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Integrating Sustainable Education from the View of Consumer Perceptions and Acceptance of Reusing Treated Greywater for Clean Water Substitution

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Abstract

Water scarcity issues worldwide are becoming increasingly prevalent, attributed mainly to environmental challenges. To alleviate the burden on clean water resources, adopting treated greywater systems presents a viable alternative. Yet, implementing such systems within the Malaysian context remains in its infancy. A comprehensive survey was conducted to gauge consumer receptivity and understand the greywater recycling concept and its potential implications. This aim is to assess the feasibility of greywater use from the consumer's perspective and to ascertain its alignment with their needs. The survey sought to enlighten consumers on the sustainability of treated greywater to reduce reliance on increasingly scarce clean water supplies. Conducted online, the questionnaire comprised two sections and targeted residents of Seksyen 7, Shah Alam. The findings revealed varying understanding and acceptance of the greywater concept across educational backgrounds. Notably, individuals with a bachelor's degree and secondary school students exhibited a higher propensity (62% and 75%, respectively) to grasp the greywater concept compared to other demographic groups. Interestingly, the survey also uncovered a generational divide in the willingness to adopt greywater systems, with older participants showing a 12% reluctance rate, in contrast to a 7% reluctance rate among younger respondents. This resistance was primarily attributed to discomfort with the nature of greywater and prevailing cultural perceptions. Despite these concerns, most (79%) respondents acknowledged the potential of treated greywater to conserve clean water resources. This recognition translated into a widespread willingness to modify household plumbing to accommodate a greywater system, underscoring the participants' robust awareness and commitment to environmental conservation. This study highlights the critical role of consumer education and cultural adaptation in the broader

adoption of greywater recycling technologies. By fostering a deeper understanding and addressing prevailing misconceptions, Malaysia can tap into the untapped potential of greywater systems to mitigate water scarcity challenges.
Keywords. Treated Greywater, Environment, Sustainability, Clean Water

Introduction

The study of greywater reuse is crucial given the rising global demand for freshwater and the increasing scarcity of clean water resources. Greywater, defined as domestic wastewater from sources such as baths, showers, hand-washing basins, laundry, and kitchens (excluding sewage), is the cleanest form of wastewater produced in households or buildings due to its relatively low organic matter content compared to blackwater. Although its composition may vary depending on the source, greywater can be effectively treated and reused, providing an alternative source of water for non-potable applications like toilet flushing, irrigation, and some industrial processes. The potential of greywater reuse addresses critical needs, particularly in areas experiencing water stress. This issue is intensifying worldwide, with projections indicating that around 800 million people currently live in regions of high water stress, a figure expected to exceed 3 billion by 2025 (Oteng-Peprah et al., 2018).

The significance of studying greywater reuse lies in its potential to mitigate the growing water crisis, alleviate pressure on freshwater resources, and reduce environmental pollution. This research benefits policymakers, environmental scientists, and communities by offering sustainable water management strategies that can minimize dependence on limited freshwater supplies. Moreover, greywater recycling has environmental benefits, reducing the impact of untreated wastewater drainage into natural water bodies and helping preserve aquatic ecosystems. Ultimately, advancing greywater treatment and reuse systems will support water conservation efforts globally, benefiting water-scarce regions, fostering sustainable urban development, and contributing to the resilience of communities facing the challenges of climate change and population growth.

Research Methodology

The study's scheme determines consumers' awareness and perception of using treated greywater daily. The framework is designed to represent the flow before and after the online survey is being conducted.

Questionnaires Survey Design

The online survey is aimed at public users in Seksyen 7, Shah Alam, whose backgrounds are unknown. The collected datasets were classified according to the respondents' responses, consisting of a five-scale ordinal level: strongly disagree, disagree, not sure, agree, and strongly agree. Each section needs to be answered by the respondents, and multiple-choice answers that represent the ordinal scale will be prepared. Responses were clustered on an ordinal scale and assessed to gain insight into consumers' views, perceptions and expectations regarding the re-use of greywater. Google Forms is a medium used to gather data viewed by users regarding grey water. Users can access the online survey using new electronic devices such as smartphones and laptops and by providing internet data. Using the Google form, the input received will be stored any time a reaction from the respondent is submitted so that the organizers can evaluate it in depth.

Evaluation and Assessment of the Online Survey

Data collected from the online questionnaire survey stored by Google form is analyzed and evaluated using Microsoft Excel. This software can assist well in aggregating data and can be used together to visualize data by using graphical analysis. The data will be computed to achieve frequency distribution, descriptive statistics, and correlation.

