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Factors, Challenges and Management of Greywater Disposal: A Case Study of Limbu Busty, Darjeeling

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Abstract

Greywater is the used water from sinks, laundry machines, and bathtubs that isn't from toilets. Several houses in Darjeeling discharge this water straight into streams and drains, which causes pollution, health hazards, and environmental issues. Due to inadequate water systems and fast urbanization, the town continues to experience water shortages despite heavy rainfall. Using random sampling, this study examines the difficulties and solutions for managing greywater in the Darjeeling Hills, with a particular focus on Limbu Busty (Ward No. 31). The findings shows that easy, inexpensive fixes like covering open drains, reusing greywater safely, and employing eco-friendly techniques can have a significant impact. Communities can safely manage greywater, conserve water, and enhance health and hygiene in the hills with the correct training, government assistance, and awareness campaigns.

Keywords: Darjeeling Hills, Greywater, Wastewater Management, Eco-friendly Practices, Public Awareness, Water Conservation

1. Introduction

Greywater is wastewater from the houses that hasn't been treated and doesn't include toilet waste. It usually has water from washing machines, laundry tubs, hand basins, bathtubs, showers, and floor waste (Zhao, 2019). The water turns grey and cloudy when it is stored for even a short time, which is why it is called greywater (WHO, 2006[3]). The main issue is that greywater, which could be useful, is still seen as trash (Vuppaladadiyam et. al., 2019). Given the growing lack of water, weak

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ecosystems, and poor infrastructure, using greywater reuse could be a long-term solution (Prakash et al., 2024). To turn greywater from a dangerous waste into a useful resource for the future, we need to raise awareness, include indigenous practices, and make policies that are relevant to the situation (Ndubuisi, 2025).

In hilly towns like Darjeeling, which is in the Eastern Himalayas, there is a constant water crisis even though it gets a lot of rain each year (Tamang, 2024). The shortage is caused by things like the terrain, the fast growth of cities, changes in the seasons, and an old water supply system from the colonial era (Ghatani, 2021). The town's fragile urban environment, growing population, and health problems, among other things, show how important it is to focus on managing household wastewater, especially greywater, which is often left out of water policy and planning (Madungwe & Sakuringwa, 2007). People in the area often put their greywater directly into drains or Jhoras, which then flow into nearby streams and rivers. In some cases, blackwater is even mixed into these channels, which has a big effect on the quality of the water downstream, where it might still be used for household purposes (Baldwin, 2021). This practice may present considerable environmental and health hazards (Samanta et al., 2020). Thus, the study is important for managing grey water in the hilly area of Darjeeling.

2. Review of Literature

Kadlec and Wallace (2009) offer a thorough synthesis of treatment wetland design principles, highlighting their adaptability and effectiveness. However, a 2009 review by Arias and Brix demonstrates that horizontal subsurface flow wetlands are an effective way to remove suspended solids and organic pollutants from household greywater. Nonetheless, Massoud et al. (2009) contend that decentralized wastewater treatment systems are affordable, flexible, and ideal for developing nations, especially those with isolated or hilly terrain. Similarly, Fletcher et al. (2015) show that nature-based solutions and Sustainable Urban Drainage Systems (SUDS) are effective ways to manage stormwater and decentralized wastewater in steep or mountainous terrain. For the best treatment performance, the study highlights design adaptation to slopes, runoff variability, and space constraints (Oteng-Peprah et al., 2018).

Five decades of worldwide experience are summarized by Vymazal (2014), who demonstrates that artificial wetlands are a reliable, affordable, and adaptable wastewater treatment technology. Furthermore, Baker et al. (2016) investigate the difficulties associated with waste management in mountainous areas, emphasizing operational limitations, environmental hazards, and sources. According to Scholz (2016), compact, well-designed wetlands can effectively remove pollutants, but they

need to be carefully managed in terms of loading rates, hydraulics, and seasonal fluctuations. On the other hand, Arden and Ma (2018) point out that artificial wetlands, particularly when combined with sufficient retention time and recirculation, efficiently remove chemical and physical contaminants from greywater. Moreover, decentralized, inexpensive treatment systems can successfully facilitate non-potable reuse, but they encounter difficulties with pathogen elimination and public acceptance (Massoud et al., 2009; Fletcher et al., 2015; Oteng-Peprah et al., 2018).

According to Fletcher et al. (2019), nature-based wastewater treatment systems in small towns offer several advantages, such as improved water quality, reduced risk of flooding, and ecological improvement. Van der Hoek and Veenstra (2020) point out that while greywater reuse has a lot of potential to lower urban water demand, it is limited by system integration issues, regulatory gaps, and health risks. Furthermore, Kayser, García, and Nascimento (2020) contrast decentralized wastewater treatment systems, emphasizing how well suited they are for isolated and hilly communities. Indeed, Boano et al. (2021) demonstrate that low-tech, small-scale wastewater treatment systems work well for rural and mountain communities, providing reasonably priced, locally adaptable solutions.

In the same way, Ma and Sutton (2022) point out that greywater reuse improves urban water systems' resilience, especially in hilly and small towns. Li et al. (2024) emphasizes the effectiveness of decentralized wastewater treatment technologies for rural domestic wastewater, emphasizing adaptability regarding small-scale and space-constrained sites. The study also emphasizes the importance that low-cost solutions, maintenance, and local context are to long-term operation.

3. Theoretical framework

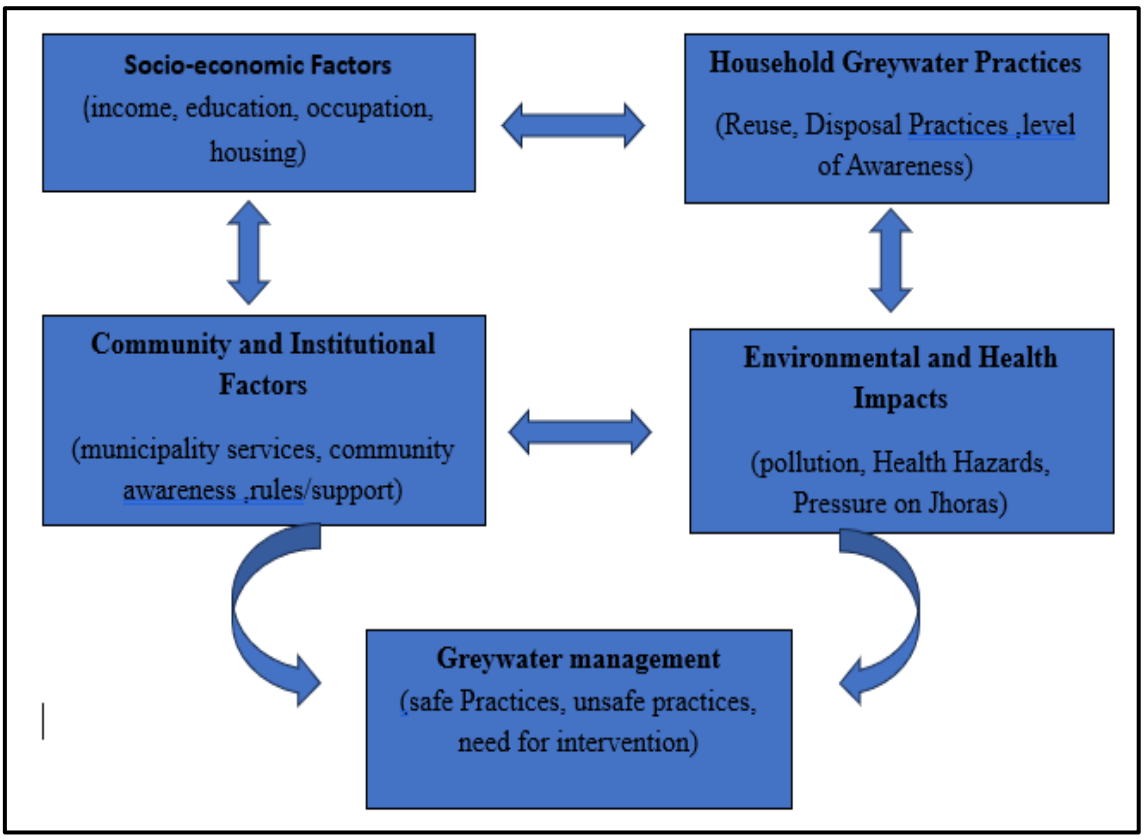
We have chosen the "Human Ecology Theory" for our study, which was given by Amos H. Hawley in 1986 and serves as a guide or aid in our comprehension of the interaction between humans and their surroundings (Hawley, 1986). The theory examines how human interactions with the environment impact society and the environment. Additionally, it views humans as part of an ecological system where social, cultural, and economic activities as well as changes in the environment affect human life. It draws attention to adaptation, resource use, and how human activity affects the environment. For example, building houses on slopes can affect soil stability and water flow, and improper greywater disposal can contaminate streams and adversely affect downstream users in hilly towns like Darjeeling. Similarly, overuse of water or fertilizers can also degrade the quality of soil and water.

