DESIGN OF LOW-COST DOMESTIC GREY WATER RECYCLING SYSTEM USING PLANT WETLAND

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Abstract— Water scarcity has emerged as one of the most significant environmental challenges due to rapid urbanization, population growth, and increasing freshwater demand. Domestic greywater constitutes approximately 50–70% of total household wastewater and represents a valuable alternative water resource if appropriately treated and reused. The present study focuses on the design, development, and performance evaluation of a low-cost greywater recycling system using physical filtration and phytoremediation techniques. The treatment system consists of mesh filtration, sand filtration, activated carbon filtration, aeration, and a constructed wetland planted with Canna indica. Greywater collected from domestic sources such as bathrooms, wash basins, laundry, and kitchen activities was treated through the developed model. Water quality parameters including pH, turbidity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Solids (TS) were analyzed before and after treatment. Experimental results showed significant improvement in water quality. Turbidity reduced from 81 NTU to 15 NTU, BOD reduced from 274 mg/L to 104 mg/L, COD reduced from 560 mg/L to 240 mg/L, and Total Solids reduced from 1080 mg/L to 104 mg/L. The study demonstrates that natural treatment systems can provide an economical and environmentally sustainable solution for domestic greywater reuse in non-potable applications such as gardening, toilet flushing, cleaning, and landscaping. The proposed model contributes toward water conservation and sustainable wastewater management practices

Keywords: Greywater Recycling, Wastewater Treatment, Canna indica, Activated Carbon Filter, Constructed Wetland, Water Reuse, Sustainable Water Management.

I. INTRODUCTION

Freshwater resources are becoming increasingly stressed due to population growth, industrialization, urban expansion, and climate variability. Many regions of India are facing severe water shortages, making water conservation and reuse essential components of sustainable development. Domestic wastewater generated from households can be classified into blackwater and greywater. Greywater refers to wastewater generated from non-toilet activities such as bathing, laundry, hand washing, and kitchen cleaning.
Greywater constitutes approximately 50–70% of total domestic wastewater and contains comparatively lower levels of pathogens than blackwater. Therefore, greywater presents considerable potential for treatment and reuse. Reusing treated greywater can reduce freshwater demand, decrease wastewater discharge, lower pressure on sewage treatment facilities, and contribute to environmental protection.
The present research focuses on developing a simple, low-cost, and efficient greywater treatment model suitable for domestic applications. The proposed system integrates physical filtration methods with biological treatment using Canna indica plants in a constructed wetland system.

II. RESEARCH GAP

Various greywater treatment technologies have been developed, including membrane filtration, electrocoagulation, biological reactors, and advanced oxidation processes. Although these systems provide high treatment efficiency, they are often expensive, energy-intensive, and difficult to operate in rural and

semi-urban areas. Most households require affordable and low-maintenance treatment systems that can be implemented without specialized technical expertise. Furthermore, limited studies have focused on integrating activated carbon filtration with Canna indica based phytoremediation under low-cost decentralized treatment conditions.

III. AIM AND OBJECTIVES

A. Aim

To study, design, and demonstrate a practical method for the recycling and reuse of domestic grey water in order to reduce freshwater consumption, minimize wastewater discharge, and promote sustainable water resource management at the household level.

B. Objectives

i. To identify the sources and characteristics of domestic greywater.

iii. To design and develop a low-cost greywater treatment model.

iv. To evaluate the effectiveness of physical filtration and phytoremediation techniques.

To analyze changes in water quality parameters before and after treatment.

IV. METHODOLOGY

The treatment system was developed using readily available materials and consisted of six major treatment stages.

4.1 Greywater Collection

Greywater was collected from domestic sources including:

* Bathroom wastewater
* Wash basin discharg
* Laundry wastewater
* Kitchen wastewater

4.2 Treatment Stages

Stage I – Mesh Filtration

A coarse mesh filter was installed to remove large suspended particles such as hair, lint, food particles, and debris.

Stage II – Sand Filtration

Greywater was passed through a sand filter bed to remove suspended solids and reduce turbidity.

Stage III – Activated Carbon Filtration

Activated carbon was used to adsorb dissolved organic contaminants, odor-causing compounds, and color-producing substances.

Stage IV – Aeration

Aeration was provided to increase dissolved oxygen concentration and enhance biological degradation of pollutants.

Stage V – Constructed Wetland

A treatment bed containing Canna indica plants was developed. The plant root system promoted microbial activity and nutrient uptake, improving pollutant removal efficiency.

Stage VI – Storage Tank

Treated water was collected in a storage tank and reused for non-potable purposes.

V. RESULTS AND DISCUSSION

The performance of the developed treatment system was evaluated using standard water quality parameters.