Results and Discussion

A total of 122 respondents have completed the survey through Google Forms. Mediums such as WhatsApp and Facebook are being utilized to distribute the questionnaire to the respondents in Seksyen 7, Shah Alam. Microsoft Excel analyzes the questionnaires and presents them as graphical charts. The data is addressed in three categories in this chapter: demographics analysis, consumers' degree of understanding about treated greywater, and consumers' level of perception and acceptance of the future treatment proposal work.

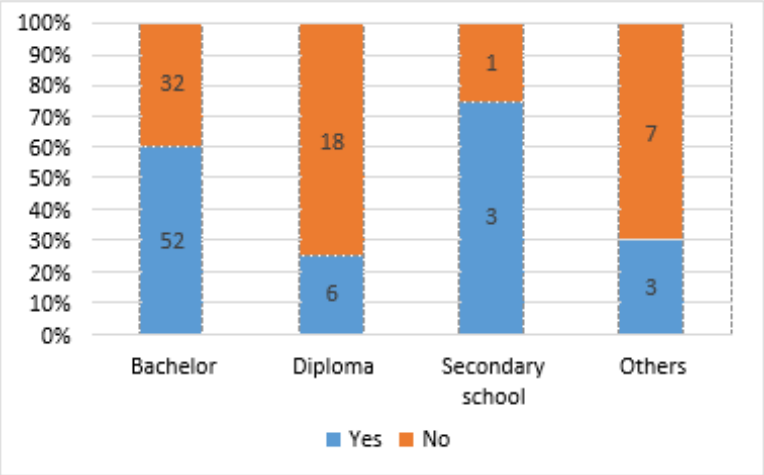

Figure 1: Understanding Greywater Based on Education Level

This section will discuss consumers' understanding of the meaning of greywater. According to Figure 1, bachelor's degree holders and secondary school students have the most significant percentage of respondents familiar with the term greywater. Even though one of the four secondary school pupils who responded to this poll did not know what this phrase meant. Bachelor's degree holders (52 respondents) familiar with this word can be connected to respondents who studied in any associated engineering area where environment and building services are essential for their course. As stated by (Khong, 2009), respondents with environmental awareness from their education react positively based on their study of socio-demographic factors. The remaining bachelor's degree holders might be those who studied and worked in other disciplines. Diploma holders who know this word have fewer responses as they haven't been exposed to enough environmental engineering in their studies. A master's degree or above may not have been exposed to this term since they solely study their specialized subject rather than environmental engineering.

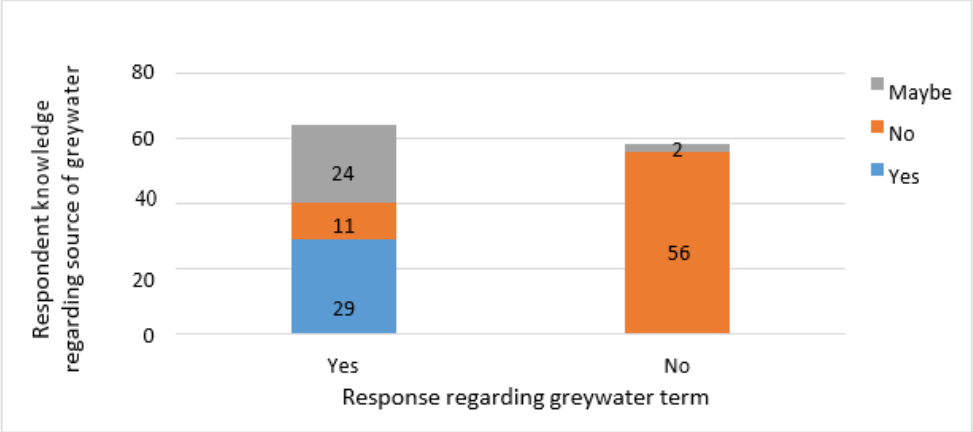

Figure 2: Respondents understanding regarding greywater source

Following that, a question on the source of greywater was posed to learn more about consumers' understanding of the term greywater, and three responses were supplied for the respondents: 'Yes,' 'No,' and 'Maybe'. Figure 2 shows that, of the 64 respondents who know the term greywater, only 29 know where the greywater originates, with the other 11 and 24 respondents knowing nothing and being unsure about the origin of greywater, respectively. Furthermore, most of those who did not recognize the term greywater had no idea where the greywater came from. This demonstrates that they were not aware of the availability of this source of recycled water near their home, even though greywater is the largest wastewater effluent generated by a household in a day, as reported by (Li et al., 2010). This also shows that respondents in this area weren't aware of this new alternative.

