information are obtained through the questionnaire. During the pilot survey, it was also found that some internet browsers did not allow the survey participants to submit their responses successfully. This difficulty was overcome by placing an announcement as to which internet browser the participants need to use to complete the questionnaire.

The human ethics panel at UWS questioned the method of personal data saving and using a particular e-mail account to receive the on-line survey responses. Their major concern was the insecurity related to the use of third party e-mail account for the survey and associated risk of breaching the privacy of the participants. The ethics approval was finally granted once enough evidence was presented to ensure that the privacy of the on-line participants and their data is secure. The survey questions and the cover letter were slightly altered in order to comply with the UWS Human Ethics guidelines.

Results and Discussion

Participants and the survey process

The on-line survey was opened to the survey participants over a period of 57 days. Based on the web page statistics, a total of 190 visitors to the survey web page attempted the questionnaire. Except two responses, all the survey responses were received from participants living in suburbs of Western Sydney. A total of 275 participants filled out the survey questionnaire. Majority of participants (71%) used the on-line version of the questionnaire and about one-third (29%) of them used the hardcopy version of the survey questionnaire.

Out of 500 hard copies of survey questionnaire distributed in 20 suburbs in Western Sydney, 79 (15%) completed questionnaire were returned. The responses were received from all the suburbs except two (Cabramatta and Harris Park). The number of responses from each suburb varied between 1 and 6.

The survey responses in the study were received from a total of 125 suburbs in Western Sydney. The majority of responses were received from Hawkesbury, outer west, central west, inner west, city/eastern suburbs and Fairfield/Liverpool areas. A small number of responses were also received from Bankstown and Blue mountains regions.

Community concern, response and support towards issues that affect the region may be influenced by age, gender and other factors. In this study, we found that the participation of people in the survey tends to decline with the age (Figure 1). In terms of age group of the participants who responded to the survey, the highest number of responses was received from participants aged between 18 and 25 and the lowest number of responses was from females over 60 years of age. Females responded more than males in 18-25, 25-40 and 40-60 age groups. Overall 40% of the

survey responders in this study were aged between 18 and 25. Part of the reason for this trend was that a considerable number of UWS students responded to the survey through the on-line version.

Motivation for reusing greywater

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

Nearly 80% of the participants think that the reuse of greywater by homeowners can help in sustaining Sydney's future water supplies, and about 50% of the participants viewed that the greywater reuse will reduce the amount of potable water usage and improve the local environment.

When asked whether greywater reuse could help reduce the impacts of water scarcity brought about by climate change scenarios, nearly half of the participants surveyed mentioned that greywater reuse could be very important to reduce the potable water use and thus mitigate the impacts of impending climate change. This is again an indication of environmental consciousness of the survey participants and their willingness to implement some practical actions at household level despite currently little incentives or support provided by the government agencies.

Is the reuse of greywater safe and affordable?

The question about different aspects that survey participants would like to consider before reusing greywater revealed some interesting facts. One in five participants (19%) thought the cost associated with the reuse was a very important consideration for them. When asked about health risk to people, plants and soil, one in three participants (38%) considered health risk to be very important for any decision on the reuse of greywater. On the other hand, for one in ten participants, health risk and cost were not very important at all.

One of the prime concerns of the survey participants was impacts of greywater on soil quality and environment surrounding greywater reuse sites. Many participants who responded to the survey were environmentally conscious and wanted to reuse greywater to cope with the water scarcity, but they often lacked information on how to reuse greywater and were concerned about its long-term effects on soil and plants. Some participants were particularly concerned about accumulation of salts and phosphorous in soil and likely impact on Australian native plants at their home sites. One participant who was concerned about the impact of greywater reuse on native plants said that his greywater reuse for the past 20 years had some positive effect on a few weeds while posed a threat to his native Banksia plants. The participant suspected that this was possibly due to the long-term greywater reuse but was not sure of the underlying dynamics of nutrient accumulation or other possible changes in soil pH and EC. In general, the health risk posed by greywater reuse is a major concern among the survey participants and can be summed up by the comments of the following two participants:

'I want to do my part in saving water but I do worry about health risks down the track - I'm talking about using rinse cycle water and recycled bath water (from 2 small children) to water new fruit trees - does the soap in the water have any effect on the fruit etc?'

