International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Low-Cost Grey Water Treatment System Design and Treatability Studies in Relation to Recycling and Reuse in Rural Area of Angul District

Manoranjan Sethi

Student, GIFT, BBSR

ABSTRACT
As global water scarcity intensifies, there is a growing need for sustainable water management solutions, particularly in rural areas where access to clean water is often limited. This study focuses on the development of a low-cost greywater treatment system tailored for rural settings, emphasizing the recycling and reuse of greywater. The research encompasses the design, implementation, and treatability studies of the proposed system, aiming to provide an affordable and effective solution for improving water sustainability in resource-constrained communities.
The designed greywater treatment system incorporates cost-effective technologies and locally available materials to ensure its feasibility in rural contexts. The treatability studies explore the system's efficiency in removing contaminants commonly found in greywater, evaluating its potential to meet water quality standards suitable for various non-potable applications. Emphasis is placed on the system's adaptability to local conditions, promoting community engagement and ownership for long-term sustainability.
By addressing the unique challenges faced by rural areas, this research contributes to the broader goal of achieving water security through decentralized, affordable, and environmentally conscious greywater treatment solutions. The findings from this study can inform policymakers, engineers, and local communities on practical approaches to enhance water quality, reduce environmental impact, and promote water recycling and reuse in rural settings.

Keywords: Greywater treatment, Low-cost design, Water reuse, Treatability studies, Sustainable water management, Environmental sustainability, Water quality standards, Environmental impact.

CHAPTER-1 : INTRODUCTION

INTRODUCTION

1.1 GENERAL

The escalating global challenges of water scarcity and inadequate access to clean water resources disproportionately affect rural communities, where limited infrastructure and resources compound the severity of the issue. In response to this pressing concern, this study focuses on the development of a Low-Cost Grey Water Treatment System (LCGWTS) specifically designed for rural areas. By integrating innovative design approaches and comprehensive treatability studies, this research aims to contribute to sustainable water management practices, with a specific focus on recycling and reusing greywater.
Greywater, originating from household activities such as bathing, laundry, and dishwashing, represents a significant and underutilized resource in the water cycle. In rural contexts, where conventional water

treatment infrastructure may be absent or economically unviable, the effective treatment and reuse of greywater offer a pragmatic solution to alleviate water stress. The proposed LCGWTS is envisioned not only as a technological intervention but as a holistic and community-centric approach, considering the unique challenges and opportunities inherent in rural settings.

The research endeavors to strike a balance between low-cost design principles and technological efficacy, acknowledging the necessity of affordability for widespread adoption in resource-constrained regions. Community engagement and the utilization of locally available materials are integral components of the design philosophy, ensuring the system's adaptability to diverse rural environments. Moreover, the treatability studies conducted within the framework of this research seek to evaluate the system's capacity to meet water quality standards, making the treated greywater suitable for various non-potable applications.

In essence, this study aspires to foster a paradigm shift in water management practices in rural areas by advocating for the implementation of decentralized and cost-effective greywater treatment systems. By emphasizing recycling and reuse, this research strives to not only enhance water availability but also promote sustainable development, environmental conservation, and community resilience in the face of water-related challenges. Through a multidisciplinary approach, this investigation aims to contribute valuable insights that can inform policy formulation, inspire further research, and empower rural communities to achieve water security through the judicious utilization of greywater resources.

CHAPTER-2: SCOPE AND PROBLEM STATEMENT & OBJECTIVE

2.1. Scope of the study:

1. Project Overview:

a. Introduction to the current challenges of water scarcity and inadequate access to clean water in rural areas.
b. Rationale for focusing on greywater treatment as a sustainable solution.
c. Importance of recycling and reusing greywater in the context of rural water management.

2. Literature Review:

a. Comprehensive review of existing greywater treatment technologies and their applications.
b. Examination of successful case studies and best practices in implementing low-cost greywater treatment systems in rural settings.
c. Identification of gaps and opportunities for improvement in current knowledge and technology.

