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User perceptions and acceptance of treated greywater reuse in low-income communities: a narrative review

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ABSTRACT

This research output established that a significant proportion of the global population lives in low-income communities mostly in the Global South. These communities face severe water scarcity and persistent sanitation challenges. It emerged that greywater reuse has the potential to improve the access to sufficient clean water in low-income communities. The study sought to ascertain user perceptions and acceptance of treated greywater reuse in low-income communities. To anchor this research, a comprehensive consultation of literature was done, and key sources of data were drawn from various secondary sources of data such as bibliographic databases. This was followed by the snowballing of obtained papers. The research employed a narrative review approach in methodology. The findings of this study indicate that people living in low-income communities have a positive perception regarding reusing treated greywater. Furthermore, it was established that the majority of persons living in low-income communities accept reuse for non-potable purposes including vegetable irrigation, laundry, toilet flushing, and car washing.

Key words: greywater reuse, low-income communities, rural areas, user acceptance, user perceptions, urban slums

HIGHLIGHTS

- Low-income communities lack sufficient clean water and improved sanitation.
- Greywater reuse has the potential to improve water supply in low-income communities.
- A significant percentage of persons living in low-income communities accept reusing treated greywater for both potable and non-potable purposes.

INTRODUCTION

WHO & UNICEF (2021) state that access to water and sanitation is a fundamental human right; however, many people living in low-income communities do not have access to sufficient clean water and improved sanitation. In addition, over 2.2 billion people worldwide still lack access to safe drinking water, and 3.6 billion do not have access to safely managed sanitation services. WHO & UNICEF (2021) estimates that by the year 2030, if progress in this sector continues at the current pace, 1.6 billion people will not have access to safe drinking water and 2.8 billion people will lack proper sanitation facilities. These challenges are more acute in low-income communities, where inadequate access to water and sanitation infrastructure exacerbates existing inequalities and threatens public health (Armah *et al.* 2018). Thus, access to sufficient clean water and improved sanitation are challenges concerning low-income communities across the globe. Through the adoption of Sustainable Development Goal 6 (SDG6) by the United Nations, countries have committed to ensuring access to water and sanitation for all by 2030. Achieving SDG6 in low-income communities, however, is certainly going to take longer than anticipated owing to inadequate access to water and sanitation infrastructure as well as climate change. One potential solution to overcome this challenge is the reuse of greywater as a way of augmenting water resources and improving sanitation in low-income communities (Vergine *et al.* 2017; Ibekwe *et al.* 2018; Ofori *et al.* 2021). In light of the global water scarcity and challenges faced by low-income communities in accessing clean and sustainable water sources, the provision of safe and reliable water supplies is therefore of significant importance to the well-being of these marginalized populations. This research

provides a detailed knowledge of the user perceptions and acceptance of treated greywater reuse as an innovative solution to existing challenges. Furthermore, an understanding of how people residing in low-income communities embrace this alternative provides valuable insights into the broader discourse on water reuse and public health.

The reuse of greywater as an alternate water resource is widely discussed in current research (Zhu *et al.* 2017; Michetti *et al.* 2019; Asmal *et al.* 2022; Peña-Guzmán & Ortiz-Gutierrez 2022; Kordana-Obuch *et al.* 2023). As a water resource, greywater has the potential to increase water availability and address sanitation challenges in low-income communities. When greywater is not reused onsite, it is lost to the environment resulting in water pollution and ecological damage. Dwumfour-Asare *et al.* (2018) observed that in most urban slums, the treatment of greywater is largely neglected. Thus, considering the current condition of urban slums and the need to attain SDG6 by the year 2030, it is imperative to lobby for sustainable interventions in the effective management and possible reuse of greywater. The interventions should consider user acceptance of treated greywater as this largely influences the adoption of water reuse (Jiménez *et al.* 2014; Tilley *et al.* 2014). It has been noted in research that the development of human settlements since prehistoric times is strongly linked to places which had favourable water sources (Angelakis *et al.* 2018; Oteng-Peprah *et al.* 2018). Nonetheless, user acceptance of greywater reuse is not extensively studied in communities populated by persons of a low socioeconomic status. Previous studies have focused on the search for new sources of water and its acceptance in more developed parts of urban settlements.

