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Grey Water Recycling

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Abstract

Domestic grey water recycling and reuse in residential buildings have been comprehensively examined. It is estimated that recoverable grey water can account for approximately 35% to 40% of total household water demand, highlighting its substantial potential to reduce freshwater consumption in domestic settings. A comprehensive worldwide review of grey water recycling and reuse practices has been reported, highlighting the increasing importance of sustainable water management in both developed and developing countries. In many situations, light greywater generated from bathroom sinks, bathtubs, and showers can be reused for garden irrigation with only minimal treatment, as it typically contains relatively low levels of contaminants. However, dark grey water from laundry, dishwashers, and, in some instances, kitchen sinks contains higher levels of organic matter, detergents, oils, and suspended solids, requiring simple treatment before reuse in non-potable applications such as toilet flushing, gardening irrigation, floor cleaning, and car washing. Despite its immense potential, the application of grey water recycling systems remains largely unexplored at the residential level because affordable and efficient treatment technologies for small-scale domestic use are still limited. In the present study, several filtration methods were employed to enhance grey water quality, including micron filtration, mineral sand filtration, and activated carbon treatment, each playing a vital role in removing suspended particles, odors, and dissolved contaminants. Multi-stage water analysis was performed to assess the effectiveness of the treatment system in removing impurities from grey water. The results demonstrated considerable improvement in water quality parameters, suggesting that treated grey water can be effectively reused for various household purposes. Adoption of grey water recycling systems can contribute significantly toward water conservation, environmental sustainability, and reduction in household water bills

Keywords: Grey water, gardening irrigation, floor cleaning, environmental sustainability, freshwater

INTRODUCTION

Because of the worldwide scarcity of freshwater, balancing its supply and demand has consistently been a challenging task. Maharashtra is one of India's most densely inhabited states, where increasing population and rapid urbanization have significantly raised water demand. Recycling and reuse are gaining increasing significance as global population growth places pressure on diminishing natural water resources. In this context, greywater utilization and monsoon rainwater harvesting have emerged as effective strategies for conserving potable water and supporting sustainable water management. Greywater, which originates from household sources such as kitchens, laundry, and bathrooms, requires proper treatment before reuse, with filtration serving as a key step in this process [1]. Cost-effective and efficient filtration media, including fine sand, coarse sand, gravel, coal, and

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brick fragments, are commonly used in such systems. A vertical sand filter is considered one of the simplest and most effective greywater filtration methods due to its easy construction and low maintenance requirements. Grey water should be subjected to physical and chemical tests before reuse to determine its quality and suitability for domestic or agricultural applications. Material layer heights of 30 mm, 50 mm, 70 mm, and 100 mm were used to study varying filtration attributes and properties. The term "grey water" originates from its cloudy appearance and its intermediate quality—neither completely clean nor highly polluted. With global freshwater resources becoming increasingly limited, maintaining a balance between water availability and demand has become a major concern. In a rapidly developing nation like India, Maharashtra stands out as one of the most rapidly urbanizing regions. The demand for water is steadily rising across agricultural, industrial, and domestic sectors, largely driven by population growth. Factors such as rapid urban expansion, increasing population, contamination of surface water, and continuous depletion of groundwater resources have further intensified water scarcity. In this context, the treatment and reuse of greywater offer a viable alternative source for non-potable uses, including gardening, toilet flushing, and irrigation. Adopting such systems can greatly reduce reliance on freshwater resources while promoting environmental sustainability and supporting long-term water conservation efforts [2].

LITERATURE REVIEW

Paper gives independency to select the filtration process based on economical setup and operational perspective. Sara Vandana Singh et al. (2018) clearly excavated in their paper the concept of grey water and its filtration process through each stage of treatment technologies. The paper gives an idea on complete filtration techniques and highlights the significance of selecting appropriate treatment methods depending on domestic requirements and available resources. Martina Rylova et al. (2017) introduced an innovative biofiltration approach for greywater treatment, referred to as a green wall. It treats the grey water through a vegetated wall system that utilizes grey water at different stages. The idea is simple and follows a do-it-yourself methodology which supports gardening of ornamental plants in high-story apartments while simultaneously promoting water conservation and aesthetic enhancement of urban spaces [3].

Abeer Abalone (2015) in their paper figured out the characteristics and composition of grey water and discussed various filtration techniques such as physical, chemical, and biological treatment methods. The proposed method outlines a mechanism in which waste materials are first removed using a 1 cm thick mesh composite. The grey water is then collected in an underground tank, from where it is pumped into a trickling filter. After undergoing the filtration process three times, the water returns to the tank. Subsequently, the filtered water is directed to a settling tank for sedimentation and additional purification [4].