Because it explains why people dispose of greywater in specific ways, how these practices affect ecosystem health and water quality, and what interventions such as treatment systems, infrastructure upgrades, or awareness campaigns can support safe and sustainable wastewater management, the Human Ecology Theory is particularly relevant to wastewater management.

4. Conceptual Framework

This study's conceptual framework helps in comprehending the various elements influencing greywater management in Limbu Busty, Darjeeling. It demonstrates how socioeconomic factors—such as a person's income, education, employment type, and housing have a significant impact on how they manage greywater. It also covers domestic habits like recycling or discarding greywater and the degree of health and safety consciousness. Both the environment and human health are impacted by these practices. For instance, improper disposal of greywater can strain natural streams like *Jhoras* and result in pollution and illnesses. Support from the government and local community is also cited as a crucial element. This covers local awareness campaigns, regulations, and municipal services. Together, these factors determine whether greywater management is done safely or not.

Figure No. 1: Conceptual Framework for the Study



Source: Prepared by Authors

This framework aids the study by illuminating the connections between environmental health, household practices, community systems, and people's living conditions. It aids in determining the primary issues and the areas that require attention, such as increased community involvement, improved infrastructure, and education. It provides a clear structure to study the issue and suggest solutions.

5. Data & Methodology

The socio-economic factors influencing household wastewater disposal in Limbu Busty (Ward No 31), Darjeeling, are investigated using a mixed-method research design that combines quantitative and qualitative techniques. While qualitative insights enhance the analysis with local context and behavioral patterns, the quantitative component offers quantifiable data on demographic and socioeconomic variables. In-depth interviews with household members are part of the study. The study's target population consists of households in Limbu Busty, a settlement in the Darjeeling Municipal area. A sample size of 60 households was chosen to represent a representative cross section of the community affected by or involved in wastewater disposal practices. Convenience sampling and purposive sampling were combined.

The selection of households that directly dispose of wastewater into neighboring Jhoras or do not have formal drainage systems was guaranteed by the use of purposeful sampling. The researcher was able to choose respondents who were available and willing to take part in the survey during the fieldwork period by using convenience sampling.

Both primary and secondary sources of data were gathered. A semi-structured questionnaire is used to collect primary data from the 60 households that were chosen. Socio-economic traits, water supply type, access to sanitation, and wastewater disposal techniques were all covered in the questionnaire. On the other hand, secondary data was gathered from official reports from the Darjeeling Water Works Department, prior research studies, municipal records, and pertinent literature on waste and water management in hilly areas. In addition to graphical analysis using bar graphs and pie charts to reveal obvious patterns and relationships between socioeconomic variables and disposal behavior, the data was analyzed using descriptive statistics tools like mean and frequency distribution to summarize and present household characteristics and wastewater practices.

6. Brief Profile of the study area

The Indian state of West Bengal contains the district town of Darjeeling in its northern most region. With a latitude of 27 °13'N to 26 ° 27 N and a longitude of 85

° 53 'E to 87 °59 'E, the town is situated on the Darjeeling-Jalapahar range of the Darjeeling Himalayan hill region at an average elevation of 6710 feet. According to the 2011 Census of India, Darjeeling town is a municipality that occupies 13.81 square kilometers and is made up of 32 wards with a total population of 120414 and about 21122 households.

For a number of significant reasons, Limbu Busty, which is situated in Darjeeling Municipality's Ward No. 31, was chosen as the study area. Due to its location on a hilly slope and medium population density, this settlement is ideally suited for research on greywater management. Because of its location and inadequate infrastructure, the area has a number of drainage, sanitation, and waste disposal issues. In Limbu Busty, the majority of homes release untreated greywater into neighboring Jhoras, or natural streams. Since other locals also use these streams for washing and occasionally for drinking water, this practice is dangerous.

Limbu Busty is a perfect place to investigate the issues and procedures surrounding greywater disposal because of the absence of adequate drainage systems, low awareness, and low income. The fact that no thorough or scientific study on greywater management had previously been carried out in this region is another factor in the decision. This provided a chance to gather fresh information and perspectives that might help make things better. Additionally, it was easier to conduct surveys and interviews because the locals were willing to take part in the study. In addition, Limbu Busty is representative of many urban poor settlements in hill towns, where waste and water management are more challenging due to the terrain, space constraints, and lack of resources.

Researching this region can help in comprehending comparable issues in other hilly areas and even other parts of Darjeeling. Because of its inadequate drainage system, obvious waste issues, lack of awareness, and community's willingness to participate in the study, Limbu Busty was selected. It provides an excellent illustration of the difficulties and potential solutions associated with managing greywater in hilly urban areas.