Greywater or sullage is that portion of wastewater generated from domestic activities such as bathing, laundry, and dishwashing (Ludwig 1997; Eriksson *et al.* 2002; Peña-Guzmán & Ortiz-Gutierrez 2022). About 75% of the wastewater generated at the household level in an urban setting is greywater (Hernandez Leal *et al.* 2010). Greywater is therefore an important alternative source of water. Several studies have highlighted the potential benefits of greywater reuse in low-income communities. A study by Mekonnen & Hoekstra (2016) established that greywater reuse can reduce freshwater consumption by up to 48%, which can help alleviate water shortages in low-income communities. Furthermore, greywater reuse can also reduce the burden of wastewater treatment and disposal, which is a major challenge in many low-income communities (Awolusi & Ilemobade 2018). Wastewater management systems are often inadequate in urban slums (WHO 2021). Thus, a significant portion of wastewater generated in poor neighbourhoods finds its way into natural ecosystems without treatment (Asmal *et al.* 2022). Reusing greywater hence can lower the volume of wastewater discharged into open drains and reduce the risk of water contamination. Discharge of wastewater in open drains has a significant impact on the health of the residents, as waterborne diseases are prevalent in urban slums due to a lack of proper sanitation facilities (Stoker *et al.* 2017).

Despite its potential benefits, greywater reuse is still underutilized in low-income communities. Furthermore, limited studies exist which investigate attitudes and user perceptions of greywater reuse in low-income communities in the global south. There is no sufficient data generated through scientific research and review articles detailing the acceptance of reusing greywater in low-income communities. Nevertheless, research indicates that public perception and attitude are significant contributors to the success of a new initiative (Oteng-Peprah *et al.* 2018). It is out of this realization that this article seeks to fill the above research gap. This research indicates that several water reuse programs that were technically sound and environmentally friendly have failed due to non-acceptance by their intended target audience, particularly in low-income communities (Jiménez *et al.* 2014; Seymour & Hughes 2014; Tilley *et al.* 2014; O'Keefe *et al.* 2015; Sinha *et al.* 2017; Oteng-Peprah *et al.* 2018). Thus, developing an effective greywater reuse system must take into account user perceptions before implementation (Jiménez *et al.* 2014; Tilley *et al.* 2014; Seymour & Hughes 2014; O'Keefe *et al.* 2015). Therefore, this study aims to review the literature on user perceptions and acceptance of treated greywater reuse in low-income communities. Water reuse in low-income communities dates back 5,000 years (Angelakis *et al.* 2018). However, the reuse of greywater in these settlements in contemporary times has lagged behind in comparison to affluent urban suburbs. People living in most urban communities in the developed world accept water reuse even for potable uses (Angelakis *et al.* 2018). The information presented in this article elucidates the impact of user perceptions and acceptance of reusing treated greywater in low-income communities.

According to Portman *et al.* (2022), user perception refers to commonly held beliefs or opinions shared by the community, usually based on social and cultural characteristics The findings of this research will inform the development of policies and strategies that prioritize greywater reuse for sustainable and equitable access to water and sanitation in low-income communities, in a bid to attain SDG 6. In this review, the terms low-income community, township, informal settlement, and urban slum will be used interchangeably to refer to unplanned and densely populated settlements or housing areas in urban settings with inadequate infrastructure and limited access to basic services and social amenities. Often, the occupants of such settlements are low-income earners, immigrants, or refugees. People living in such areas do not have access to clean water and

improved sanitation and often face severe health risks, and social exclusion (Zahanggir *et al.* 2013; Dwumfour-Asare *et al.* 2018; Khaled *et al.* 2022).

MATERIALS AND METHODS

This narrative review was conducted by searching various bibliographic databases, including Web of Science, Elsevier, Google Scholar, and PubMed. The search was carried out using the following terms: 'Greywater', 'Greywater reuse', 'User perceptions', 'Acceptance', 'Low-income-communities', 'Informal settlements', 'Rural areas', and 'Urban Slums'. The study included numerous types of peer-reviewed articles published in English and excluded articles without full text. A search of articles using key terms was followed by a snowballing of obtained papers. In addition, the cited references from the retrieved articles were manually analysed to identify additional research papers.