'My biggest concern about the greywater reuse is the detergents, soap and washing powder we use. If someone can assure us that chemicals we are using will not harm the soil and environment, then we can reuse greywater without any fear'.

In general, the cost involved in plumbing and health risks to people, plants and soil are the two important issues that need attention. Some form of financial support from government and information packages that explain best practices to avoid risk to human health, soil and plant will be valuable in achieving widespread reuse of greywater in the region.

Water scarcity and individual homeowners

Majority of the survey participants (84%) were aware of the current water scarcity in Western Sydney, but a relatively small proportion of participants (16%) were of the opinion that they were not aware of the scarcity. The percentage of the total number of survey participants who were affected in some way in their daily lives by the current water scarcity is 43%. It is interesting to note that this percentage was similar to those who reuse greywater (49%) in Western Sydney. About 37% of survey participants reused greywater to save the environment, a similar proportion of participants (35%) to cope with the current water scarcity and 4% of them just wanted to try out the greywater reuse.

Harvesting rainwater is what many people said would do to combat the current water scarcity. Further, they are willing recycle more greywater and try using less water in their daily activities to conserve potable water supplies. When participants were asked about what they would do in the future to cope with the on-going water scarcity in the region, 92% of them indicated that they will reuse more greywater. The study clearly shows that majority of people are conscious about the emerging problems in their region and are trying to do something to overcome the water scarcity.

Regardless of their age and gender, water quality is the most important aspect of water for the participants, and the availability of water without restriction is the least important aspect of water (Figure 2). These indirectly means that majority of people want access to high quality water in sufficient quantity and are prepared to pay higher prices and can put up with water restrictions.

Educational resources for safe greywater reuse

The concerns expressed by the participants in this survey about health risks and long-term impacts on soil and plant are really the signs of lack of useful information required for safe and sustainable greywater reuse. The data from this study indicate that about one-third (36%) of the total number of participants were not aware of the problems associated with greywater reuse. The study also indicates that, whether someone is reusing or not reusing greywater, there is not much difference in their views on the long-term effects of greywater reuse. This means, there is a general need for greywater reuse education in the community. For the reuse to occur widely, there is need for easily accessible, user friendly information packages to create 'greywater reuse literacy' throughout in the community (including in schools).

According to Western Australian draft guidelines for the reuse of greywater, native plants belong to Proteaceae family and are probably susceptible to excess phosphorus in soil as a result of greywater reuse. Further, shade loving and acid loving plants such as Azaleas, Camellias, Gardenias, Begonias and Ferns would not prefer the alkalinity created by the long-term reuse of greywater (Western Australian Department of Health, 2002). Thus, information on the salt tolerant and non tolerant plants must be made readily available to homeowners who wish to reuse greywater, particularly by water from washing machines.

Greywater reuse in practice

Out of 275 participants surveyed, about half of them reused greywater regularly or sometime in the last few years. Also, the study indicated that more female participant reused greywater than males at home. Among the participants who have been practising greywater reuse, about seven out of 10 indicated that they have been reusing greywater for irrigation at least once a week. Furthermore, participants who reused greywater with a frequency once a fortnight, once a month and irregularly accounted for one out of 10 in each in these three frequency categories.

The largest number of survey participants (38%) reused greywater from both wash and rinse cycles from washing machines, followed by bathroom water (23%), kitchen wastewater (17%) and rinse cycle of washing machines (15%) (Figure 3). Also, it is interesting to note that those participants who are practising greywater reuse, 23% of them used some sort of a greywater treatment system involving initial investment.