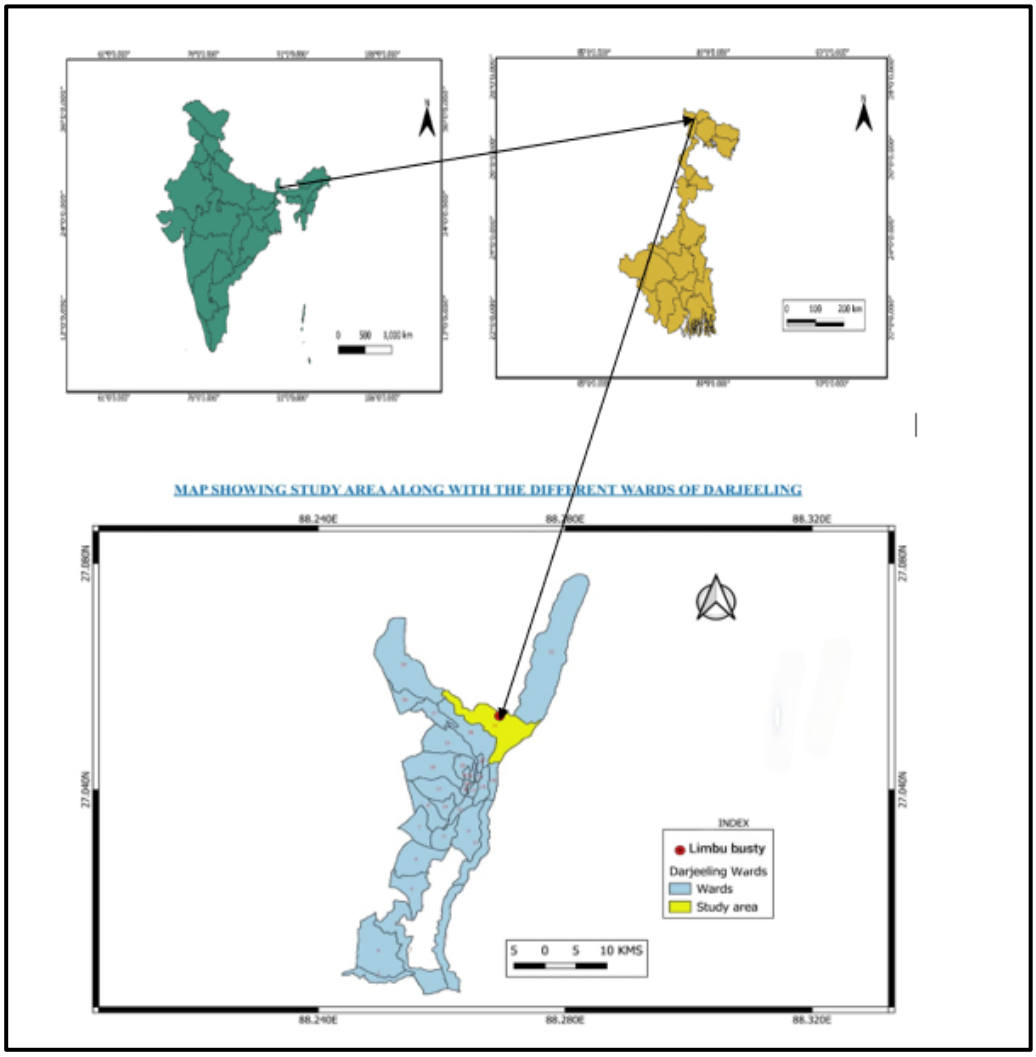


Figure No. 2: Location Map of the study area

Source: Prepared by Author

7. Socio-economic Profiles of Respondents

The survey has covered 60 households. The key socio- demographic characteristics are, age, gender, education, occupation and qualification of the respondents have been taken into accounts. The socio-demographic data reveals that the majority of the respondents were (48%) fall within the 31-45 age group, indicating that most of the responses came from individuals in their working age who are actively involved in household decision making (figure 3). Only a small portion (21%) were senior citizens, which means that the opinions gathered largely reflects the views of the economically active population.

Figure No. 3: Age Distribution of Respondents (in %)

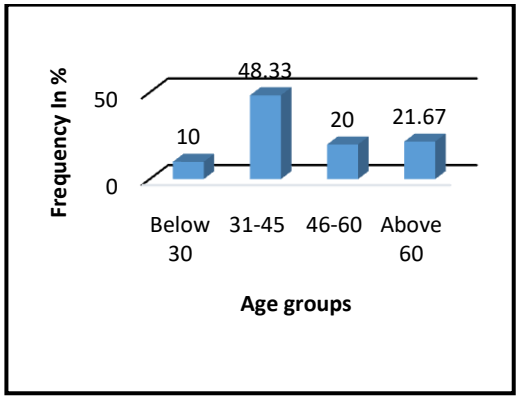
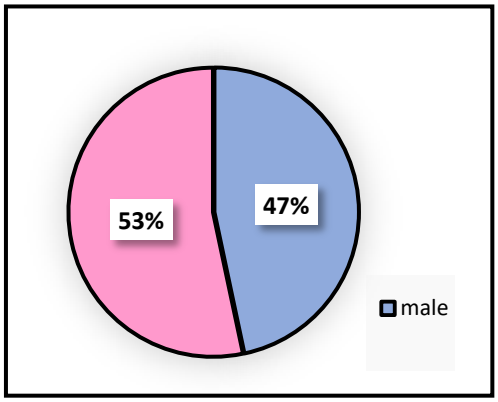


Figure No. 4: Gender Distribution (in %)



Source: Primary Survey, 2025

The gender distribution shows a slightly high number of females respondents (53.33%). This is important as women often manage household level water use and sanitation, and their views play a crucial role in understanding greywater management practices in the community (figure 4).

In terms of education, most respondents had completed secondary (46%) or higher secondary (30%) levels. Only a small number had graduate -level education, which points to limited access to higher education in the area. Since education can influence awareness and adoption of environmental practices, this may be a factor affecting how people understand and manage water (figure 5).

Figure 5: Education Qualification (in %)

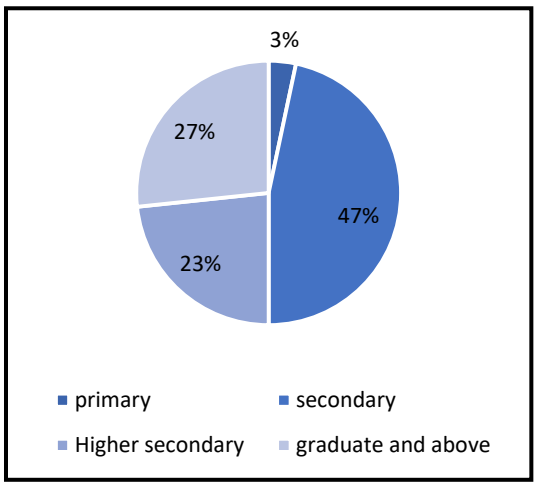
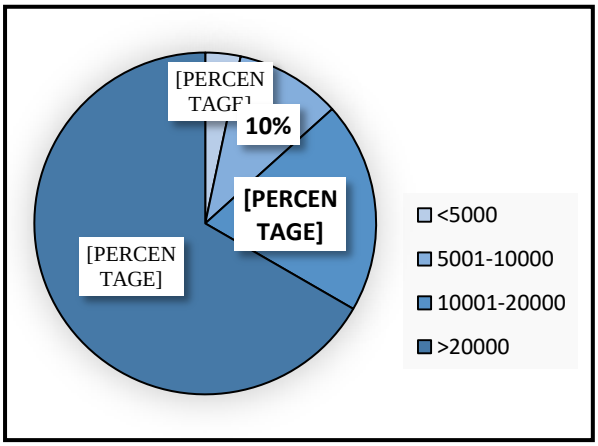


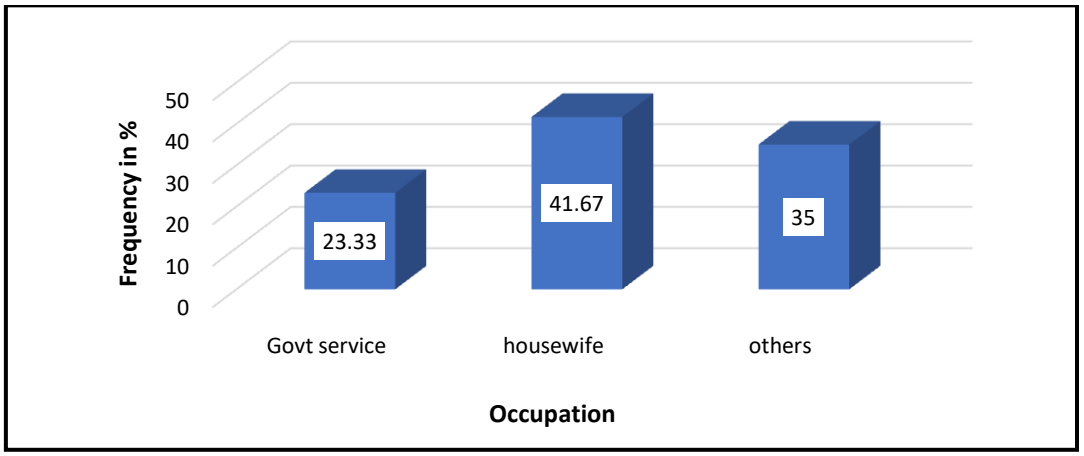
Figure 6: Monthly income (in %)



Source: Primary Survey, 2025

A majority of the household (66.67%) reported a monthly income above 20000 rupees suggesting that the area has relatively stable economic conditions compared to typical rural or hilly regions. This economic capacity might support the adoption of improved wastewater management practices, although other factors like awareness or infrastructure could still act as barriers (figure 6).