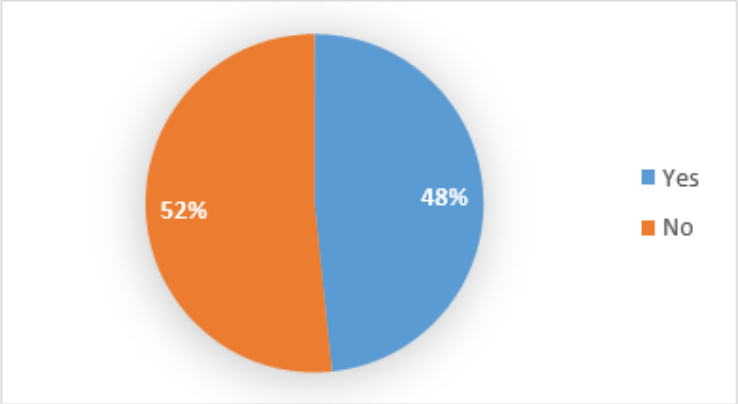

Figure 3: Treated greywater used for non-potable activities

Figure 3 shows respondents' awareness of greywater usage for non-potable activities such as toilet flushing, crop irrigation, and vehicle washing. 52% of respondents indicated they didn't know how this alternative could be utilized, while just 48% knew that treated greywater may be used for non-potable activities. This demonstrates that respondents are unaware of how greywater can be used for daily activities and how treated greywater may assist consumers during times of water scarcity. Plus, the respondents also didn't notice that using greywater treated for non-potable purposes can cover about half of the total potable water given to a household daily.

Consumers' Level of Perception and Acceptance section

This section denotes consumers' perceptions and acceptance of greywater treated in their daily activities.

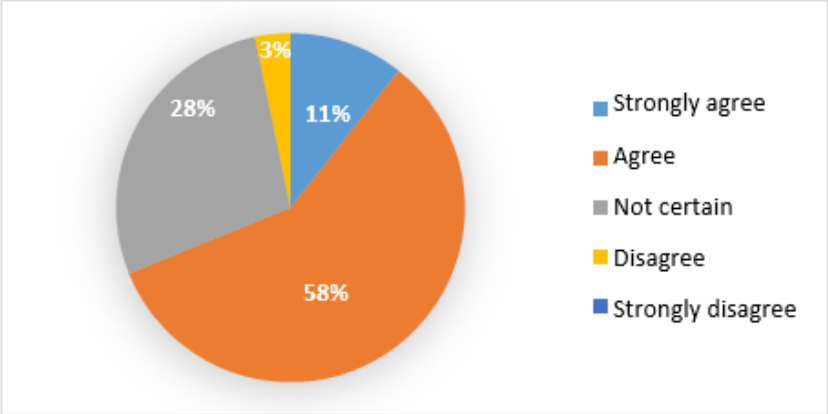

Figure 4: Perception of the treated greywater impact during water rationing

As shown in Figure 4, respondents were asked about their perceptions of the greywater impact during water restrictions and five options were provided: Strongly agree, Agree, not certain, Disagree, and Strongly disagree. A 5-point scale of answers was given to determine the level of acceptability of the respondents towards this water if any water shortages happened in their region. As stated before, regarding respondents' experience with water scarcity or water rationing in the region, 74% acknowledged occasionally suffering water shortages or water restrictions, followed by 16% of respondents who often had water shortages and 10% of respondents never had any water shortages. As a result, this question will reveal how people would react to whether this alternative is helpful during water scarcity.

According to Figure 4, 11% of respondents strongly agree that this alternative will have a significant influence during water restrictions. The biggest share of responses comes from respondents who agree on the alternative impacts, with a percentage of 58%. It is then followed by respondents who are uncertain about the impacts of greywater and respondents who disagree with this viewpoint, with a percentage of 28% and 3%, respectively. Many respondents agree with this viewpoint as they realize how difficult it is for them to locate other alternatives around urban areas if clean tap water isn't available. Other approaches, such as rainwater harvesting, were equally ineffective since the rain schedule cannot be reconciled with the water scarcity schedule, which can occur at any moment without warning. Meanwhile, respondents who disagree or are unsure about this alternative may have come up with the option of using an extra or external water tank that they have installed at their home. As a result, they do not appear to require this approach since they assume that installing a water tank will help them survive any water shortage event.