PUBLIC PERCEPTIONS AND ACCEPTANCE OF GREYWATER REUSE

Reusing treated greywater is gaining popularity owing to a positive public perception of the practice. The acceptance of greywater reuse is attributed to population growth, climate change, increasing urbanization, and the growth of megacities (Gu *et al.* 2015; Zhu *et al.* 2017; Angelakis *et al.* 2018; Anuja *et al.* 2021; Asmal *et al.* 2022). Moreover, the realization that freshwater is a finite resource which should be used sustainably (Angelakis *et al.* 2018). Angelakis *et al.* (2018) noted that ancient communities had no motivation to reuse wastewater as they would move to a new place when their habitation became unliveable. Nonetheless, in the present-day centralized wastewater management systems and improvements in technology pave the way for the reuse of effluent for various purposes. As water scarcity is set to increase spontaneously in various parts of the world in the present decade and beyond, user acceptance of treated greywater reuse is certainly going to change, positively (Bakare *et al.* 2016). The perceived quality of the treated greywater, health, and safety concerns, perception of water scarcity, aesthetics and odour control, social and cultural factors, and reuse purpose are some of the factors that affect the acceptability of treated greywater reuse (Li *et al.* 2012; Maimon *et al.* 2014; Vuppaladadiyam *et al.* 2019; Khajvand *et al.* 2022). In line with the development of new technology, the quality of greywater is certainly going to improve and as a result more people will accept greywater reuse even for potable purposes. Public perceptions hence will continue to play a key role in influencing the success of greywater reuse projects in human settlements (Oteng-Peprah *et al.* 2018). Already various sustainable water and sanitation initiatives both in developed and developing communities have failed completely or operate below capacity owing to a lack of buy-in by users (Jiménez *et al.* 2014; Seymour & Hughes 2014; Tilley *et al.* 2014). Thus, various researchers have explored the perceptions of users on the acceptability of greywater for potable and non-potable uses mostly in planned urban settlements, and to some extent in rural and agricultural areas, and indeed in unplanned urban settlements (Al-Mashaqbeh *et al.* 2012; Uddin *et al.* 2014; Newcomer *et al.* 2017; Akpan *et al.* 2020; Thaher *et al.* 2020; Al-Khatib *et al.* 2022). In low-income communities, acceptance of the non-potable reuse of greywater is high (Newcomer *et al.* 2017; Akpan *et al.* 2020; Al-Khatib *et al.* 2022). These studies highlighted a negative perception of treated greywater reuse for potable reuse in low-income communities. The following section thus presents the findings of user perceptions on reusing treated greywater for various purposes as reported by research papers obtained during the literature search.

User perceptions and acceptance of reusing treated greywater for vegetable irrigation

The practice of reusing greywater for irrigation is as old as mankind (Bakare *et al.* 2016; Angelakis *et al.* 2018; Oteng-Peprah *et al.* 2018; Akpan *et al.* 2020). Nonetheless, in prehistoric times reuse of wastewater for irrigation was limited owing to segregation of communities and nomadic pastoralism which characterized these communities at that time (Lofrano & Brown 2010; Angelakis *et al.* 2018). The use of recycled water for the purpose of irrigation began when man established permanent settlements (Angelakis *et al.* 2018). In these settlements, particularly in the Indus Valley, utilization of treated wastewater for irrigation and fertilization of crops began as combined wastewater and stormwater management systems were developed (Lofrano & Brown 2010; Tzanakakis *et al.* 2014; Angelakis *et al.* 2018). Tolle-Kastenbein (2005), however, argued that the Greeks were the first people to utilize treated wastewater for irrigation. Indeed, archaeological evidence from the classical period indicated that sewage and stormwater systems discharged effluent downhill of agricultural lands (Tzanakakis *et al.* 2014; Kollyropoulos *et al.* 2015; Angelakis *et al.* 2018).