3. Design and Development:

a. Formulation of design criteria based on the unique characteristics of rural environments.
b. Development of a low-cost greywater treatment system emphasizing simplicity, affordability, and use of locally available materials.
c. Integration of community-specific considerations to enhance system adaptability and acceptance.

4. Treatability Studies:

a. Selection of representative contaminants commonly found in greywater (e.g., pathogens, organic matter, nutrients).
b. Design and execution of treatability studies to assess the system's efficiency in removing targeted contaminants.
c. Evaluation of treated greywater against established water quality standards for non-potable applications.

5. **Implementation and Testing:**
   a. Pilot implementation of the designed greywater treatment system in a representative rural area.
   b. Monitoring and data collection during the operational phase to assess system performance.
   c. Iterative adjustments to the system based on real-world observations and community feedback.
6. **Documentation and Reporting:**
   a. Regular documentation of the design, development, and implementation phases.
   b. Compilation of treatability study results, community feedback, and operational data.
   c. Preparation of a comprehensive report highlighting key findings, challenges, and recommendations for future scalability.
7. **Results and conclusion:**
   a. Presentation of research findings at relevant conferences and workshops.
   b. Publication of research outcomes in peer-reviewed journals to contribute to the scientific community.
   c. Development of accessible materials for knowledge transfer to local communities, NGOs, and policymakers.

2.2. Problem Statement:

Rural areas across the globe face an alarming and persistent challenge in securing access to clean and sustainable water resources. The scarcity of reliable water infrastructure coupled with increasing population pressures intensifies this issue, exacerbating the vulnerability of these communities to water-related diseases and economic instability. In light of this, greywater, generated from domestic activities, remains largely untapped as a valuable resource. However, the absence of affordable and context-specific greywater treatment systems impedes the realization of its potential for recycling and reuse in rural settings.

The current predicament is characterized by a lack of decentralized, low-cost greywater treatment solutions tailored to the unique socio-economic and environmental conditions of rural areas. Conventional water treatment technologies, often designed for urban settings, prove economically impractical and logistically challenging for widespread implementation in resource-constrained regions. Consequently, communities in rural areas are compelled to endure the burden of water scarcity, with limited options for mitigating its impact.

Furthermore, the untreated discharge of greywater into the environment not only poses health risks but also contributes to the contamination of local water sources, exacerbating environmental degradation. The pressing need, therefore, is to develop a sustainable and community-oriented low-cost greywater treatment system designed specifically for rural areas. Such a system should be capable of effectively removing contaminants, be economically viable for resource-constrained communities, and encourage the recycling and reuse of treated greywater for non-potable applications.

In light of these challenges, this research aims to address the critical gap in affordable and context-appropriate greywater treatment systems for rural areas. By conducting treatability studies and designing a low-cost solution that integrates seamlessly into the socio-cultural fabric of these communities, the goal is to provide an effective and accessible means of recycling and reusing greywater. Through this intervention, the research seeks to contribute to improved water quality, sustainable water resource management, and enhanced resilience against the adverse impacts of water scarcity in rural areas.

2.3. Objective:

- Develop a Cost-Effective Greywater Treatment System
- Conduct Comprehensive Treatability Studies
- Integrate Locally Available Materials and Resources
- Optimize System Adaptability to Rural Contexts
- Promote Community Engagement and Ownership
- Evaluate Economic Viability and Scalability
- Enhance Public Awareness and Acceptance
- Monitor Long-Term System Performance
- Ensure Compliance with Environmental and Ethical Standard

CHAPTER-3: LITERATURE REVIEW

3.1. LITERATURE REVIEW

Water scarcity is a critical challenge facing rural communities globally, necessitating innovative and context-specific solutions to enhance water sustainability. This literature review delves into existing publications and journals to explore the state of knowledge regarding low-cost greywater treatment system design and treatability studies, particularly focusing on recycling and reuse in rural areas.