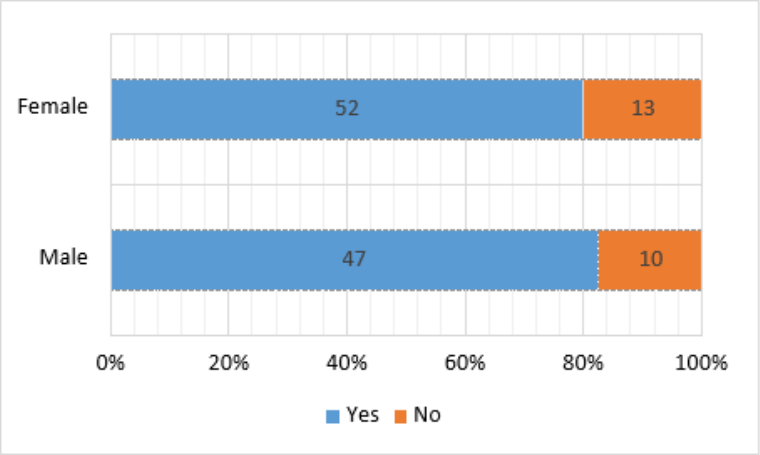

Figure 5: User willingness to use treated greywater according to gender

It is shown in Figure 5 that the user willingness to use the treated greywater-based gender variable is quite impressive, as a total of 99 respondents were willing to use this option, with a total of 52 females and 47 males. It is then followed by the small percentage of respondents who are unwilling to use this option, with 23 responses, 13 from female and 10 from male respondents. Although the count shows female has a higher percentage than males, the ratio of female and male respondents is different, and females have higher responses rather than males. This shows that the male population is more willing to use this option than the female population. The results indicate that positive output may vary from non-potable consumption of this alternate water. Non-potable activities such as gardening, washing clothes, and toilet flushing account for many households' daily consumption. Hence, these variables contribute to respondents' willingness to utilize this water as an alternative. Furthermore, female respondents are less likely to adopt this alternative than male respondents since they may feel uncomfortable using it to wash clothing since some of them may oversee cleaning clothes for a household, and utilizing this treated wastewater may not be the greatest option to substitute clean tap water.

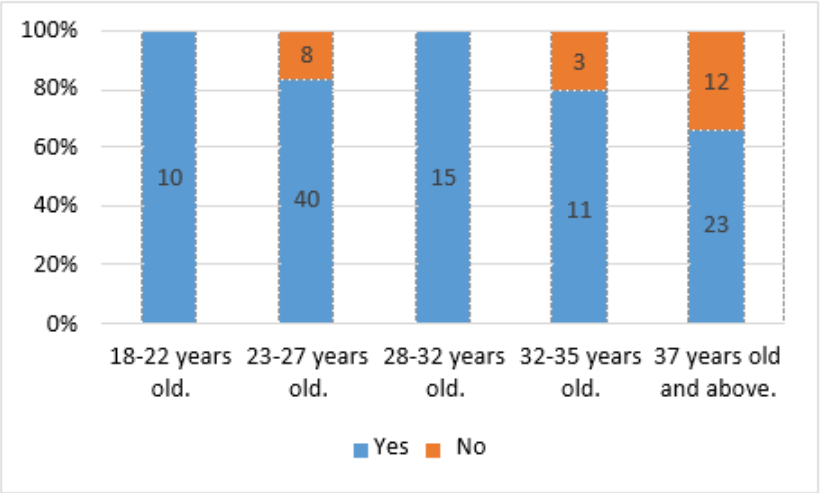

Figure 6: Respondent willingness to use greywater treated according to age

Based on the age variable in Figure 6, ranging from 18-22 years old, 23-27 years old, 28-32 years old, 32-35 years old and 37 years old, it is possible to determine which age group has the greatest desire to utilize greywater treated as an alternative. Starting from the group age ranges of 18-22 years old and 28-32 years old, all 25 respondents are willing to utilize this greywater as an alternative. These age groups may be aware of the possibility of future water shortages and are fully aware that alternatives must be implemented to address the challenges that have occurred regularly in their area. For the age group 23-27 years old, 8 respondents (17%) are unwilling to utilize this option since they may have studied this matter (wastewater process) in college or university and are aware of the expense and reliability of this option. Following that, there is a minor decrease in respondents who prefer this alternative for the age groups 32-35 years old and 37 years old and above. This may vary depending on their level of awareness regarding the depletion of freshwater supplies and their preference for quality over quantity when it comes to utilizing water for household activities. Older respondents are also more likely to seek freshwater sources, such as clean tap water, as they are more concerned about their health.