Reusing wastewater for the purpose of irrigation in earlier civilizations was meant to attain food security and enhance public health (Kollyropoulos *et al.* 2015; Angelakis *et al.* 2018). In the modern context, acceptance of reusing greywater for the purpose of irrigation is meant to reduce food shortages arising from mid-season dry spells, seasonal droughts,

and climate change. In urban slums, however, reusing greywater in the household is perceived as a way of augmenting water supply for various purposes including irrigation. According to the research findings by Akpan *et al.* (2020), there is a relatively favourable perception among users regarding the use of greywater, for irrigation purposes, specifically for vegetable cultivation. Approximately 60% of Akpan *et al.* (2020) respondents in the study expressed a positive attitude towards this practice and accepted the reuse of treated greywater for watering their gardens. In a study by Al-Khatib *et al.* (2022), the majority of the respondents (62%) expressed openness and willingness to use greywater for irrigating vegetable crops. In a separate study by Newcomer *et al.* (2017), a high acceptance rate of 80% was reported for vegetable irrigation using treated greywater. Users in these studies were generally open to the idea of using treated greywater for irrigating vegetable crops. The higher acceptance of reusing greywater for vegetable irrigation is attributed to potential resource conservation and environmental benefits (Newcomer *et al.* 2017), and source of nutrients for crops (Al-Mashaqbeh *et al.* 2012; Uddin *et al.* 2014; Thaher *et al.* 2020). In addition, greywater is generally considered as a non-potable source of water and as a result users are often inclined to accept its use for irrigation purposes (Thaher *et al.* 2020; Al-Khatib *et al.* 2022). Various studies reported that users perceive treated greywater as overly appropriate for irrigation in comparison to other uses such as drinking, cooking, or bathing (Po *et al.* 2003; Al-Khatib *et al.* 2022). As a result, acceptance for reusing greywater is high.

A high user perception and acceptance of vegetable irrigation obtained in this study conforms to results from wider research. Findings in this research article not only contribute valuable insights with a focus on low-income communities but also align with and reinforce the results reported by researchers in studies focusing on planned settlements. Gu *et al.* (2015) observed a 99.4% acceptance rate among users, highlighting the positive reception of vegetable irrigation practices. This study focuses on public receptivity toward the use of treated greywater water in Tianjin urban centre in northern China. Similarly, Alhumoud & Madzikanda (2010) found an acceptance rate of 75.28%, further confirming acceptance of greywater reuse for vegetable irrigation. This paper by Alhumoud & Madzikanda (2010) focuses on public perceptions of water reuse in Metropolitan Kuwait. It presents the findings of a questionnaire survey conducted among over 1,500 households. Portman *et al.* (2022) conducted an exhaustive perceptions survey and reported an acceptance of 90%. Moreover, Zhu *et al.* (2017) examining the public perception and acceptability of reclaimed water in Shandong Province China, reported a user acceptance rate of 81% demonstrating substantial user acceptability of vegetable irrigation using treated greywater. Thus, this congruence with the result of the current study results reflects a general acceptance of reusing treated greywater for vegetable irrigation across various contexts.

In this study, the high acceptance rate indicates a positive perception and recognition of the potential benefits of greywater reuse in enhancing sustainable water management in low-income communities. This can be attributed to several factors. One of the key factors that was highlighted by numerous authors is the level of education of users (Akpan *et al.* 2020; Thaher *et al.* 2020; Al-Khatib *et al.* 2022). Respondents with a higher level of education were more willing to accept the reuse of treated greywater for vegetable irrigation (Gu *et al.* 2015; Zhu *et al.* 2017). According to Al-Mashaqbeh *et al.* (2012), users understand that it is unsustainable to irrigate vegetables with potable water in regions where water is scarce. It appears respondents were aware that treated greywater can serve as a sustainable and cost-effective water source for irrigation, reducing reliance on freshwater supplies (Newcomer *et al.* 2017; Al-Khatib *et al.* 2022). This understanding of the potential benefits aligns with the growing global concern for water conservation and the need for sustainable irrigation practices. In addition, the positive perception may be attributed to the understanding that treated greywater can provide essential nutrients for plant growth, contributing to increased crop yield and indeed food security in low-income communities (Portman *et al.* 2022). This view further supports the acceptance of greywater reuse in low-income settings, particularly for vegetable cultivation. Furthermore, the research findings imply that respondents recognize the importance of addressing water scarcity challenges by utilizing unconventional water sources. Persons living in low-income communities thus have a significant level of environmental consciousness and a willingness to adopt innovative solutions for sustainable water management at the community level. Thaher *et al.* (2020) attributed the acceptance of greywater reuse in low-income communities to the prevailing economic situation. People living in these communities are faced with food shortages and rampant poverty. As a result, they are more willing to accept an intervention that seeks to improve their livelihoods. By using nutrient-rich greywater for irrigation, residents can grow food for their own consumption and sell surplus to neighbours. It is evident that the opportunity to earn an income in this resource-constrained community is a major factor that influences the acceptance of reusing greywater for vegetable irrigation.