Figure 7: Occupation (in %)



Source: Primary Survey, 2025

In terms of housing, most respondents (87%) reported owning their homes, which were pucca houses showing a sense of settlement stability. However, a few still live in informal or encroached settlements, which may not have proper drainage systems affecting how they dispose of grey water (figure 7). The occupation data indicates that a large number of respondents were housewives (41.67%) followed by individuals in government services (23.33%). The presence of daily wage workers and self-employed individuals reflects a mixed economy where both formal and informal employment coexist. This socio-demographic profile provides useful background for interpreting the community greywater management behaviour as factors like age, gender, occupation income, education all have an influence on household level practices.

8. Grey Water Disposal Practices

The survey revealed that although 77% of the households have closed drainage systems and 23% rely on open drains all respondents ultimately dispose greywater into nearby *Jhoras* or open land, showing that even closed systems lack proper outlets (figure 8). This indicates that presence of infrastructure alone does not ensure safe disposal, as untreated wastewater continues to affect the natural environment.

Figure 8: Type of Drainage

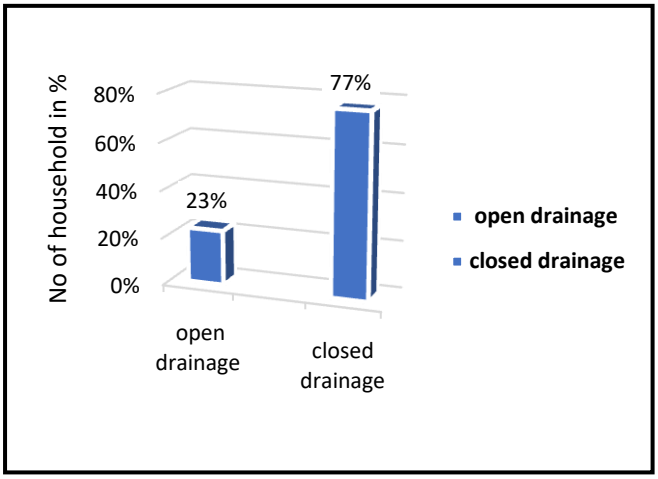
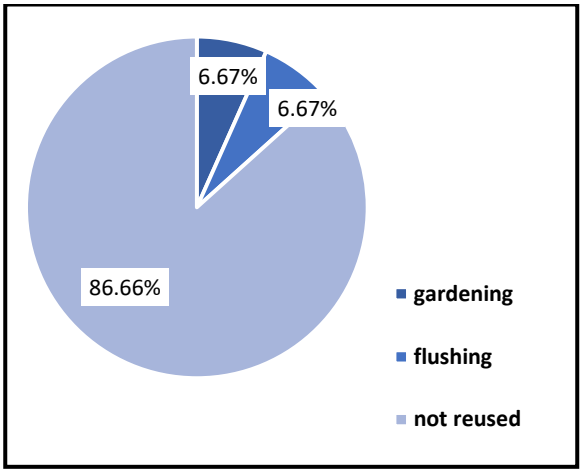


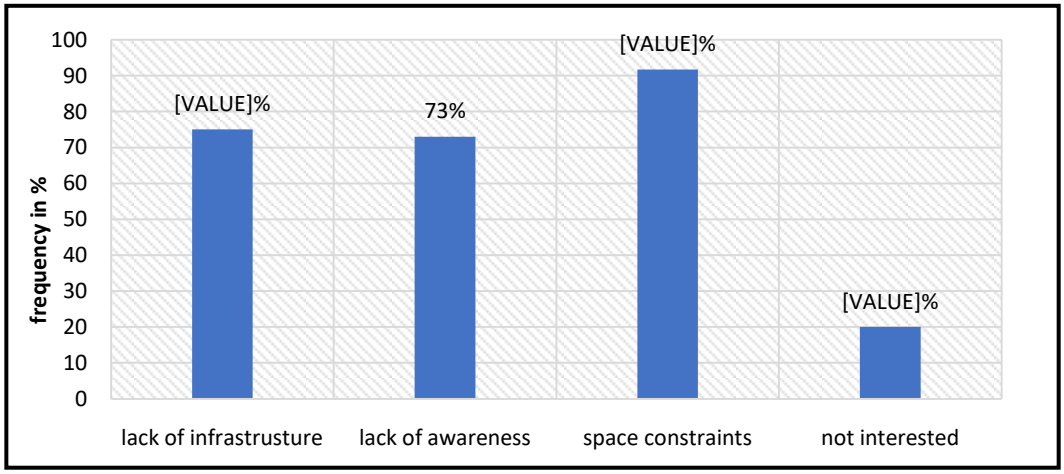
Figure 9: Reuse of greywater



Source: Primary Survey, 2025

A Major concern is the lack of awareness, with 88% of the households unaware about the disposal of the greywater rules which reflects poor information dissemination. As a result, 86.67% do not reuse greywater while only a small portion use it for flushing (6.67%) or gardening (6.67%). This shows that reuse practices are extremely limited (figure 9).

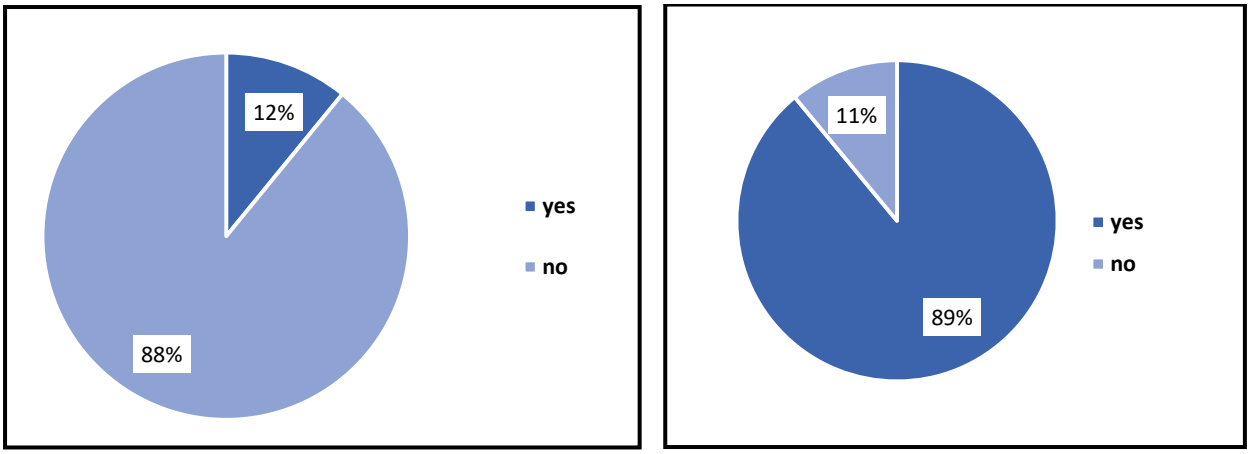
Figure 10: Barriers of Greywater Management



Source: Primary Survey, 2025

Barriers to greywater reuse are mostly practical in nature (91.67%) cited space constraints, followed by lack of infrastructure (75%) and lack of awareness (73%). A small share (20%) showed no interest in reuse. However, it's encouraging to see that 89% of the household are willing to reuse greywater if proper support is provided.

Figure 11: Awareness of Greywater Figure 12: Willingness to Adopt Greywater



Source: Primary Survey, 2025

The current wastewater management practices are shaped by combination of physical limitations, lack of knowledge and absence of localised solutions. There is strong potential for improvement through community level awareness programs and better infrastructure support.