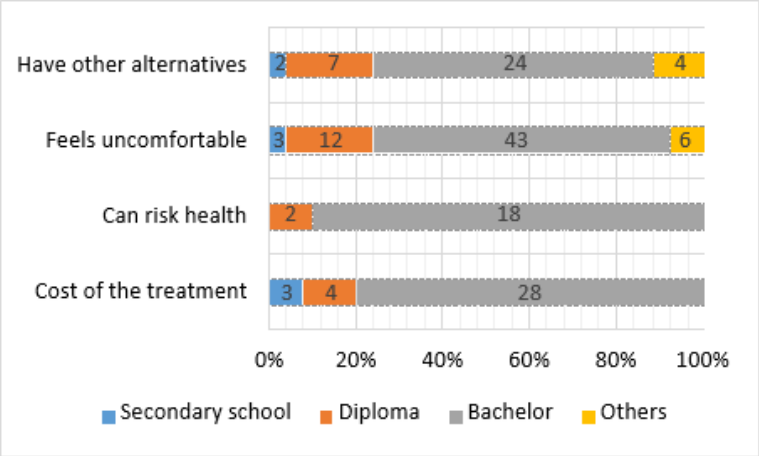

Figure 7: Respondent unwillingness factors to use treated greywater according to education levels

In this question in Figure 7, respondents are asked about their perception of why they are unwilling to use the treated greywater. Four available options relate to a user's unwillingness to utilize this water. The choices are 'Have other alternatives' and 'Feels uncomfortable'. 'Can risk health' and 'Cost of the treatment'. These options were developed based on the users' general concerns, such as monthly cost, health, and culture, as well as their awareness of other alternatives. This question's analysis will be dependent on the respondent's educational background.

According to the graph, bachelor's degree holders had the highest percentage for all four answers since they had the most respondents in this poll. Furthermore, most are engineering students who are well-versed in applying wastewater treatment in daily life. As a result, they are likely to recognize that any treated wastewater would pay expensive treatment costs, pose a health risk, and make them feel uncomfortable since this country has not yet mastered the technology to treat and distribute it effectively to consumers. Plus, they also know that other alternatives can be found in this country instead of having this wastewater as a clean water substitute. Diploma, secondary school, and Master's or Ph.D. degree holders had the

highest percentage of responses to the second choice of answer, 'Feels uncomfortable,' since they have no experience utilizing this clean water as a substitute.

The worry may stem from the fact that this water has been processed from wastewater effluent and cannot be consumed. This indicates that if they continue to develop the concept that this water is uncomfortable, this option may be difficult to apply for home use.

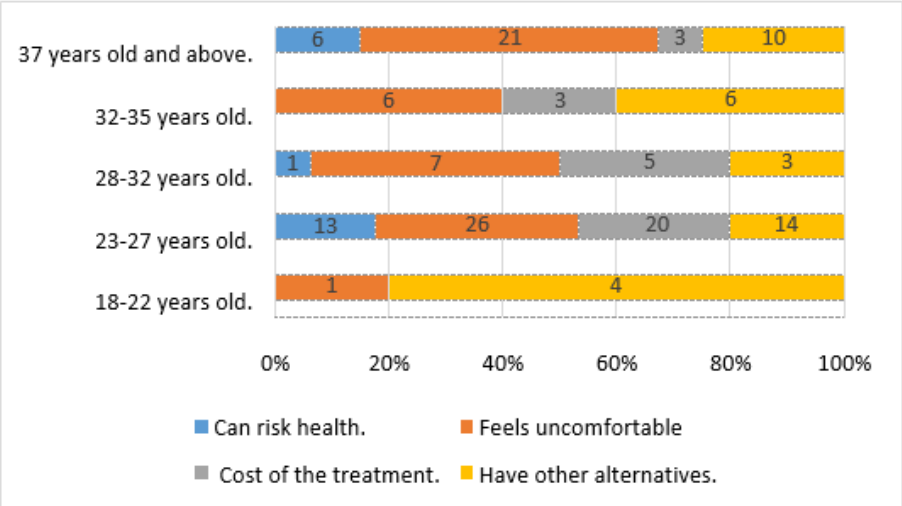

Figure 8: Respondent unwillingness to use treated greywater according to age range