The study revealed that the most common method of transferring greywater from the source to the irrigated area is the use of an extension pipeline (72%) and the manual bucketing is the second most commonly used method (28%). Transfer of greywater from the source to garden via manual bucketing has a number health risks, particularly that the water may be contaminated with hazardous microbes. Moreover, collecting water from the source and taking it to the garden seems

to be time consuming, laborious and may result in personal injury (e.g., spinal and back injury). Guidelines are being released by state government agencies as to the safe reuse of greywater in domestic situations. For example, in NSW all the outlet pipes carrying treated greywater from domestic greywater treatment systems must be colour coded in purple according to Australian Standard (AS 2700) and must indicate the “*warning recycled/reclaimed water – do not drink*” sign (AS 1345) (NSW, Department of Energy, Utilities and Sustainability 2007). Users must also make sure that they are not using a sprinkler that would otherwise create greywater aerosols (ACT Health and Health Protection Service, 2007). Despite their best intentions, these guidelines still do not provide all the information needed by homeowners to implement reuse and some requirements imposed in the guidelines do not encourage the reuse. In other words, such difficulties point out to a number of policy issues that need to be examined and harmonised while ensuring the safe and sustainable reuse of greywater in the future.

Another important finding of this survey is the lack of greywater reuse by people living in dwelling types other than single houses. Survey data indicated that most people who reuse greywater were from single houses (46%). In flats, semi-detached dwellings and townhouses, the percentage of people who are not reusing greywater was greater than that of those who are reusing greywater. The most likely reasons for this may be related to the limited space in those dwellings, life style and restrictions by the landlords.

From the group of participants who reused greywater, 73% of them have reused greywater at least once a week (Figure 4). Further analysis of data indicates that most of these participants (60%) are probably those who reuse washing machine water, since once a week pattern matches to the weekly washing by homeowners.

The study indicated that there is not much difference, whether someone is a user or non-user of greywater, in participant’s views on the long-term effects of greywater reuse. One of the interesting findings of this study is that about 11% of the total number of survey participants was not aware of the long-term consequences of greywater reuse for irrigation at their home gardens. This means, appropriate educational program on the safe and sustainable reuse of greywater will be critical in achieving widespread reuse around homes.

The present study showed that majority of the people who used greywater was from single dwellings. Reasons for not receiving much acceptance by the people who live in other types of dwellings seem interesting to investigate. One survey participant, who lives in a rental property, was unable to reuse/install the greywater system because the landlord did not want it. Another one said landlord refuses this idea because future tenants may not be committed to the greywater reuse and the investment is unlikely to be economically viable.

Strategies for greywater reuse into the future

Issues seem to be arising when retrofitting the existing plumbing system to cater for the new greywater stream. One survey participant mentioned that they wanted to install a gravity tank for storing water for reuse, but the plumbing required was a quite costly exercise. In another instance, homeowner had to bear the total cost of site inspection by the local water authority for the installation of a gravity tank to collect rainwater, use it in washing machine and then reuse it for irrigation of garden. The two examples simply indicate that the cost of plumbing and current regulations as such impede greywater reuse by the majority of homeowners. To overcome such difficulty, many participants suggested some kind of incentive scheme by the government for both existing and new homes to cater for greywater flows. One concerned participant said: “*Government should assist those who wish to make plumbing changes in order to use greywater. Subsidies should be available to people in older homes to help with the cost of plumbing upgrades to encourage the use of grey and recycled water*”.

Many participants commented on making government funds readily available to eco-friendly citizens to save water. Two such responses that justify what people are thinking:

‘I believe that using greywater is a good idea, but I do not have the money to outlay on this and would be more interested in doing this if there was an incentive to do so.’

‘If the government started an initiative with greywater recycling just as they introduced yellow recycling bins, people would find it much easier and with little effort start recycling water as well.’

