

COMPARATIVE STUDY OF ECO-FRIENDLY GREYWATER FILTRATION: A SUSTAINABLE ALTERNATIVE USING DATE PALM FIBER AND SUGARCANE BAGASSE

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Abstract: This paper presents the fabrication of a greywater purification system aimed at recycling and treating greywater for non-potable purposes, such as irrigation, domestic purposes etc. The proposed system incorporates a multi-stage purification process, comprising physical, biological, and chemical treatment methods. The physical treatment stage involves the removal of large solids and debris through a series of filters, settling tanks, and screens. Subsequently, the greywater undergoes biological treatment in which microorganisms break down organic matter through aerobic or anaerobic processes, promoting the removal of pathogens. Antinutrients enhance the purification efficiency, an advanced chemical treatment stage is implemented, incorporating techniques such as coagulation, flocculation, and disinfection., TSS, TDS, BOD, COD. The results reported the removal efficiency in the biological oxygen demand (86.2%), chemical oxygen demand (81.1%). Consequently, this biofiltration method is natural, simple, and low cost-effective treatment. Disinfection techniques, including chlorination or ultraviolet (UV) disinfection, are employed to eliminate remaining pathogens and ensure the safety of the treated greywater. In this study, we reviewed Greywater characteristics and various treatment technologies with the schematic of Greywater recycling system with specific Designed. Greywater Amount varies from 50 % to 80% of the wastewater volume produced by households. Technologies used for Greywater treatment are classified into physical, chemical, biological, and natural system, or a combination of these. Constructed wetland (Bio-sand filtration) can be regarded as the most environmentally friendly and cost-effective technology for Greywater treatment and reuses. Finally, the study suggests the possible Greywater recycling scheme for irrigation and toilet flushing. This paper presents the design of laboratory scale grey water treatment system, The system has been found as more effective for treating the Physical-chemical parameters such as pH, electrical conductivity

Key Words: Grey Water, Eco-Friendly, Filtration, Recycling, Sustainable.

I. INTRODUCTION

Grey water can be defined as the wastewater generated from the baths, showers, hand basins, washing machines, laundries and kitchen sinks. The main objectives of this project are to investigate the viability of grey water recycling as a sustainable solution for water management in water scare regions. The application of greywater reuse in urban water systems provides substantial benefits for both the water supply subsystem by reducing the demand

for fresh clean water as well as the wastewater subsystems by reducing the amount of wastewater required to be conveyed and treated. Water scarcity is a major issue throughout the world, especially in deserts and places that are dry. Greywater management is a way to conserve the amount of water we will need to get the job done by providing us with a sustainable way of providing us with non-reusable uses and reducing freshwater use.

Greywater recycling reduces freshwater consumption significantly. Water plays a vital role in our survival on Earth, but many countries around the world including India suffer from extreme amounts of water pollution and climate change. India represents approximately 18% of the World's population and has about 4% of the total World freshwater. Due to this huge disparity between the population and the total amount of freshwater, the northern states of Rajasthan, Gujarat.



Fig.1 Village reuse Greywater

II. PROBLEM STATEMENT

Rapid urbanization and population growth have significantly increased the demand for freshwater, while the availability of usable water resources continues to decline. A large amount of greywater

from households—bathrooms, kitchens, and laundry—is discharged untreated into drains. This leads to water waste, pollution, and stress on freshwater sources.

Conventional greywater treatment technologies, like membrane systems and chemical treatments, are often expensive, energy-intensive, and complex. These factors make them unsuitable for small-scale and low-income communities. Simultaneously, large amounts of agricultural waste, such as date palm fibres and sugarcane bagasse, are discarded, creating challenges in waste management. Therefore, there is a critical need to develop low-cost, eco-friendly, and sustainable greywater treatment systems that use natural and locally available materials.

This project aims to address those issues with filtration units made from date palm and sugarcane bagasse, which can improve water quality. This project seeks to solve these problems by developing a sustainable, low-cost greywater filtration system that uses these natural materials to improve water quality for non-potable reuse.

III. METHODOLOGY

The first stage involves procuring materials. Eco-friendly and locally sourced items like date palm fiber, sugarcane bagasse, charcoal, fine sand, and aggregates were chosen. These selections were based on their filtration efficiency, adsorption capacity, availability, and environmental sustainability. Before use, the materials were cleaned and prepared for effective filtration.