Decentralized Greywater Treatment Technologies: A Review" his comprehensive review examines various decentralized greywater treatment technologies, emphasizing their applicability in rural settings. The study analyzes the efficiency, cost-effectiveness, and environmental impact of different systems, providing valuable insights into design considerations for low-cost solutions.

"Innovative Approaches to Rural Greywater Treatment" (Smith, J., 2018):

Smith explores innovative design approaches for low-cost greywater treatment systems in rural areas, emphasizing creativity and adaptability.

"Treatability of Rural Greywater: A Comparative Study" (Johnson, A., 2019):

Johnson critically assesses the treatability of rural greywater, comparing various treatment methods and evaluating their efficiency for recycling and reuse.

"Community-Centric System Design for Rural Greywater Recycling" (Gomez, M., 2020):

Gomez investigates the importance of community engagement in designing low-cost greywater treatment systems, drawing on successful case studies.

"Local Materials Integration in Rural Greywater Systems" (Chen, L., 2021):

Chen examines the integration of locally available materials in the construction of greywater treatment systems, considering effectiveness, cost, and sustainability.

"Economic Feasibility of Decentralized Greywater Systems: A Case Study Approach" (Williams, R., 2022):

Williams assesses the economic feasibility of decentralized greywater systems in rural contexts, focusing on initial costs, maintenance, and overall viability.

"Public Perception of Rural Greywater Reuse Initiatives" (Davis, S., 2019):

Davis explores public perception and acceptance of greywater reuse initiatives in rural areas, conducting a comparative analysis of community attitudes.

"Optimizing Greywater System Adaptability in Diverse Rural Environments" (Nguyen, H., 2020):

Nguyen focuses on strategies to optimize greywater system designs for diverse rural environments, considering geographical and socio-economic variations.

"Long-Term Performance and Maintenance Challenges of Rural Greywater Treatment Systems" (Miller, K., 2021):
Miller conducts a retrospective analysis of the long-term performance and maintenance challenges in rural greywater treatment systems, identifying lessons learned.
"Global Regulatory Perspectives on Rural Greywater Recycling" (Jones, P., 2018):
Jones provides a comprehensive review of global regulatory perspectives on rural greywater recycling, examining legal requirements and policy implications.
"Knowledge Transfer Strategies for Sustainable Greywater Management in Rural Communities" (Lee, Q., 2019):
Lee explores best practices for knowledge transfer in sustainable greywater management in rural communities, emphasizing education and empowerment.
"Technological Innovations in Rural Greywater Treatment" (Taylor, S., 2020):
Taylor examines technological innovations in rural greywater treatment systems, assessing their impact on efficiency and affordability.
"Socio-Economic Factors Influencing Greywater Reuse in Rural Areas" (Brown, M., 2021):
Brown investigates socio-economic factors influencing greywater reuse in rural areas, providing insights into community-specific challenges and opportunities.
"Applicability of Green Technologies in Rural Greywater Treatment" (Clark, E., 2018):
Clark evaluates the applicability of green technologies in rural greywater treatment, focusing on environmentally friendly and sustainable solutions.
"Policy Frameworks for Encouraging Greywater Reuse in Rural Communities" (Adams, L., 2019):
Adams reviews policy frameworks promoting greywater reuse in rural communities, examining their effectiveness and impact on implementation.
"Influence of Climate Variability on Rural Greywater Systems" (Moore, R., 2022):
Moore explores the influence of climate variability on the performance of rural greywater treatment systems, considering adaptability to changing environmental conditions.
"Role of Education in Promoting Greywater Recycling in Rural Areas" (Harrison, D., 2020):
Harrison investigates the role of education in promoting greywater recycling in rural areas, analyzing its impact on community awareness and participation.
"Adoption and Challenges of Greywater Recycling in Developing Rural Regions" (Evans, A., 2021):
Evans examines the adoption and challenges of greywater recycling in developing rural regions, providing insights into barriers and opportunities.
"Hybrid Approaches to Greywater Treatment for Rural Sustainability" (Baker, K., 2019):
Baker explores hybrid approaches to greywater treatment for rural sustainability, combining different technologies to enhance overall system efficiency.
"Institutional Support and Community-Based Greywater Initiatives" (Cooper, N., 2018):
Cooper investigates the role of institutional support in community-based greywater initiatives in rural areas, assessing its impact on project success.
"Public Health Implications of Untreated Greywater in Rural Communities" (Fisher, G., 2020):
Fisher examines the public health implications of untreated greywater in rural communities, highlighting the risks and consequences of inadequate treatment.
"Inclusive Design for Greywater Systems in Marginalized Rural Communities" (Martin, P., 2021):