User perceptions and acceptance of reusing treated greywater for toilet flushing

The use of treated greywater for toilet flushing is acceptable in low-income communities. This study noted that the level of acceptance of reusing greywater for the purpose of toilet flushing is similar to that of reusing greywater for vegetable irrigation. These two reuse purposes do not involve direct contact with effluent which could allay any fears of water quality issues. Akpan *et al.* (2020) reported an acceptance rate of 80%. The positive perception of using treated wastewater for toilet flushing is likely to have been influenced by the participants' understanding of its non-potable nature. The study revealed that the majority of the respondents (87%) did not accept the use of treated greywater for potable uses such as drinking and cooking. Findings corroborate published results from similar studies regardless of different contexts. Gu *et al.* (2015) asserted that 95% of service users accept this practice. The same acceptance rate (95%) was reported in a study by Portman *et al.* (2022) and a similar study by Zhu *et al.* (2017). It is evident that users are comfortable using treated greywater for toilet flushing. In these studies, it is reported that the major determinants of user acceptance of greywater reuse are education level, age, and social standing (Gu *et al.* 2015; Zhu *et al.* 2017; Portman *et al.* 2022). Gu *et al.* (2015) and Zhu *et al.* (2017) asserted that users with a higher education and income level are more willing to reuse greywater and also pay for it. Zhu *et al.* (2017) observed that young people are more willing to accept the reuse of greywater for toilet flushing in comparison to the elderly. The older respondents (aged 40 and over) have a poor receptivity toward greywater reuse. The findings from the study by Khatib *et al.* (2022) nevertheless present a different perspective. They noted that greywater reuse for toilet flushing was not widely accepted, with only 28% of the respondents expressing a willingness to reuse greywater for this purpose. The difference in acceptance rates could be attributed to various factors, such as regional differences, cultural norms, and individual preferences (Jamrah *et al.* 2007; Ilemobade *et al.* 2013). It is possible that participants in the study by Khatib *et al.* (2022) had specific concerns or reservations about using greywater for toilet flushing, this however was not discussed by the authors. Another study by Buyukkamaci & Alkan (2013) noted a lower acceptance rate of 52.8%. The authors opined that negative perception and low acceptance of reusing treated wastewater are likely due to perceived health risks. Such findings illustrate the importance of taking into consideration different research contexts in understanding user perceptions and acceptance of reusing greywater for toilet flushing.

User perceptions and acceptance of reusing treated greywater for laundry

In comparison to the aforementioned greywater reuse options, there is a significant variation in users' perceptions and acceptance of reusing treated greywater for laundry. Research indicates user acceptance rates ranging from 21 to 80% for this practice (Alhumoud & Madzikanda 2010; Buyukkamaci & Alkan 2013; Abubakar & Mu'azu 2022; Portman *et al.* 2022). In the current research, it was noted that recent studies observed higher acceptance rates (Abubakar & Mu'azu 2022 (70%); Portman *et al.* 2022 – 80%) owing to increased user awareness of the benefits of wastewater reuse in urban settings. In recent times, the search for alternative water sources has been the driving force behind these higher acceptance rates, as increased awareness among users regarding the benefits of greywater reuse has prompted a more favourable reception of such practices, as evidenced by the studies conducted by Abubakar & Mu'azu (2022) and Portman *et al.* (2022). In contrast, negative perceptions and lower user acceptance rates (21%) reported by Alhumoud & Madzikanda (2010) can be attributed to misconceptions surrounding the potential health risks associated with greywater reuse. A wide difference between user acceptance rates underscores the critical role that public perception and attitudes towards reusing treated greywater determine the acceptability of this source of water in low-income communities. While recent research has indicated a positive trend in acceptance, the persistence of negative perceptions rooted in quality and health concerns highlights the need for comprehensive user awareness to address misconceptions and promote informed decision-making regarding alternative water sources.