Following that, a study of user perceptions of their unwillingness to use treated greywater is conducted based on their age as shown in Figure 8. For the 18-22 age group, 80% of respondents indicated that they are unwilling to use this option because they are more interested in other alternatives. The 23-27 years old, 28-32 years old and 37 years old and above are more concerned about the nature of greywater since the answer 'feel uncomfortable' received the highest percentage for these age groups. Meanwhile, respondents in the age range
32-35 years old indicate they are not interested in this choice since they prefer other alternatives and are uncomfortable with the treated greywater nature.

It was discovered that, based on the respondents' educational background and age, they are unwilling to use this alternative because they are uncomfortable with it, and that discomfort may be a factor in their decision to employ other alternatives. The community's social awareness of greywater reuse must be improved since they appear to have an issue with the nature of greywater even after it has been treated. Furthermore, there is an indication that cultural factors are contributing to this problem. Malaysia has abundant water resources that are constantly available due to the annual rain events. It has established a tradition in the minds of all people that the only water received in a household is water processed by river water. As a result, gaining respondents' trust in this option is a little more challenging.

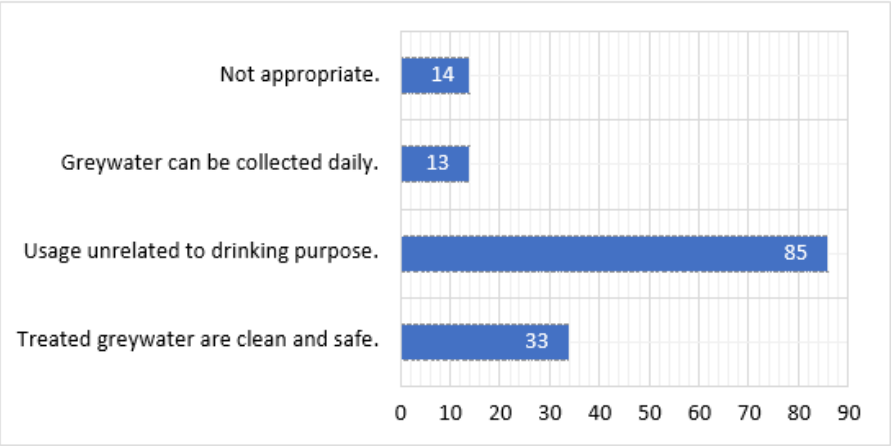

Figure 9: Respondents' reasons for using greywater treated at home

For the data shown in Figure 9, the respondents are asked why they use treated greywater at their home, with 4 multiple choices of answers being provided. Out of 122 respondents, 85 of them agreed to use this greywater as its usage is not related to drinking purposes. As treated greywater may be used to water plants, flush toilets, wash vehicles, and wash clothing, it may persuade them to choose this alternative. Based on the prior explanations about their discomfort with this option, they are willing to utilize this water for non-potable purposes other than cooking.

Only around 33 out of 122 respondents believe that treated greywater is clean and safe to use in their house, maybe because they have no experience utilizing it for home applications. Respondents may also believe that this treated water cannot be utilized for potable purposes as it still contains pollutants. Their reasons can be further enhanced by their concern about the effectiveness of this water in cleaning clothing and the complications that may happen to their plants if this water is not safe for them. Only 13 respondents agreed to use this water in their homes because it could be collected daily, and only 14 thought it was inappropriate to use in their homes. It may be influenced by the fact that there are other better alternatives for respondents to use rather than options that have not been proven effective.