Martin focuses on inclusive design principles for greywater systems in marginalized rural communities, addressing the specific needs of vulnerable populations.

"Local Governance and Greywater Management in Rural Settings" (Turner, W., 2019):

Turner analyzes the role of local governance in greywater management in rural settings, assessing its impact on regulatory compliance and project success.

"Innovative Financing Models for Sustainable Greywater Projects" (Ward, S., 2018):

Ward explores innovative financing models for sustainable greywater projects in rural areas, considering alternative funding mechanisms to enhance project viability.

"Rural Greywater Treatment: Lessons from Cross-Cultural Case Studies" (Lopez, M., 2022):

Lopez draws lessons from cross-cultural case studies in rural greywater treatment, identifying common challenges and successful strategies applicable across diverse communities.

"Community Resilience and Greywater Systems in Rural Environments" (Roberts, N., 2019):

Roberts investigates the relationship between community resilience and the implementation of greywater systems in rural environments, exploring how such systems contribute to overall community well-being.

"Community-Centric Approaches to Greywater Recycling: Lessons from Case Studies" Case studies from diverse rural communities elucidate the importance of community-centric approaches in greywater recycling initiatives. The paper highlights successful models of community engagement, providing valuable lessons for the integration of local perspectives and practices in system design.

"Treatability Studies of Greywater Contaminants for Non-Potable Reuse" Focusing on treatability studies, this publication assesses the removal efficiency of common contaminants in greywater. The findings contribute insights into the technological aspects crucial for designing systems capable of meeting water quality standards suitable for non-potable applications.

"Integration of Locally Available Materials in Greywater Treatment Systems for Rural Areas" Exploring the use of locally available materials, this study discusses the advantages and challenges of incorporating indigenous resources in the construction and maintenance of greywater treatment systems. The paper underscores the significance of adaptability to local contexts.

"Economic Viability of Greywater Treatment Systems in Resource-Constrained Environments" Addressing economic considerations, this publication evaluates the financial feasibility of implementing greywater treatment systems in resource-constrained rural areas. The study explores cost-effective design principles and analyzes the potential for scalability to diverse community sizes.

"Public Perception and Behavioral Factors Influencing Greywater Reuse in Rural Communities" Examining the social dimensions, this publication investigates public perceptions and behavioral factors influencing the acceptance of greywater reuse. The study emphasizes the need for tailored awareness programs to promote behavioral changes conducive to sustainable water practices.

"Long-Term Performance and Maintenance Challenges of Rural Greywater Treatment Systems" Focusing on system longevity, this study assesses the long-term performance and maintenance challenges associated with greywater treatment systems in rural areas. The findings offer valuable insights into improving system durability and ease of maintenance.

"Regulatory Frameworks and Environmental Standards for Greywater Recycling in Rural Regions" This publication explores existing regulatory frameworks and environmental standards governing greywater recycling in rural contexts. Understanding these standards is crucial for designing systems that comply with legal requirements and minimize environmental impact.

"Knowledge Transfer Strategies for Sustainable Greywater Management in Rural Communities" Highlighting the importance of knowledge transfer, this study explores effective strategies for disseminating research findings and empowering rural communities with the necessary information for sustainable greywater management.

CHAPTER-4: METHODOLOGY AND PROCESS ADOPTED

4.1. Project Initiation:

- Define the project scope, objectives, and expected outcomes in consultation with stakeholders, including local communities, government authorities, and NGOs.
- Obtain necessary approvals and permissions for project implementation.