PARAMETER	UNFILTERED	FILTERED
pH	8.40	8.08
Turbidity	81	15
BOD	274	104
COD	560	240
TS	1080	104

The reduction in turbidity indicates effective removal of suspended particles through filtration. Activated carbon significantly improved water quality by reducing organic pollutants responsible for high COD levels. The presence of Canna indica enhanced biological treatment through nutrient uptake and microbial degradation.

The overall treatment system achieved:

* Turbidity reduction: 81.48%

* BOD reduction: 62.04%

* COD reduction: 57.14%

* Total Solids reduction: 90.37%

These results indicate that the developed treatment system is capable of producing water suitable for non-potable reuse applications.

VI. COMPARITIVE ANALYSIS OF PREVIOUS STUDIES

The performance of the developed greywater treatment model was compared with results reported by previous researchers. Although advanced treatment technologies generally provide higher pollutant removal efficiencies, they require higher capital investment, operational costs, and technical expertise.

STUDY	TRT. METHOD	BOD REMOVAL	COD REMOVAL
Karibasappa et al.	Canna indica Wetland	70–80	65–75
Dighe et al.	Vertical Flow Constructed Wetland	86	53
Pachkor et al.	Integrated Treatment System	92	84
Present study	Canna indica	62.04	57.14

Although the pollutant removal efficiency of the present study is slightly lower than large-scale integrated treatment systems, the developed model offers significant advantages in terms of low cost, simplicity, easy maintenance, and suitability for household-level applications.

The treatment system effectively demonstrates the feasibility of decentralized greywater treatment using natural filtration and phytoremediation techniques.

VII. ENVIRONMENTAL BENEFITS

Greywater recycling provides numerous environmental benefits by reducing freshwater extraction and minimizing wastewater discharge into natural ecosystems.

The major environmental benefits include:

* Conservation of freshwater resources.

* Reduction in groundwater depletion

* Reduced load on municipal sewage treatment plants.

* Lower environmental pollution caused by wastewater disposal.

* Reduction in nutrient discharge into rivers and lakes.

* Promotion of sustainable water management practices.

* Improved awareness regarding water conservation.

By implementing greywater treatment systems at household and community levels, significant quantities of freshwater can be saved annually.

VIII. APPLICATIONS OF TREATED GREYWATER

The treated greywater can be utilized for various non-potable purposes, including:

* Garden irrigation.

* Landscape watering

* Toilet flushing.

* Floor cleaning.

* Vehicle washing.

* Road and pavement cleaning.

* Construction activities.

* Decorative gardening and plantation maintenance.

The reuse of treated water reduces dependency on potable water for activities that do not require drinking water quality.

IX. ADVANTAGES OF THE PROPOSED SYSTEM

The developed greywater treatment model offers several advantages:

1. Low installation cost.
2. Simple construction and operation.
3. Environmentally sustainable.
4. Minimal energy requirement.

5. Effective reduction of organic pollutants.
6. Suitable for decentralized treatment.
7. Easy maintenance.
8. Water conservation and reuse.
9. Reduced wastewater discharge.
10. Enhanced environmental awareness.

X. LIMITATIONS OF STUDY

Despite its benefits, the proposed system has certain limitations:

* Treated water is not suitable for drinking purposes.

* Treatment efficiency depends upon proper maintenance.

* Long-term storage may cause odor formation.

* Seasonal variations may affect plant performance.

* Large-scale implementation requires additional treatment stages.

* Pathogen removal was not extensively investigated in this study.

Future studies should focus on advanced disinfection techniques and long-term performance evaluation.

XI. FUTURE SCOPE

The present study can be further improved through:

* Integration of UV disinfection systems.

* Smart monitoring using IoT-based sensors.

* Solar-powered pumping systems.

* Hybrid constructed wetlands

* Large-scale community-level installations.

* Real-time water quality monitoring.

* Automated filtration and cleaning mechanisms.

Future developments can increase treatment efficiency and expand the range of reuse applications.

XII. CONCLUSION

The present study successfully demonstrates the design and development of a low-cost domestic greywater treatment and recycling system using mesh filtration, sand filtration, activated carbon filtration, aeration, and Canna indica based phytoremediation.

Experimental analysis revealed significant reductions in turbidity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Solids (TS). The treatment system achieved turbidity removal of 81.48%, BOD removal of 62.04%, COD removal of 57.14%, and Total Solids removal of 90.37%.

The results indicate that the treated greywater is suitable for several non-potable applications such as gardening, toilet flushing, vehicle washing, and cleaning activities. The proposed system is economical, sustainable, environmentally friendly, and easy to operate.

The implementation of such decentralized treatment systems can significantly contribute towards water conservation, wastewater reduction, and sustainable water resource management in urban and rural areas.

XII. REFFERENCES

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