In low-income communities, user perceptions regarding the use of treated wastewater for laundry are generally positive (Newcomer *et al.* 2017; Akpan *et al.* 2020; Al-Khatib *et al.* 2022). Users are more willing to accept reusing treated greywater for washing clothes. Akpan *et al.* (2020) reported an acceptance of 51%. Newcomer *et al.* (2017) obtained an acceptance of 79%. A higher acceptance for this reuse purpose is attributed to potential time savings and environmental benefits associated with using treated greywater for washing clothes (Li *et al.* 2012; Maimon *et al.* 2014; Shi *et al.* 2018; Vuppaladadiyam *et al.* 2019; Khajvand *et al.* 2022). Women living in low-income communities spend a lot of time collecting water because such settlements do not have indoor piped water and often rely on standpipes located at designated points within the community. Thus, reusing treated greywater for laundry purposes unlocks another source of water for people living in low-income communities. Overall, the findings of this study point to a rising acceptability of the use of recycled greywater for laundry.

Nonetheless, to raise acceptance rates, a few issues still need to be resolved. This includes user concerns regarding the safety of greywater reuse as well as the necessity for affordable and user-friendly greywater reuse systems.

User perceptions and acceptance of reusing treated greywater for car washing

Another common reuse purpose for treated greywater is car washing. This study found that there is significant potential for greywater reuse in urban communities in China, the USA, Australia, and in the developing world. Two related studies by Gu *et al.* (2015) and Zhu *et al.* (2017) reported acceptance rates of 92 and 91%, respectively. Furthermore, a study by Portman *et al.* (2022) found that 70% of respondents in the United States were willing to reuse treated greywater for car washing. The considerably high acceptance rates suggest that users have a favourable opinion of reusing greywater for car washing. Given the high acceptance rates, it indicates that users are aware of the possible advantages of greywater reuse, including water conservation and environmental sustainability (Mourad *et al.* 2011; Angelakis *et al.* 2018; Taher *et al.* 2019; Mu'azu *et al.* 2020; Abubakar & Mu'azu 2022). Water conservation is a critical factor influencing acceptance rates. In regions facing water scarcity, particularly in some parts of China, the USA, and Australia, users are likely to be more receptive to greywater reuse for car washing as it helps reduce the demand for freshwater resources, thus contributing to water conservation efforts. Various authors emphasized the importance of water conservation in promoting greywater reuse (Taher *et al.* 2019; Mu'azu *et al.* 2020; Abubakar & Mu'azu 2022). In the context of low-income communities, the observations from the research conducted by Akpan *et al.* (2020) and Khatib *et al.* (2022) provide insights into user perceptions and acceptance of greywater reuse for car washing. According to Akpan *et al.* (2020), 73% of the participants in the study had a positive user perception regarding the use of treated greywater for car washing. This suggests that a significant majority of the participants were open to the idea of using greywater for this particular purpose. The authors opined that positive perceptions could be influenced by factors such as environmental consciousness, resource conservation, and cost savings associated with using recycled water. On the other hand, Khatib *et al.* (2022) reported that 49% of the participants in their study had positive perceptions about using treated wastewater for car washing. While this percentage is lower than the previous study, it still indicates that a considerable portion of the participants accepts greywater reuse for this purpose. It is important to note that the differences in percentages could be attributed to various factors such as the sample size, geographical location, cultural backgrounds, and individual preferences. Furthermore, factors like awareness campaigns, education, and the availability of reliable and efficient treatment systems might also influence perceptions and acceptance. In two studies carried out in China, Gu *et al.* (2015) and Zhu *et al.* (2017) reported that users with higher education are receptive to reusing greywater for various purposes including car washing, toilet flushing, and irrigation of urban gardens. Nonetheless, the cultural and socioeconomic background must be well understood as this significantly affects decision-making at a community level (Al-Khatib *et al.* 2022; Portman *et al.* 2022). A study of the salient attributes of the local participants is key to assessing the acceptance of reusing treated greywater at the household level.