9. Socio-economic Factors for Grey Water Disposal

The way people dispose away grey water depends on their social and economic conditions, like how much money they earn, how educated they are, what kind of house they live in, and what services are available to them (World Health Organization. 2006). People with more income usually live in better houses with good drainage systems. They can pay for safe ways to remove wastewater or connect to the city's sewage system (Dibaba,2018). But people with less money often live in poor houses with no proper drains, so they may throw wastewater in open areas, which is not safe (McGranahan,1993).

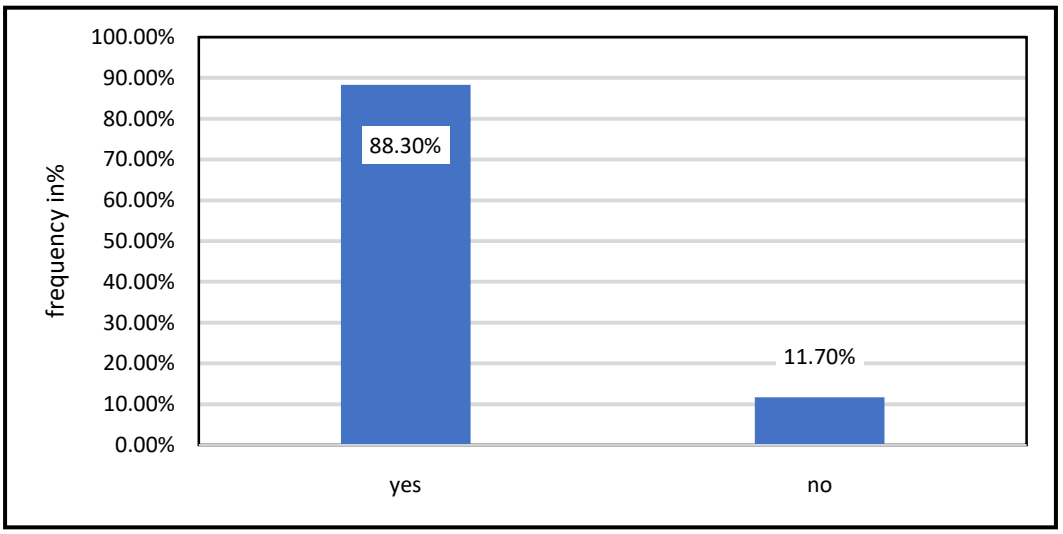
Education is also very important. People who are educated understand the health risks and environmental problems caused by dirty water (Everett,1992). They try to manage wastewater properly. People with less education may not know the right way to handle wastewater or how dangerous it can be. The presence of community services like drains, garbage collection, and health awareness programs also helps people manage wastewater better. In villages or hilly places, such services are often missing, so it becomes harder to manage wastewater in a clean and safe way (Rose,1999). Therefore, the socio-economic factors for wastewater disposal are discussed below in detail.

9.1. Income and House Type Factor

The given data shows that 88.30% of people said 'yes', they believe that the type of house and how much money a person earns does affect how they manage wastewater. Only 11.70% of people said 'No', meaning they think housing type or income does not matter in managing wastewater. This means that most people think that a person's income and housing condition are important in managing wastewater (figure 3.6).

For example, people with higher income may have better drainage systems or ways to treat wastewater. On the other hand, people with lower income might face more problems. Very few people disagreed, showing that only a small number think these factors do not matter.

Figure 13: Income and House types affects the Wastewater Management



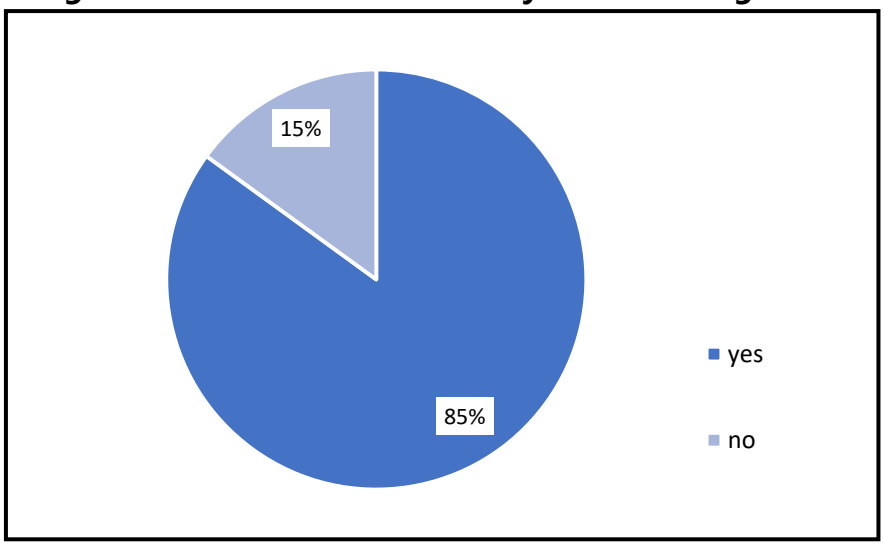
Source: Primary Survey, 2025

9.2. Educational Factor

The pie chart shows people's opinions on whether education affects greywater management, which means how people handle used water from sinks, baths, and washing (figure 13). According to the chart, 85% of people said 'Yes', meaning they believe that education helps in managing greywater properly. Only 15% said 'No', meaning they think education does not make a big difference. This shows that most people think education is important for better greywater handling. Education can teach people how to safely reuse or dispose of greywater, keep their surroundings clean, and use eco-friendly methods.

Educated people are more likely to follow good waste practices, treat greywater before reuse, and understand the health risks of poor water management. A few people think education is not important, possibly because they face other problems like low income, lack of proper drainage systems, or follow traditional ways. Therefore, the pie chart shows that education plays a key role in helping families manage greywater in a safer and more effective way (figure 14).

Figure 14: Education Affects Grey Water Management



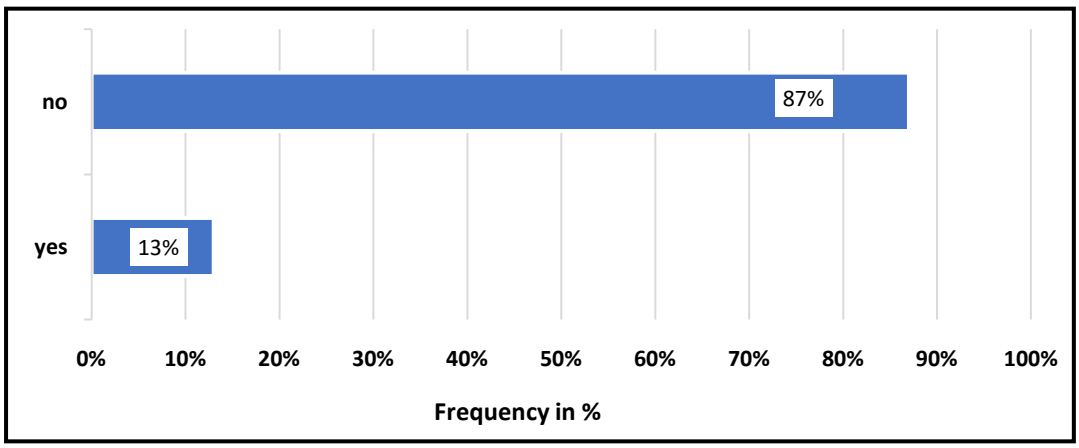
Source: Primary Survey, 2025

9.3. Health and Awareness

The primary survey shows how health factors play a significant role for many people who suffered from water-related illnesses (figure 15). According to the survey, 87% of people said 'No', meaning they did not get sick from water. Only 13% said "Yes", meaning they did suffer from illnesses caused by water. This means that most people have not faced any health problems due to water, which could mean they are using clean water and following good hygiene habits.

