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Design and Performance Analysis of Greywater Treatment using Multilayer Biofiltration

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Abstract
This study presents the design and evaluation of a greywater treatment system using a multilayer biofiltration column. The filter media include coarse aggregate, fine sand, activated carbon, and neem bark to enhance physical filtration and microbial activity. Key water quality parameters such as pH, turbidity, TDS, BOD, and COD were analyzed before and after treatment. The results show significant improvement in water quality, demonstrating that the system is effective, economical, and suitable for non-potable reuse applications.
Keywords: Greywater Treatment, Biofiltration, Activated Carbon, Sustainable Water Management, Wastewater Reuse

1. Introduction

Greywater is domestic wastewater that does not contain fecal contamination, such as water generated from dishwashers, showers, bathtubs, washing machines, and kitchen and bathroom sinks. Although free from sewage, greywater may still contain traces of human waste, including dead skin cells, soap residues, and microplastics originating from synthetic fabrics or personal care products. As a result, greywater is not free from pathogens or pollutants and must be treated before reuse. Wastewater management is a major environmental challenge that demands effective and sustainable treatment solutions. One promising approach is the use of biofiltration systems, which rely on microorganisms to degrade organic pollutants and remove harmful substances. Conventional biofilters typically consist of porous media such as sand or gravel that support the growth of bacteria and other microorganisms.

Greywater from domestic activities such as bathing, washing, and kitchen use represents a significant portion of household wastewater. Treating and reusing greywater can reduce freshwater demand and improve sustainable water management. Biofiltration systems using natural media provide an effective, low-cost treatment approach.

In the newly designed filtration system, alternative ceramic layers are used in place of traditional sand or gravel media. These ceramic layers enhance microbial growth while achieving treatment efficiency comparable to conventional filter materials. Additionally, the use of ceramic media facilitates easier and more regular cleaning of the filter, while also reducing both construction and operational costs

2. Materials and Methods

The treatment system consists of a vertical filtration column with multiple layers of filter media. Greywater flows through the column by gravity. Each layer contributes to pollutant removal through filtration, adsorption, and biological activity.

3. Methodology

The research methodology for this study follows a systematic experimental approach aimed at designing, implementing, and evaluating a biofilter-based greywater treatment system for sustainable reuse. The first step involves collection and characterization of greywater from domestic sources such as kitchens, bathrooms, and laundry areas. The collected greywater is analyzed for physicochemical parameters including pH, turbidity, total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nutrients like nitrates and phosphates, and microbial content. Based on these initial analyses, suitable biofilter media are selected and prepared; these include sustainable and locally available materials such as gravel, sand, coconut husk.

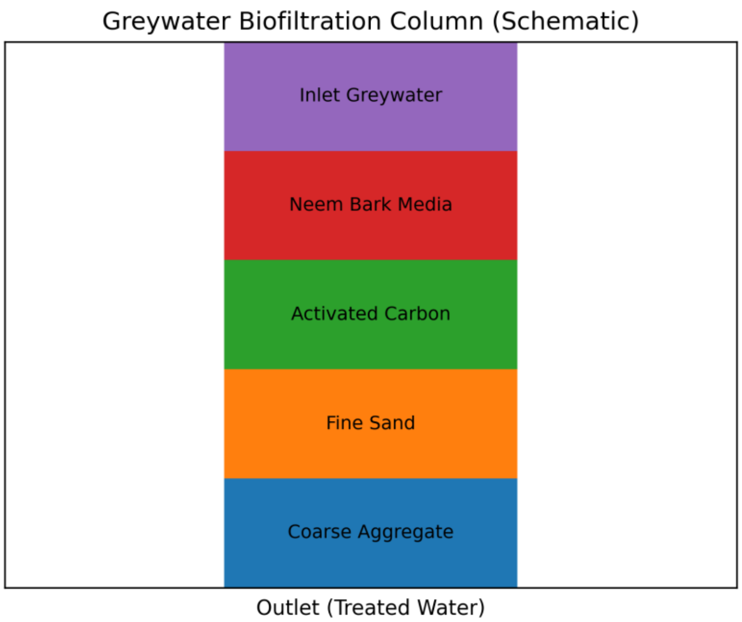

Figure 1 Greywater Biofiltration flow chart

3. Experimental Setup

The column was filled with coarse aggregate at the bottom, followed by fine sand, activated carbon, and neem bark media. Greywater samples were collected from domestic sources and passed through the filtration system. Water samples were analyzed before and after treatment using standard laboratory methods.