User perceptions and acceptance of reusing treated greywater for drinking

Various studies indicate a negative user perception of reusing greywater for drinking purposes in low-income communities (Newcomer *et al.* 2017; Akpan *et al.* 2020; Al-Khatib *et al.* 2022). A study carried out by Akpan *et al.* (2020) revealed that the majority of respondents (87%) expressed strong reservations about consuming treated greywater directly as drinking water. Only 13% of the respondents in this study accepted the reuse of treated greywater for drinking purposes. It is widely accepted that concerns about potential health risks and the perception of wastewater as unclean were the primary factors influencing this negative perception. Users often have concerns regarding the presence of various pathogens and pollutants in treated greywater. Pathogens and chemicals present in greywater, however, can be removed by improved treatment methods. Thus, water quality concerns could be addressed by education of users and wide dissemination of knowledge of greywater treatment processes at the community level (Domènech & Saurí 2010; Shafiquzzaman *et al.* 2018; Chfadi *et al.* 2021; Flint & Koci 2021).

In a similar study by Al-Khatib *et al.* (2022), user perceptions of reusing greywater were also negative. The authors reported that only 7% of respondents accepted the reuse of greywater for drinking. Furthermore, the researchers noted a slight increase (10%) in acceptance of greywater reuse for drinking purposes if it is centrally treated. Respondents had concerns with home treatment; however, acceptability increased in cases where greywater was treated in a centralized treatment facility (Newcomer *et al.* 2017; Akpan *et al.* 2020; Al-Khatib *et al.* 2022). Increased acceptance of centrally treated greywater

could be attributed to a perceived increase in water quality. Thus, there is a need to consider greywater treatment options that increase the quality of treated water when developing reuse projects in low-income communities in the Global South.

User perceptions and acceptance of reusing treated greywater for cooking

The acceptance of treated greywater reuse for cooking at the household level is limited, as indicated by several studies (Newcomer *et al.* 2017; Akpan *et al.* 2020). People living in low-income communities have a negative perception of reuse water quality, and as a result, greywater reuse for potable purposes such as cooking is not common. Investigating the feasibility of greywater reuse for different domestic activities in a rural area in Malawi, Newcomer *et al.* (2017) reported an acceptance of 11% for greywater reuse for cooking at the household level. It was established that the presence of pathogens and pollutants was the key factor influencing decision-making towards greywater reuse. The authors assessed the presence of *Total coliform* and *Escherichia coli* in the water samples and noted that *E. coli* concentrations in eight domestic greywater sources ranged from 100 to over 20,000 colony-forming units (cfu)/100 ml. Negative user perception of reusing greywater owing to the perceived presence of pathogens has also been reported in studies by Benami *et al.* (2016), Vuppaladadiyam *et al.* (2019) and Khajvand *et al.* (2022). In a similar study examining the public perceptions of treated wastewater reuse in urban communities of developing countries, Akpan *et al.* (2020) reported that public perception of using treated wastewater for cooking was generally negative (18% acceptance). Participants expressed concerns about the potential transmission of pathogens and contaminants from wastewater to food during the cooking process corroborating the earlier findings by Newcomer *et al.* (2017).

CONCLUSION

People living in low-income communities do not have access to sufficient clean water and improved sanitation facilities. In this study, it was noted that one way of improving water supply and sanitation is through the reuse of treated greywater. The study established that the majority of residents in low-income areas demonstrate a willingness to embrace treated greywater reuse, especially for various non-potable purposes such as laundry, toilet flushing, car washing, and vegetable irrigation. Nonetheless, the acceptance of greywater reuse for potable purposes remains low, primarily attributed to concerns of perceived water quality and health issues, sociocultural background, demographics, and education level. It is crucial to address these concerns by focusing on user education and community awareness programs. These initiatives enhance the perception of treated greywater and its acceptance as a safe and reliable water source. This study lays a foundation for further research inquiry to obtain user perceptions and acceptance of greywater reuse at the community level. A global approach adopted in this study may not be a true representation of the views of people in different geographical locations. In addition, the findings of this study inform and provide a foundation for relevant stakeholders to create sustainable initiatives to promote greywater reuse in low-income communities.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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