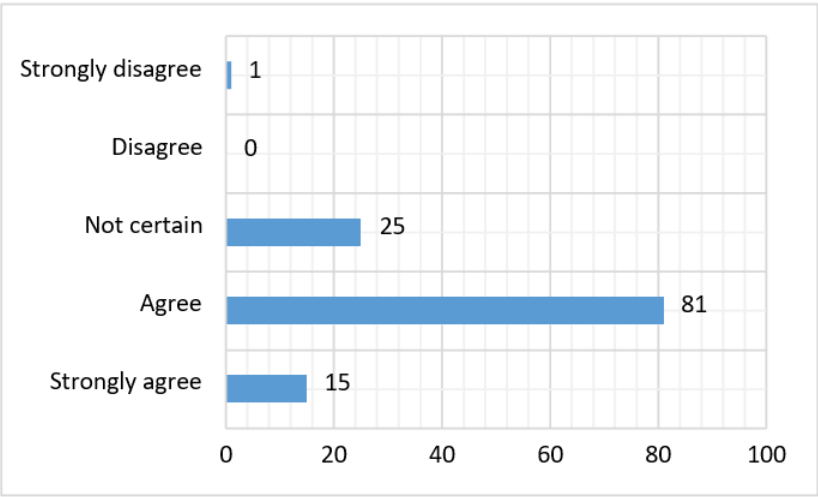

Figure 10: Perception on the treated greywater impact in conserving clean water resources

In this question, the opinions of the respondents regarding the impact of greywater in conserving clean water resources are being asked with five options answers provided: Strongly agree, Agree, not certain, Disagree, and Strongly disagree. A 5-point scale of answers was given to determine the level of acceptability of the respondents towards this statement. Based on Figure 10, 96 out of 122 respondents positively reacted that using treated greywater can help in conserving clean water resources, where 15 of them strongly agree with this statement, and the rest only agree with this statement. 25 out of 122 respondents are uncertain about the influence of greywater treated, while one respondent strongly disagrees that the existence of greywater can conserve clean water resources.

The data in Figure 10 shows that more than half of the respondents are aware that technologically enhanced alternatives can impact the environment. They are also deeply concerned about the current environmental crisis, in which pollution in the river is rising annually, as well as aware that depending on clean water resources can never address water scarcity problems. Respondents who are unsure and disagree with this statement may be unaware of the benefit of using alternative water sources for the society and environment as well as for the development of the country itself.

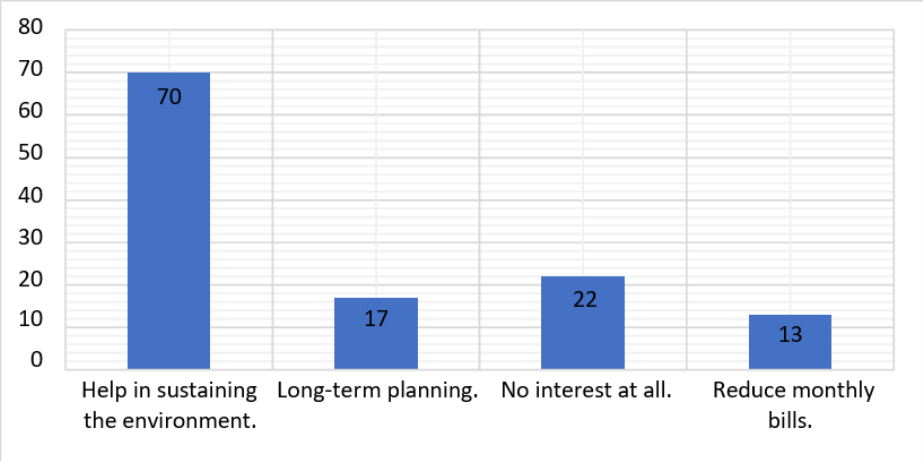

Figure 11: Respondents' willingness to re-plumbing into greywater

As shown in Figure 11, there are four multiple-choice reasons for the respondents' readiness to re-plumb their home into greywater. This will demonstrate their concern about upgrading and spending money to put the system in their home for future use. About 82% of the respondents are willing to upgrade their plumbing system, whereas the rest aren't interested. 57% out of 82% of the respondents justified that they are willing to tear-plumb to help sustain the environment. These respondents understand clean water supplies may become scarce at any time and are accountable for taking action to conserve them properly. They also noticed that wastewater effluent created daily is a huge waste if not utilized for other beneficial purposes.

14% of the respondents are willing to upgrade their plumbing system for long-term planning. In this scenario, they understand how a water shortage event might affect them, and planning to overcome it is a reasonable solution to ensure that they can manage clean water effectively if a water scarcity event occurs again. Furthermore, 11% of respondents said they are

considering lowering their monthly bills if they upgrade to this system. Even if the initial cost of re-plumbing this system is rather high, the return will be obtained afterward, and this is how much they are willing to spend on it. Plus, as clean water consumption was limited to potable usage and showering only, a reduction in their monthly costs would be proven later if they utilized greywater treated efficiently for domestic usage.