However, the 13% who did suffer is still an important number to look at, especially in places where people may not have safe drinking water or proper drainage. Water-related illnesses can happen when people drink or use dirty water or live near open drains and waste. These illnesses may include diarrhea, skin infections, or stomach pain. So, even though most people are not affected, the chart shows that some people are still at risk, and this highlights the need for clean water, better sanitation, and awareness about safe water use.

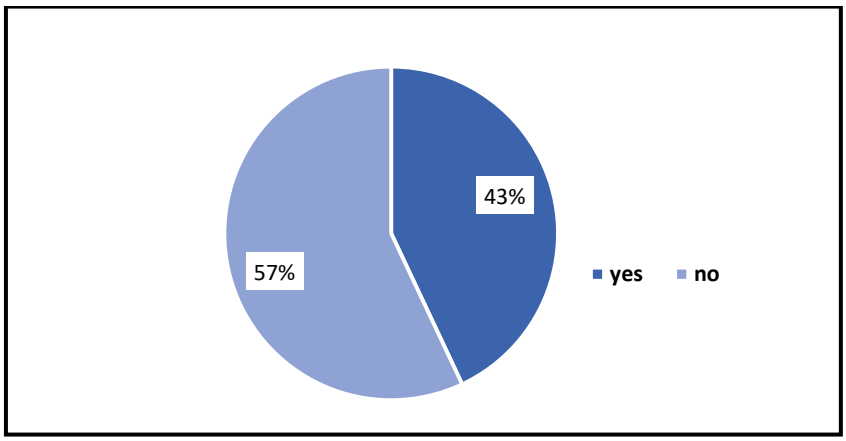
Figure 15: Suffered from water related illness



Source: Primary Survey, 2025

Similarly, the below given information shows how many people know about health risks related to water use, hygiene, and sanitation. According to the data, 43% of people said 'Yes', meaning they are aware of these health risks. But 57% said 'No', which means they are not aware (figure 16). This is a serious issue because more than half of the people do not understand the dangers of using dirty water or having poor drainage. If people are not aware, they may use untreated water, live near open waste, or follow unsafe habits, which can cause diseases like diarrhea, cholera, and skin problems.

Figure 16: Aware of Health Risks



Source: Primary Survey, 2025

The 43% who are aware may take better care of their water use, follow good hygiene, and keep their families safe. This pie chart shows that more health education and awareness programs are needed, especially in villages or poor areas where people may not have much information. Therefore, the survey highlights that while some

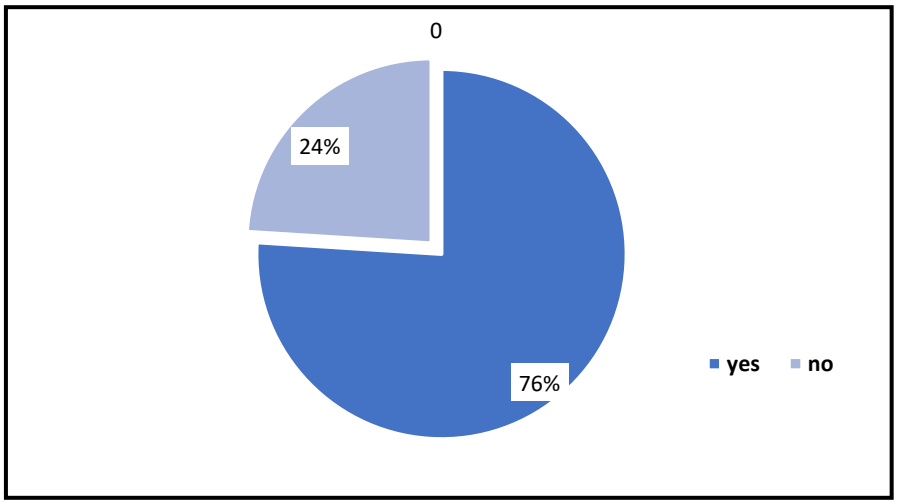
people know about the health risks, many others still need to learn how unsafe water and poor sanitation can harm their health (Jadhav, 2018).

9.4. Community Awareness and Greywater Management

The field survey also discusses how much the community knows about greywater management, which means how people handle, or reuse used water from sinks, baths, and washing (figure 17). According to the chart, 76% of people said 'Yes', they are aware of how to manage greywater. This shows that most people understand the importance of managing greywater in a safe and useful way. They may know how to reuse it properly, reduce pollution, and keep the environment clean. However, 24% of people said 'No', which means they do not know about greywater management. This is still a good number of people who may throw away greywater in unsafe ways, which can lead to health problems and water pollution.

Therefore, the survey shows that most of the community is aware, but there is still a need to provide basic awareness and training to the remaining people about safe greywater practices. This can be done through awareness programs, training, and simple information sharing to help everyone manage water in a better way.

Figure 17: Community Awareness regarding greywater management



Source: Primary Survey, 2025

10. Challenges for Grey Water Management

To manage greywater, there are many challenges. In places like Limbu Busty, Darjeeling (Ward No 31), managing greywater is a big problem because of poor drainage systems, low-mid family income, and lack of awareness. Since Darjeeling is a hilly area, water flows downhill very fast, which makes it hard to build proper drainage. Many people throw greywater in open spaces, which causes bad smells,

mosquito breeding, and health problems. Also, many families do not have enough money to build safe systems, and government help is often not available. Because of these issues, managing greywater is a serious challenge and needs quick attention to protect people's health and the environment.

10.1. Undulating topography

The study area (Limbu Busty, Darjeeling, Ward no 31) is a hilly region, which makes it difficult to build and maintain proper drainage systems. Because of the steep slopes, rainwater and wastewater flow downhill very quickly (Rai, 2016). If the drainage is not planned well, this fast-flowing water can cause flooding, landslides, and damage to roads and houses. (Hung, 2022). In many parts of Darjeeling, there are no proper drains or only open drains, which cannot handle heavy water flow, especially during the monsoon season. The water often overflows, carrying waste into the streets and nearby water sources (BOMJAN, 2010). This not only damages infrastructure but also creates health risks for the people (Nejidat, 2005). It is also hard to repair or clean drainage lines in such steep and narrow areas, especially in crowded towns and tea garden settlements.

In addition, the lack of space adds to the problem, making it even harder to build new or improved drainage systems (Zeng, 2017). Therefore, the hilly nature of Darjeeling creates serious challenges for proper wastewater disposal and overall sanitation. To solve this, the local government and community must work together to plan safe and low-cost drainage systems that suit the hilly terrain. Using local knowledge and simple technologies can also help reduce the risks caused by poor wastewater management.

10.2. Drainage System

In many parts of study area, drainage systems are not properly covered. some drains are open, which causes several problems for both people and the environment. These open drains often carry dirty water from kitchens, bathrooms, and other household activities (Bayles, 1878). As a result, they produce a bad smell and make the surroundings unpleasant and unhygienic (Al-Obaidy, 2021). Open drains are also a breeding ground for mosquitoes and insects, which can spread diseases like dengue, malaria, and stomach infections (Sharma, 2013).

During the rainy season, these drains often overflow, and the dirty water mixes with drinking water sources (Cutter, 2012). This can lead to serious health issues, especially in children and the elderly. In some areas, people throw garbage into the open drains, which blocks the water flow and causes flooding on roads and paths

(Trikha, 2022). This also pollutes nearby rivers, springs, and streams, which many people depend on for daily water needs. The lack of proper drain covers also increases the risk of accidents, especially for children and older people walking near these drains (Kalu, 2023).