In some states, it is a requirement that greywater must be disposed of by means of subsurface irrigation (Western Australian Department of Health, 2002). This means, if the greywater is to be reused through surface irrigation, it needs to be treated to a required standard to ensure that there is no risk to the human health. The quality of the greywater discharged can be improved by allowing water to pass through some commercially available domestic greywater recycling unit (DGRU). In this study, we found that 23% of the total number of participants who were reusing greywater installed DGRU and the rest were reusing untreated greywater directly on their garden areas. For more people to use DGRU, there is a need to develop low-cost DGRU to achieve widespread reuse of greywater while ensuring safety and sustainability of greywater reuse.

The comments of the individual participants indicate that there is a need for easily available, user-friendly information on reusing greywater at domestic level. Since the majority of homeowners reuse water from washing machine for irrigation, in the first instance, it will be helpful if guidelines and information package targeted for the reuse of greywater from laundry.

There is a need to develop strategies that will promote greywater reuse by people living in dwelling types other than single houses. This is to be done in collaboration with the landlords and real estate agents. The frequency of greywater reuse could be increased if the homeowners are encouraged to reuse greywater from other sources such as bathroom or kitchen. However, appropriate guidelines and information packages must be made available before promoting such reuses.

Participant's views through the open-ended question in the survey indicated that there is poor communication between people who regulate reuse and general public. As such, this remains a major issue for the future widespread reuse of greywater among homeowners with different socio-economic backgrounds. People are environmentally conscious and interested in saving water at domestic level provided there is a proper encouragement given by government, local councils and other authorities that regulate water supplies in their area. Greywater systems can be incorporated with rainwater tanks, and the people are asking for more information about this 'grey' area of greywater reuse. In other words, the greywater reuse needs to be consciously incorporated into the total water cycle management and water conservation strategies and policies need to be refined to remove current barriers for reuse.

Conclusions

Regardless of their age and gender, water quality is the most important aspect of water for the survey participants, and the availability of water without restriction is the least important aspect of water. Majority of the survey participants (84%) were aware that the region is confronting a severe water scarcity and about half of them (43%) were affected by the scarcity in some way in their daily lives. In order to combat the water scarcity, they suggested firstly to harvest as much as rainwater as possible, and secondly to recycle more greywater at domestic level.

Greywater reuse is becoming increasingly common among households in Western Sydney as a response to the ongoing water scarcity. People are conscious of the local water and other environmental issues and many of them are willing to do whatever they can possibly to improve the situation. Nearly half of the participants in this study were reusing greywater regularly or occasionally in the last few years to cope with the current water scarcity and help the environment. The cost of plumbing and health risks to people, plants and soil are the two the important issues that need attention.

When considering the different sources of greywater, the most common source of greywater for reuse was the wastewater from washing machines. The second most common source of greywater was from bathroom, but there is concern that this water may be a risk to human health if reused without proper treatment.

The study indicated that some form of financial support and educational program from the government will be valuable in achieving widespread reuse of greywater in the region. Also, there is a need to develop proper educational resources for homeowners and improve communication between people who regulate the reuse and general public. In general, people are environmentally conscious and interested in saving water provided there is proper encouragement given by government, local councils and other authorities that regulate water supplies and use.

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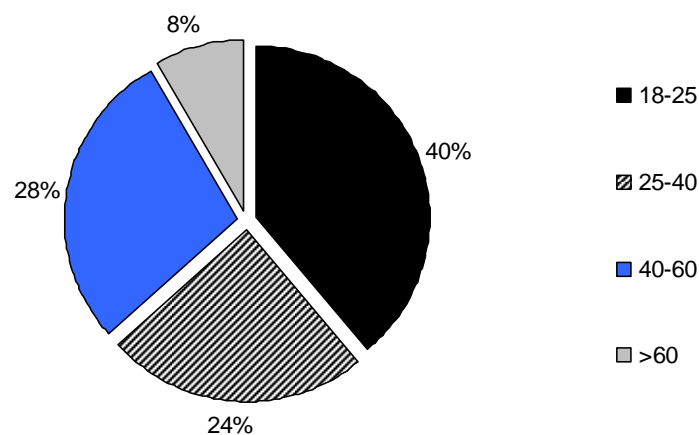


Figure 1. Distribution of survey participants based on four age groups.