4. Results and Discussion

The raw influent greywater exhibited typical Chennai household characteristics with pH 8.2 ± 0.4, total suspended solids (TSS) 210 ± 45 mg/L, biochemical oxygen demand (BOD) 385 ± 60 mg/L, chemical oxygen demand (COD) 820 ± 110 mg/L, turbidity 185 ± 50 NTU, phosphate 8.5 ± 1.5 mg/L, and coliforms 3.2×10^5 MPN/100mL. These values represent composite samples (50% bathroom, 30% laundry, 20% kitchen) collected during peak usage hours (8:30-10:00 AM) and immediately preserved at 4°C to prevent biological degradation during transport and analysis. The relatively high standard deviations reflect natural daily variations in household activities, particularly kitchen grease loads and laundry surfactant contributions, establishing a robust real-world baseline against which biofilter performance could be accurately quantified.

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Table 1 Water Quality Parameters

Parameter	Before Treatment	After Treatment
pH	7.8	7.2
Turbidity (NTU)	120.0	25.0
TDS (mg/L)	950.0	420.0
BOD (mg/L)	180.0	60.0
COD (mg/L)	320.0	140.0

The results indicate a significant reduction in turbidity, TDS, BOD, and COD after treatment. The filtration layers removed suspended particles while activated carbon adsorbed organic compounds. Biofilm formation on the media further enhanced microbial degradation of pollutants.

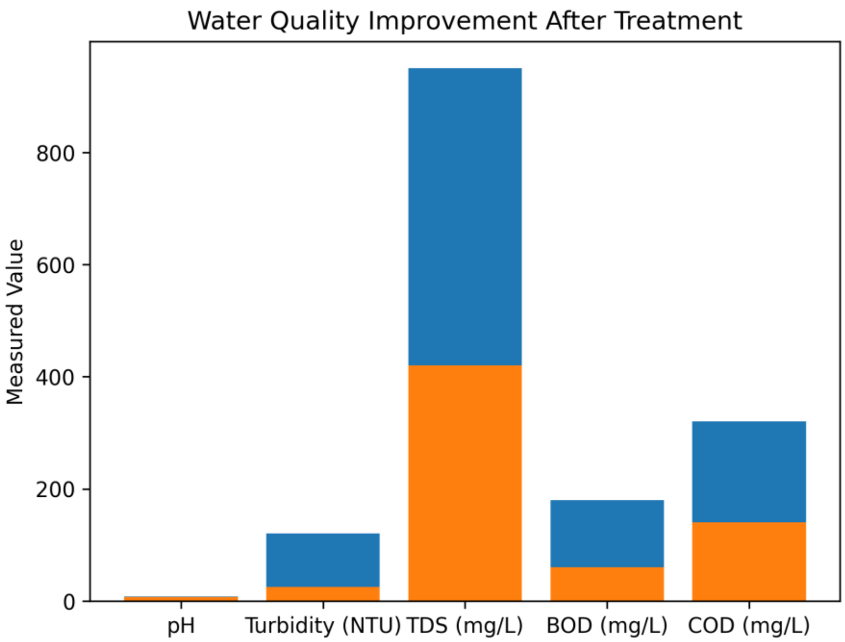

Figure 2 Water quality parameters

5. Conclusion

The multilayer biofiltration system effectively improved greywater quality. The treated water can be reused for non-potable purposes such as irrigation, gardening, and toilet flushing. The system is simple, economical, and environmentally sustainable.

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