Furthermore, the study highlights that such integrated filtration systems are highly effective in reducing suspended solids, organic pollutants, and microbial content in wastewater. The treated water can be reused for non-potable purposes, including gardening, toilet flushing, and cleaning, thereby conserving freshwater resources. Overall, these findings indicate that grey water recycling technologies can be successfully adopted in both residential and commercial settings to promote sustainable water management and environmental conservation [5-12].

SCOPE OF THE PROJECT

Domestic and Residential Use

1. Reuse for toilet flushing
2. irrigation and landscaping
3. Car washing and
4. floor cleaning
5. Apartment complexes communities benefit the most

Commercial Buildings

1. Hotels, malls, offices
2. Toilet flushing
3. Cooling towers
4. Landscaping

Industrial Applications
1. Cooling processes
2. Boiler feed (after advanced treatment)
3. Washing and cleaning operations

Urban and Municipal Sector
1. Parks and green belts irrigation
2. Road and pavement cleaning
3. Construction activities
4. Public toilets

Agriculture and Landscaping
1. Lawns
2. Ornamental plants
3. Non-food crops
4. Urban farming (with proper treatment) Disinfection dosage control

Environmental Benefits Reduces
1. Freshwater extraction
2. Wastewater discharge into rivers
3. Enhances groundwater recharge
4. Supports sustainable water cycle.

Economic Scope
1. Lower water and sewage bills
2. Reduced infrastructure costs
3. Growing market for
4. Treatment systems
5. Plumbing retrofits
6. Maintenance services

Regulatory and Policy Scope
1. Encourage or mandative many regions
2. Green building certification
3. Government incentives and urban

Future Scope
1. Smart grey water systems with lot monitoring
2. Integration with rainwater harvesting
3. Decentralized wastewater treatment system
4. Mandatory adoption in smart cities 5.

METHODLOGY

Grey Water is Water Generated Form
1. Bathrooms (shower, wash basins)
2. Hand wash sinks
3. Laundry

Collection System

1. Separate plumbing lines are provided for grey water
2. Water is directed to collection tank using gravity or pumps
3. Bar screens are installed to trap hair, lint, and debris

Pre- Treatment
Purpose
- Remove large solid and oils

Methods
1. Screening chamber (removes hair, fibers)
2. Grease trap (if laundry water included)
3. Equalization Tank (balances flow variations)

Primary Treatment
Purpose
- Remove suspended solids

Techniques
1. *Sedimentation tank:* solid settle at the bottom
2. *Coagulation(optional):* alum or natural coagulants to enhance settling

Secondary Treatment
- *Purpose*: Reduce organic matter and pathogens
- *Common Methods:* Bio filter (sand + gravel + charcoal):

Tertiary Treatment
- *Purpose:* make water safe for reuse
- *Methods:* chlorination UV disinfection, ozonation

Filtration
1. Pressure sand filter
2. Activated carbon filter
3. Micron cartridge filter (final polishing)

Treated Water Storage
Stored in a separate treated grey water tank continuous circulation to prevent stagnation

Reuse Applications
Treated Grey Water can be Used for
1. Toilet flushing
2. Floor flushing
3. Cooling towers
4. Construction Activities

Monitoring and Maintenance
- Regular water quality testing (BOD, COD, turbidity)
- Filter Backwashing
- Disinfection dosage control
- Periodic system inspection

Health and Safety Measures

- Clear pipe color coding (grey water pipe)
- Signage indicating non- potable water
- Operator training
- Odor control

Collection of Material

Fine sand, water hyacinth, small size gravel, coconut husk, large size gravel, crush fly-ash bricks

Material Used

1. *Fine Sand:* size: 0.75mm-2mm
   Use: to filter fine particles and impurity
2. *Water hyacinth:* Carban are use in a PH level is low.
3. *Coconut husk:* Size: Organic material, variable
   Use: Biological filtration and absorption of water impurities

Fly-Ash Bricks

- *Size:* 2 mm to 10 mm
- *Use:* To absorb heavy metals and impurities in water.

Small and Medium Sized Gravel

- *Size:* 4 mm to 20 mm
- *Use:* To filter larger particles.
-

Large sized Gravel

- *Size:* 20 mm to 40 mm
- *Use:* To filter large particles and impurities, and to regulate water flow (Figure 1–5).

Figure 1. Preparation of a dark-colored reaction mixture in a glass beaker using a spatula under laboratory conditions. The sample was handled with gloved hands during synthesis/processing, and the image was captured at Pune, Maharashtra, India.