Therefore, the absence of covered drains in Darjeeling is a big problem. It not only affects health but also damages the environment and public spaces (Bhutia, 2014). To solve this, the local government should focus on building covered drainage systems and running awareness programs to stop people from throwing waste into drains (Bloch, 2012). This will help make the town cleaner, safer, and healthier for everyone.

10.3. Low Income of Households

Many families in Limbu Busty have low to medium income and cannot afford to build or use proper systems to dispose of wastewater. Because of financial problems, they are unable to install covered drains, soak pits, or small treatment units. As a result, they often throw wastewater from kitchens, bathrooms, and washing areas into open spaces, streets, or nearby open drains. This practice can be harmful to both people and the environment. The dirty water flows through the area, creating bad smell, mosquito breeding grounds, and spreading diseases like diarrhea and skin infections. In some places, wastewater even flows near houses or footpaths, making daily life difficult, especially during the rainy season.

Low to medium income families may also lack awareness about the health risks of improper wastewater disposal. Even if they want to manage wastewater better, they do not have enough money or support to do so. To solve this problem, there is a need for low-cost, simple wastewater solutions that poor households can use. The government and local bodies should also provide support, training, and materials to help these families manage wastewater safely. This will help improve public health and make the surroundings cleaner for everyone.

10.4. Lack of Awareness

Some people in the study area are aware of the health problems that can be caused by dirty wastewater but not aware of its management. Because of this lack of awareness, they often dispose of wastewater in open areas, drains, or roadsides without thinking about its impact. In addition, many people also do not know the right ways to manage greywater safely. They may not understand how to reuse greywater for gardening or how to build simple soak pits or filters to clean it. This happens mostly in areas where there are less education and no health awareness programs.

Without proper knowledge, people continue with unsafe practices, which harm their health and pollute the environment. Children and elderly people are especially at risk. To improve the situation, it is important to spread awareness through community meetings, schools, and local campaigns (Filer, 2021). People should be taught about the dangers of dirty wastewater and the benefits of managing it properly (World Health Organization, 2015). When people understand the health risks, they are more likely to change their habits and follow safe and clean methods for greywater disposal (World Health Organization, 2006).

10.5. Weak Infrastructure

In many parts of the study area, there is no proper sewage system to manage wastewater. This is a big problem, where people do not have access to safe and clean ways to dispose of dirty water. In towns, some areas may have drainage lines, but they are often old, broken, or blocked. In some places, there are no underground sewage pipes, so people throw wastewater into open drains, fields, or roadside areas. This creates dirty surroundings, spreads bad smells, and increases the risk of diseases. The municipal services are limited and often do not reach the far-off areas. Many people have to manage wastewater on their own without any help from local authorities.

There is also no regular cleaning or maintenance of drains, which makes the situation worse during the rainy season. Due to the lack of proper sewage systems, wastewater mixes with drinking water sources in some places, making it unsafe for daily use. To solve this problem, the government should invest in building simple and low-cost sewage systems (Curtis, 2007). Local bodies should also increase services and regular maintenance to keep the environment clean and healthy.

10.6. Growing Population

The growing population in the Limbu Busty (Ward No 31) is putting more pressure on the already weak sanitation system. As more people move to towns and villages or as families grow larger, the amount of wastewater being produced also increases (Mushtaq, 2023).. However, the drainage and sewage systems are not strong enough to handle this extra load. Many areas still have old or damaged drains, and some places do not have any proper system for wastewater disposal. As the number of people rises, these systems become overloaded, leading to overflowing drains, dirty streets, and polluted water sources (Dibaba,2018).

The problem is worse in crowded areas, where many families live in small spaces with limited or no sanitation facilities (Owusu,2010) When too many people use the same

poor drainage system, it gets blocked or breaks easily, creating health risks for the whole community. This shows that the current system cannot support the growing needs of the population. To solve this, the government and local bodies should upgrade and expand sanitation services to meet the needs of the increasing population. Without this, the pressure on the weak system will continue to grow, leading to unsafe and unhealthy living conditions (Radingoana, 2021).

11. Findings and Discussion

Firstly, the study found that all the people (100%) who were part of the survey discharged their greywater directly into the nearby *Jhora* (small natural water stream). This means none of the households treated the greywater before releasing it. Out of all the respondents, 77% had closed drainage systems, mostly made with pipes. However, even though these systems were closed, the final outlet was still informal and untreated, meaning the dirty water still went into open spaces or the Jhora without any cleaning. The remaining 23% of the people used open drains, which carry dirty water in open channels. These can cause bad smells, mosquito breeding, and health problems.

The study clearly shows that no household treated greywater in a proper way before disposing of it. This is a serious issue, especially in hilly areas like Darjeeling, where water flows quickly and can carry pollution to other places. It highlights the urgent need for proper greywater treatment methods and better awareness among the people.

Secondly, a more serious issue was found during field visits and informal talks with local people. In many homes, toilet waste (blackwater) was being directly released into nearby Jhoras (small natural streams). This is very dangerous because some of these Jhoras are also used by people for drinking water, washing, or other daily needs. When dirty toilet water mixes with clean water, it creates a high risk of water contamination and disease. This problem becomes even worse during the monsoon season, when heavy rains carry the waste quickly downhill. The dirty water can spread to larger areas, polluting more water sources and increasing the chances of diarrhea, cholera, and other serious health problems.

The study shows that blackwater disposal is a major concern in the area. There is an urgent need for proper toilet connections, safe sewage systems, and better awareness so that people do not release toilet waste into natural water sources.

Thirdly, the study also found that most households do not reuse greywater. About 86.67% of households throw away greywater without using it again. Only 6.67% reuse it for flushing toilets, and another 6.67% use it for gardening. This means that

reuse of greywater is very limited in the study area. When people were asked why they don't reuse greywater, the main reasons were space problems (91.67%), lack of proper infrastructure (75%), and lack of awareness (73%). This shows that many families do not have enough space, tools, or knowledge to manage greywater safely.

However, the study also found some good news. Around 89% of the people said they are willing to reuse greywater if they get the right help. This means that people are open to learning new methods, but they need support, training, and simple, low-cost systems to do it. To improve greywater reuse, it is important to teach people about the benefits and show them safe ways to reuse water. Simple ideas like soak pits, sand filters, and small storage tanks can be introduced. These systems should be easy to build, especially in small spaces. The government and community groups should also support families by giving materials, training, and guidance. With proper help, greywater reuse can become a safe and common practice, improving health and hygiene in the community.

Fifth, the study also found that awareness about greywater management is very low in the community. About 88% of people did not know about any rules or government policies for greywater disposal. Also, 57% of people were not aware that improper wastewater disposal can cause health problems like infections or diseases. Another important finding is that 100% of the people had no knowledge about traditional or local methods for reusing or managing wastewater. This shows that old, eco-friendly practices have completely disappeared in the area, and people no longer follow or remember them. When it comes to community involvement, the situation is also not good. About 76% of respondents said there had never been any awareness program or community-led activity related to wastewater management. Only 24% had taken part in any such event.

These findings show that most people think of greywater management as a personal or household issue, not as a shared community responsibility. There is a strong need for awareness campaigns, community training, and group efforts to make people understand that managing wastewater is important for everyone's health and the environment. Collective action can bring better results than working alone.

Sixth, the field report traced that many hotels in the area release their wastewater into town drains, which later flow into open streams. This adds a lot of extra pressure on the already weak drainage system, especially during the tourist season when the number of visitors is high. Hotels and other commercial places use a large amount of water for cleaning, bathing, and cooking. If their wastewater is not treated properly, it can lead to water pollution, bad smells, and health risks for local people.