Fig.2 Diagram of Methodology

After collection, the greywater underwent testing, which included physical, biological, and chemical

analysis. Physical tests measured parameters like turbidity and suspended solids. Chemical tests measured pH, total dissolved solids (TDS), electrical conductivity, COD, BOD, oil and grease, and total hardness. These tests provided insight into the pollution levels of raw greywater before treatment.



3.1 COLLECTION SAMPLE OF GREYWATER



Fig.3 Sample of greywater and Filtered Greywater

From the picture, it is possible to identify how the greywater samples were collected and analyzed during the experiment. The clean and clearly labeled containers were used to store greywater from chosen sources for possible identification and tracking. From the picture, the containers store raw greywater and those that have undergone filtration for analysis and comparison purposes.

3.2 EXPERIMENTAL SETUP



Fig.4 Rectangular Glass shape filter and filling with materials

The experimental setup for the greywater filtration system was designed to test the performance of natural filtration materials in treating household greywater. A rectangular transparent tank, 45 cm tall, was used so observers could clearly see the arrangement of layers and water flow during the experiment. While charcoal layer forms the first stage of treatment, its thickness is 4 cm. Below the charcoal, a sugarcane bagasse layer 4 cm thick was added. The fine sand layer, also 4 cm thick, is the next layer used for mechanical filtration. Below the layer of sand, a date palm Fiber layer 4 cm thick is provided. A 7 cm thick aggregate layer is placed at the bottom of the filtration unit. The aggregate layer provides a support bed for all the filtration materials that lie above it. Below the aggregate layer, a zone for collection of 7.5 cm is provided. Material used for filtration systems are grey water samples, Aggregate, Fine sand, Palm Fibers, sugarcane bagasse and charcoal.

4. RESULTS AND DISCUSSION



Fig.5 Greywater sample Testing in Environmental Lab

The turbidity level seen was high, indicating the presence of particles such as dirt, organic matter, fibres, or soap scum.

4.1 GREYWATER QUALITY RESULTS TABLE

S No	Parameter	Initial Value (Raw Greywater)	Final Value (Filtered Water)	Typical Acceptable Range
1	pH	6.8	7.45	6.5 – 8.5
2	Turbidity (NTU)	255 NTU	20 NTU	10–25 NTU
3	TDS (mg/L)	800 mg/L	560 mg/L	500–1000 mg/L
4	Conductivity (µS/cm)	1200 µS/cm	650 µS/cm	1000–1500 µS/cm
5	BOD (mg/L)	120 mg/L	20.5 mg/L	30–50 mg/L
6	COD (mg/L)	250 mg/L	110 mg/L	100–150 mg/L
7	Oil & Grease (mg/L)	20 mg/L	8.5 mg/L	10 mg/L
8	Total Hardness (mg/L)	330 mg/L	180 mg/L	300 mg/L
9	Suspended Solids (mg/L)	150 mg/L	35 mg/L	50 mg/L

The table below shows the results of various water quality parameters measured for greywater before treatment (raw greywater) and after treatment (filtered water) using the eco-friendly filtration system. This also includes the typical acceptable range in most cases for comparison to a reference standard.

4.2 DATA ANALYSIS AND COMPARING OF INITIAL AND FINAL RESULTS

This table makes a comparison between the quality of raw grey water and treated grey water based upon the selected physical and chemical parameters. It also defines the acceptable range, the level of improvement, and a scientific explanation of the improvement in terms of the parameter. This assists the reviewer to comprehend the extent of improvement and the implications of improvement