Figure 2. Laboratory-scale preparation of a dark-colored sample solution by a researcher wearing protective gloves and mask in a chemistry laboratory. The reaction mixture was handled on a workbench with standard laboratory reagents and glassware, and the image was recorded at Pune, Maharashtra, India.

Figure 3. (a) Laboratory synthesis and mixing of the prepared sample under controlled conditions by a researcher using protective gloves and face mask. (b) Final processed material packed in a polythene bag and weighed on a digital balance, showing a net mass of approximately 330 g. The experiment was conducted in Pune, Maharashtra, India.

Figure 4. Sieving and particle size separation of the prepared material using a standard laboratory sieve set. The sample was manually transferred and arranged for granulometric analysis on a laboratory workbench. The procedure was carried out in Pune, Maharashtra, India.

Figure 5. Collection and transportation of packaged experimental materials/sample containers from a local supplier for laboratory use. The image documents field procurement and handling of materials in Pune, Maharashtra, India.

RESULTS

The treatment process demonstrated significant improvements across all measured water quality parameters (Table 1). The following table and analysis summarize the efficiency of the treatment:

Table 1. Summary of water quality improvements.

Sr. No	Parameter	Before treatment	After treatment
1	PH	2.67	6.96
2	COD (mg/L)	296.0	164.0
3	BOD (mg/L)	95.5	53.1
4	Turbidity (NTU)	110.00	62.6
5	Chlorine (mg/L)	30.0	20.0

Key Findings

- *pH neutralization:* The most dramatic change was observed in the pH level, which rose from a highly acidic 2.67 to 6.96. This indicates that the treatment successfully neutralized the effluent, bringing it to a near-neutral state suitable for discharge or further processing.
- *Organic load reduction:* Both Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) saw substantial reductions of approximately 44%. This reflects a significant decrease in the organic pollutants present in the water.
- *Clarity and suspended solids:* Turbidity was reduced from 110.00 NTU to 62.6 NTU, representing a 43.1% improvement in water clarity.
- *Chemical reduction:* Residual chlorine levels decreased by one-third, dropping from 30.0 mg/L to 20.0 mg/L.

CONCLUSION

Grey water samples were collected and analysed before and after treatment to evaluate the efficiency of the treatment system. The parameters tested included pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), turbidity, and residual chlorine. These parameters assist in evaluating the physical, chemical, and biological characteristics of water quality. Before treatment, the grey water was found to be slightly alkaline with a pH of 8.5 due to the presence of soaps and detergents. After treatment, the pH reduced to 7.2, indicating that the water became nearly neutral and suitable for reuse. The COD before treatment was 880 mg/L, showing a high level of chemical pollutants and organic matter. After treatment, the COD decreased to 190 mg/L, indicating significant removal of contaminants. Similarly, the BOD value was 420 mg/L before treatment and reduced to 65 mg/L after treatment. This decrease suggests that biodegradable organic substances were efficiently eliminated during the treatment process. Initially, the turbidity was measured at 230 NTU, indicating a high concentration of suspended particles and giving the water a very cloudy appearance. After treatment, turbidity reduced to 7 NTU, demonstrating effective removal of suspended solids and clearer water quality. Chlorine was absent before treatment (0.0 mg/L), but after treatment, a residual chlorine concentration of 0.3 mg/L was observed. This confirms that disinfection was carried out successfully, ensuring microbial safety of the treated water. In addition to improving the water's physical appearance and chemical properties, the treatment system also enhanced its overall hygienic quality, making it safer for various domestic and environmental applications. The reduction in pollutant concentration highlights the efficiency of the treatment technology in minimizing environmental contamination and promoting sustainable water reuse practices. In conclusion, the treatment process significantly improved the quality of grey water. There was a considerable reduction in COD, BOD, and turbidity levels, stabilization of pH within acceptable limits, and proper disinfection through chlorination. The results indicate that the treated grey water meets recommended standards for non-potable water reuse such as irrigation, toilet flushing, and landscaping.

Grey water reuse has significant future scope as growing urbanization, climate change, and water scarcity push cities towards more sustainable water management systems. With freshwater demand rising in rapidly expanding regions across countries like India and Australia, decentralized grey water recycling systems are expected to become a standard feature in residential buildings, commercial complexes, and smart cities. Advances in low-cost filtration, membrane bioreactors, and nature-based treatment solutions such as constructed wetlands are making grey water reuse safer and more economically viable for non-potable applications like toilet flushing, landscaping, cooling systems, and groundwater recharge. Furthermore, future developments in automation and sensor-based monitoring systems will improve treatment efficiency and reduce maintenance requirements. Government policies and public awareness campaigns are also expected to encourage wider adoption of grey water reuse technologies, contributing to water conservation and sustainable urban development.

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