This shows that hotels and businesses also play a role in poor wastewater management. It is not only a household issue. There is a need for better rules and monitoring for commercial establishments so that they treat their wastewater before releasing it. Therefore, the findings highlight that commercial waste adds to the problem, and stronger action is needed to manage hotel wastewater properly and protect the local environment.

Seventh, the study found that 87% of households did not report water-related illness, even though they follow some unsafe practices. This may be mainly because many families boil their drinking water regularly, which is a simple but effective way to prevent disease. Surprisingly, people are doing this without formal awareness programs, which shows the power of simple household habits.

However, the study also found that none of the respondents knew about traditional methods of greywater reuse or management. Interestingly, this was unexpected in a hill area like Darjeeling, where in the past, indigenous knowledge helped guide local water systems. Clearly, modern settlements seem to have moved away from older, eco-friendly practices, possibly due to changes in lifestyle and urban growth.

Importantly, many people said they are willing to adopt new ways of managing greywater, but they need support, access to tools, and awareness. This clearly shows that the problem is not resistance, but the lack of help and information. Therefore, people are ready for change, but they need the right guidance and support. Together, community involvement and government help can lead to better greywater management in both rural and urban hill areas.

12. Suggestions and Recommendations

Greywater is the used water from sinks, bathrooms, and washing clothes. It is not dirty like toilet water, so it can be reused or managed in simple ways. In places like Darjeeling, where proper drainage systems are not always available, managing greywater properly is very important for health and cleanliness. If not handled well, greywater can cause bad smells, mosquito breeding, and diseases. But with the right knowledge and simple methods, families and communities can reuse greywater and reduce pollution. The following suggestions will help in managing greywater in a safe, low-cost, and eco-friendly way.

12.1. Reuse Greywater

People can reuse greywater which is used water from the kitchen, bathing, and washing in simple and useful ways (McFarlane, 1996). Instead of throwing this water away, families can use it for gardening, watering plants, cleaning outdoor spaces, or

flushing toilets (Neibauer, 2003). This helps to save clean water and also reduces the amount of wastewater around the house.

Reusing greywater is very helpful in hilly areas like Limbu Busty, where many homes do not have proper drainage systems. It is a cheap and eco-friendly method that anyone can follow (Yihdego, 2015). When greywater is used properly, it keeps the surroundings cleaner and helps to prevent water-related diseases (World Health Organization, 2006). People should be taught about these simple ways to manage water better and improve health and hygiene (Unicef, 2016). Therefore, reusing greywater in daily life is a smart and sustainable way to manage water in Limbu Busty and other similar places.

12.2. Cover Open Drains

Open drains should be properly covered to stop problems like bad smells, mosquito breeding, and the spread of diseases (Poorvasivam, 2025). When drains are left open, dirty water flows out in the open air, which not only smells bad but also becomes a breeding place for mosquitoes and flies (Veeder, 1899). These insects can cause illnesses like dengue, malaria, and stomach infections (Rao, 2015). By covering the drains, we can keep the area clean and safe for everyone. Covered drains prevent accidents, especially for children and elderly people walking nearby (Bogh, 2002). They also look better and help improve the overall hygiene of the place. In places like Limbu Busty (Darjeeling), where drains often overflow during rain, covering them can also help stop water pollution and flooding (Clifforde, 1993). It is a simple and low-cost step that can bring big health and environmental benefits. So, covering open drains is important for a cleaner and healthier community (Parkinson, 2003).

12.3. Awareness Programs

It is important to teach people about the dangers of dirty greywater and how to manage it in a safe and clean way. Greywater, if not handled properly, can cause bad smells, mosquito breeding, and serious health problems like skin infections and stomach illness (World Health Organization. 2006). Many people are not aware of these risks, so we need to spread the message in simple ways. Schools, community centres, and local meetings can be used to educate children and adults about safe greywater practices (Tengku Ibrahim, 2025). Posters, wall paintings, and loudspeaker announcements can also help share the message with the whole community (Lewis, 2015).

When people understand the problems caused by dirty water and learn easy and low-cost solutions, they are more likely to change their habits (World Health Organization, 2006). Raising awareness is the first step toward cleaner surroundings and better health (Domis, 2019). With the right information, communities can take action to manage greywater properly and keep their homes safe (World Health Organization, 2006).

12.4. Training for Local People

It is a good idea to train community members to build and take care of simple wastewater systems. This helps people learn useful skills and also creates job opportunities for them (Wenger, 2010). When local people are trained, they can build soak pits, filters, and covered drains using low-cost and local materials (Clarke, 2016). They can also fix and clean these systems regularly, which helps keep the area clean and healthy (Palaniappan, 2010). Training local people also means that the community does not always have to wait for outside help. They can solve their own problems quickly and in a way that suits their area. This is especially helpful in rural and hilly areas where government services are limited.

Therefore, training people in greywater and wastewater management not only improves the environment but also gives people work and builds local knowledge and responsibility (Ibrahim, 2025). It is a simple and smart way to improve sanitation in the community.

12.5. Need Government Support and Grants

The government should support poor families by giving them money, tools, or materials to help them build drainage systems or soak pits for managing greywater (Palaniappan, 2010). Many families cannot afford to build these on their own, so this help will make it easier for them to keep their surroundings clean and safe (Tegelberg, 2010). The government can also send workers or experts to guide the families on how to build and use these systems properly. In addition to that, there should be regular checks and maintenance to make sure the drainage systems are working well and not blocked or damaged (Madramootoo, 1999). With proper help and follow-up, the community can have better hygiene, fewer diseases, and a cleaner environment (Michael, 2018). Therefore, government help and regular care can make a big difference in managing wastewater in poor areas.

12.6. Promote Eco-Friendly Methods

Natural filters like sand and gravel beds should be promoted to clean greywater before it is reused or released into the ground (Khalaphallah, 2012). These filters are simple, low-cost, and eco-friendly. When greywater passes through layers of sand, gravel, and stones, dirt and harmful substances are removed (Ramesh, 2015). This makes the water safer for watering plants or cleaning. These methods are easy to build and do not require machines or electricity, so they are perfect for rural and hilly areas like Darjeeling (Hossain, 2015). Using natural filters helps protect health and the environment while also saving clean water.

12.7. Need Proper Plan for Mountain areas

In hilly areas like Darjeeling, it is important to design drainage systems that work well on slopes. When it rains or when wastewater is released, the water quickly flows downhill (Cajee, 2018). If the drains are not built properly, the water can enter roads, houses, and low-lying areas, causing damage and health problems (Clarke, 2016). To stop this, drains should be planned carefully to match the shape and slope of the land. The drainage system should carry water safely away from homes and roads without overflowing. Strong materials should be used, and the drains should be covered and regularly cleaned to keep them working well (World Health Organization,2006). Proper drainage design on slopes helps to prevent flooding, landslides, and pollution. It also makes the surroundings safer and cleaner for everyone (Parkash,2019). Therefore, well-designed slope-friendly drains are very important for protecting people, property, and the environment in hilly regions.

13. Conclusion

In conclusion, greywater management in hill towns like Darjeeling is a serious problem that is often not given enough attention. This study shows that most households discharge wastewater directly into natural streams (Jhoras) without any treatment, which can be harmful to both health and the environment. People are not fully aware of the risks or the proper ways to manage greywater, and they do not know about any rules or traditional methods. However, many families are willing to change if they receive the right support, tools, and knowledge.

This means that the real problem is not unwillingness, but the lack of proper drainage systems, space, awareness, and help. With the right support from the municipality, community programs, and better planning, we can find low-cost and eco-friendly solutions like soak pits, natural filters, and traditional methods. By working together and raising awareness, it is possible to make greywater

management safe, healthy, and sustainable, especially in hilly and environmentally sensitive areas like Darjeeling.

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