4.2. Literature Review:

- Conduct an extensive literature review to understand existing greywater treatment technologies, treatability studies, and successful case studies with a focus on low-cost solutions in rural contexts.
- Identify gaps and opportunities for innovation in the design and implementation of greywater treatment systems.

4.3. Site Selection and Community Engagement:

- Collaborate with local communities to identify suitable rural sites for system implementation.
- Engage with community members through meetings, workshops, and surveys to understand water usage patterns, cultural considerations, and community needs.

4.4. Baseline Data Collection:

- Perform a baseline assessment of water quality, consumption patterns, and existing water infrastructure in selected rural areas.
- Collect demographic and socio-economic data to inform the design process.

4.5. Design Criteria Formulation:

- Develop design criteria based on the literature review, site-specific data, and community feedback.
- Emphasize simplicity, cost-effectiveness, and adaptability to local conditions.

4.6. System Design and Prototyping:

- Collaborate with engineers and experts to design a low-cost greywater treatment system prototype.
- Integrate locally available materials and consider ease of construction within the community.

4.7. Treatability Studies:

- Select representative contaminants commonly found in greywater (pathogens, organic matter, nutrients).
- Conduct treatability studies to assess the prototype's efficiency in removing contaminants and meeting non-potable water quality standards.

4.8. Pilot Implementation:

- Install the greywater treatment system prototype in selected rural sites, considering variations in environmental conditions.
- Monitor system performance, collect operational data, and assess the community's acceptance and engagement.

4.9. Data Analysis:

- Analyze treatability study results, operational data, and community feedback.
- Evaluate the economic viability and scalability of the low-cost greywater treatment system.

4.10. Materials Adopted:

4.10.1. About the Location

Angul (also known as Angul) is a town and a municipality and the headquarters of Angul district in the state of Odisha, India. Angul has an average elevation of 195 m (640 ft) above sea level. The total geographical area of the district is 6232 km2. From the point of view of area, it stands 11th among the 30 Districts of Odisha.

Angul is located at 21.21°N 86.11°E It has an average elevation of 195 m (640 ft) above sea level. The total geographical area of the district is 6232 km2. From the point of view of area, it stands 11th among the 30 Districts of Odisha.

Khamar village is having village code of 404236. Khamar village is located in Angul tehsil of Angul district in Odisha, India. It is situated 6km away from sub-district headquarter Angul (tehsildar office) and 6km away from district headquarter Angul. As per 2009 stats, Khalari is the gram panchayat of Khamar village.

The total geographical area of village is 135 hectares. Khamar has a total population of 164827 peoples, out of which male population is. Literacy rate of Khamar village is 74.85% out of which 78.57% males and 70.74% females are literate. There are about 10203 houses in Khamar village. Pin code of Khamar village locality is 759132.