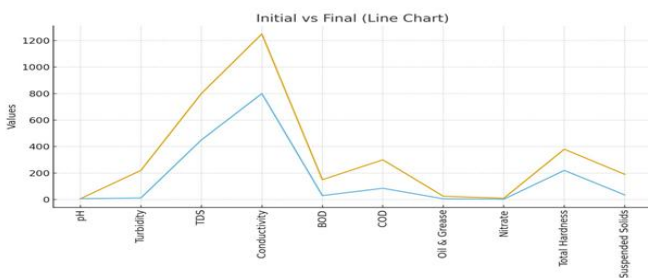
SL. NO.	Parameter	Raw Greywater Value	Treated Greywater Value	Typical Acceptable Range	In % Improvement	Scientific Interpretation
1	pH	6.8	7.45	6.5 – 8.5	9.56%	pH became neutral after filtration, safe for reuse in irrigation & flushing.
2	Electrical Conductivity	1200µS/cm	650 µS/cm	1000-1500µS/cm	45.83%	Slight reduction, indicates removal of some dissolved ionic compounds.
3	Turbidity	255 NTU	20 NTU	10-25 NTU	92.15%	Still slightly above potable limit but safe for gardening, toilet flushing, and cleaning floors.
4	Total Dissolved Solids	800mg/L	650 mg/L	500-1000 mg/L	20.5%	Reduced slightly, indicates effective filtration of dissolved detergent residues.
5	COD	250 mg/L	110 mg/L	100-150 mg/L	56.25%	Major reduction (water now acceptable for non-potable reuse)
6	BOD	120 mg/L	20.5 mg/L	30-50 mg/L	82.91%	BOD reduced drastically (250 → 110). Slightly above irrigation limit but still acceptable after natural sunlight exposure
7	Oil & Grease	20 mg/L	8.5 mg/L	10 mg/L	56.5%	Now within safe limit due to activated carbon / sand layer
8	Total Hardness	330 mg/L	180 mg/L	300 mg/L	45.45%	Slightly reduced hardness due to media filtration. Acceptable.
9	Suspended Solids	150 mg/L	35 mg/L	50 mg/L	76.67%	Excellent improvement (150 → 35 mg/L). Now suitable for almost all non-potable applications.

Table :4.2 Data analysis and Comparison Table

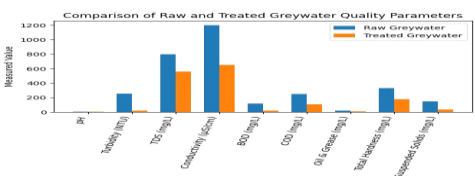
For pH, the actual value of greywater of 6.8 rose to 7.45. The percentage value depicts that the pH has now stabilized at an appropriate level, thereby indicating that the filter has neutralized the water. The electrical conductivity values decreased from 1200 µS/cm to 650 µS/cm, which indicated a significant reduction in the concentration of dissolved ions.

4.3 INITIAL AND FINAL QUALITY PARAMETER IN LINE CHARTS

This graph allows a comparison of the raw quality of the greywater against the treated quality of the greywater after being treated using the eco-friendly filter developed using the date palm fiber, sugarcane bagasse, sand, charcoal, and aggregates. Every two columns are able to clearly compare the qualities of the water treated.



Line chart; 4.1 Initial and Finals Quality of Greywaters in Line Chart



Bar Charts :4.2 Comparison of Greywater sample and Treated Greywater in Graph

4.4 PURPOSE OF CALCULATION

This calculation helps to determine the efficiency of the treatment system. This indicates the amount of

improvement achieved after filtration in percentage form, thus facilitating easy comparisons with respect to different parameters.

Formula Used

$$\text{Improvement (\%)} = \frac{\text{Final value} - \text{Initial value}}{\text{Initial value}} \times 100$$

This formula expresses the change relative to the initial condition, which is the standard method used in environmental and water quality studies.

Step-by-Step Explanation (Example: pH)

- Initial pH (Raw greywater) = 6.8
- Final pH (Treated greywater) = 7.45

Step 1: Find the difference

$$7.45 - 6.8 = 0.65$$

Step 2: Divide by the initial value

$$\frac{0.65}{6.8} = 0.095588$$

Step 3: Convert to percentage

$$0.095588 \times 100 = 9.56\%$$

5. CONCLUSION

This study adequately probed the potential of greywater recycling as a water management practice that is rather environmentally friendly and appropriate even for arid areas that water scarcity is worrying. Based on the above-mentioned aims of this paper, this study was able to convey that greywater from households can be adequately treated by the help of environmentally friendly materials such as date palm fiber and sugarcane bagasse.

The results obtained confirmed that the designed filtration system was able to remove key pollutants such as turbidity, suspended solids, organic matter (BOD and COD), oil and grease, and hardness effectively while keeping the pH within acceptable limits. This clearly establishes the feasibility of using inexpensive natural filtration media alternatives to expensive technologies.

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