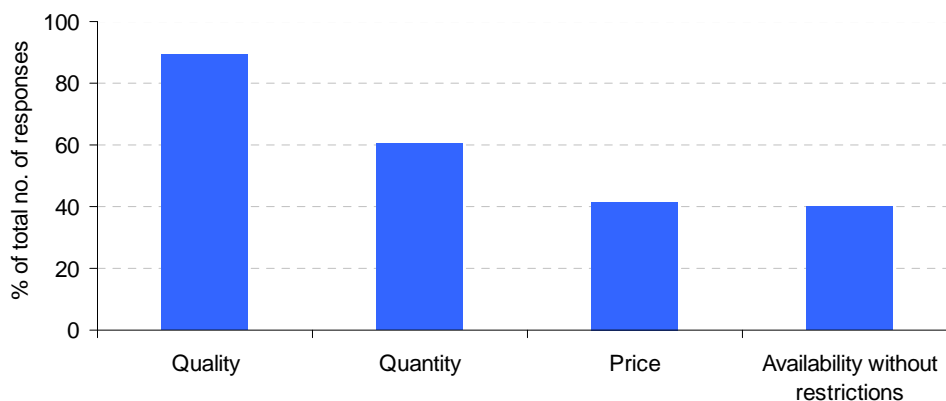


Figure 2. Response of survey participants as to what they value the most in water.

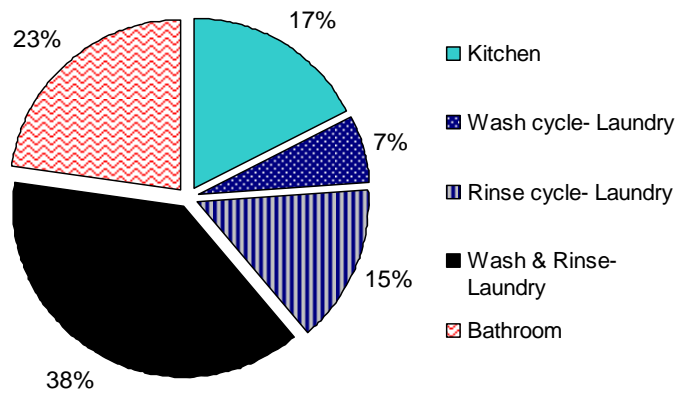


Figure 3. Different sources of domestic greywater used by the survey participants.

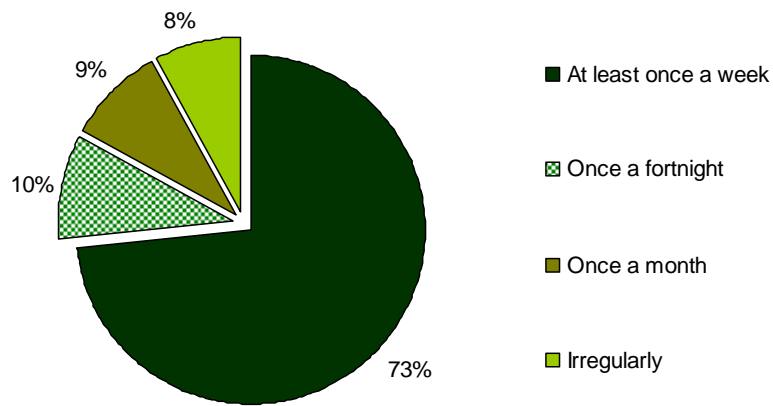


Figure 4. The variation of percentage of the total number of participants who reused greywater and frequency of their reuse.