The remaining respondents who are unwilling to use this system comprise 18%. They may be unwilling to re-plumb because they do not feel that this treated greywater will significantly impact their daily clean water use. They may also be unwilling to spend money on this option rather than attempting other alternatives, such as installing an additional water tank or putting some effort into collecting water before any water scarcity crisis occurs.

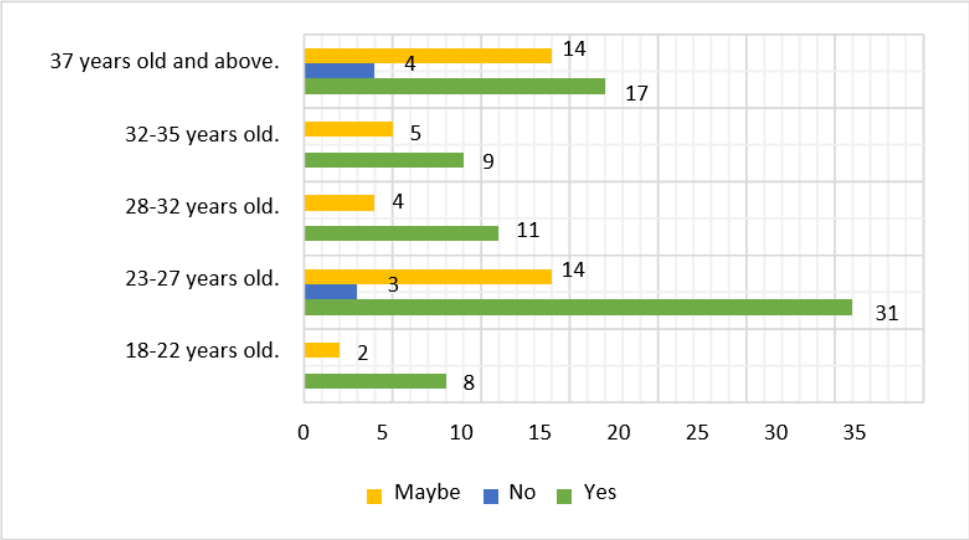

Figure 12: Respondents' perception in supporting government initiative towards the implementation of a greywater system

For the last question, respondents were asked if they would support the government if this initiative were extensively implemented in Malaysia. As shown in Figure 12, the data is being examined by age groups to identify which group will strongly support this initiative. According to the survey, all age groups have positive views, with 76 out of 122 respondents from each age group agreeing to support the government for this initiative. Meanwhile, 39 respondents across all age categories are hesitant to support the government, while 8 are unwilling to support this program.

In this situation, where most respondents face water shortage annually, they are willing to help if the government adopts this program widely. They are also aware that without the community's support, any new development initiated by the government will be impossible to achieve, interfering with any government effort to fix any problem involving necessary needs. Respondents who expressed doubts about this government initiative may be willing to see the government employing this program initially in public areas such as shopping centres, commercial buildings, and industrial plants. Meanwhile, those unwilling to support the government may not have prepared themselves for something they are uncomfortable with, and they may have concluded that this investment is not worth doing.

Conclusion

The findings of this study show that most respondents in this region occasionally experience water shortages even though the length of time they have lived in the area varies. This demonstrates that although it is in an urban area, this region has water supply issues and that events occur regularly. Greywater definition and origin were observed to be known by respondents with higher education and engineering backgrounds. They also have less knowledge of how treated greywater can be utilized daily. In terms of consumer levels of perceptions on greywater treated, it is noticed that more than half of the respondents (69%) agree that greywater treated can have a good impact during water rationing as they realize that there aren't any other alternatives that might aid them during water rationing. Furthermore, for user willingness towards treated greywater, the gender and age of the respondents were compared to identify any relations from those demographics. It is observed that male has a higher willingness (82%) to use this treated greywater rather than female (80%). Besides, regarding respondents' age, elder respondents (12%) are less willing to accept this water than young respondents (7%). The young respondents who are unwilling to use this treated greywater (7%) tend to be more aware of this option's expense and reliability. These variables may be influenced by the fact that most of them (70%) chose this option since its use is unrelated to drinking purposes. Consumers also disclosed why they are unwilling to use treated greywater, with the most answers being "feels uncomfortable" and "have other alternatives". In addition, in terms of education, it is observed that the bachelor's degree holders are less likely to choose this alternative since they are more aware of the nature and procedure of wastewater treatment, where it will be costly, pose a health risk, and feel uncomfortable. However, most respondents (79%) agree that using greywater treatment can benefit the conservation of clean water resources.

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