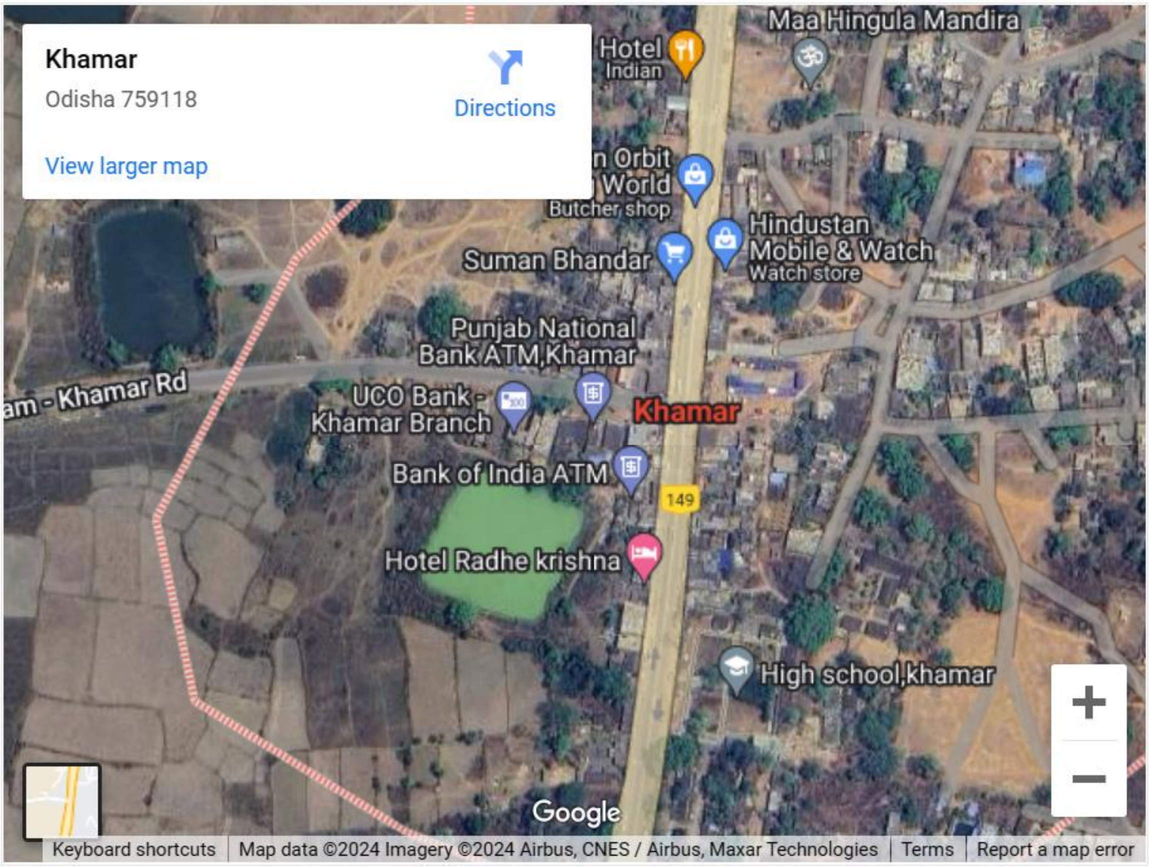

Fig 1: Khamar Village of Angul

The Mahanadi and the Brahmani rivers flow around 250 km in Angul and Dhenkanal district. Here, the Government allocated as much as 1,028.039 cusec of water to total 26 industries where as only 11.38 cusec of water was allocated only to three urban bodies of these two districts. The aggregate water allocation from Mahanadi and Hirakud reservoirs reflects the highest degree of pressure compared to other water bodies.

The people of the Brahmani and Mahanadi basins have resented over unmatched water allocation to industries and lack of irrigation facilities. Around 6 lakh people have been affected directly for it. 15 per cent land has been irrigated in 36 years and vast ayacut area diverted. Moreover, as much as 300.16 cusec water has been allocated only from Samal Barrage on Brahmani at Talcher to four industries.

Now thousands of farmers, who are deprived of getting required drinking water and irrigation water from the river, are resenting against allocation of water to only various industrial houses. The Rengali multipurpose project with a masonry gravity dam of 1,040 Mt length, with a maximum height of 75M across river Brahmani near village Rengali in Angul district has great irrigation potentiality.

On the other hand, vast mineral deposits in the catchment area, availability of water and good infrastructure lured industrialization and subsequently resulted in deterioration of water quality in the river. Today Brahmani is considered one of the most polluted rivers in the country. The inhabitants along the banks have felt the effects of river water pollution and there has been a hue and cry about the deteriorating water quality and the adverse impact on human and animal health and on the natural flora and fauna.

Affected by severe pollution, people are now coming to the street. The condition of river Mahanadi has deteriorated as it has become the dumping area for urban garbage and mostly untreated sewage. Official sources said people of Cuttack and Sambalpur situated on the Mahanadi banks are affected by jaundice mainly due to consumption of contaminated water of this river.

While waste water generation from Sambalpur stretch of Mahanadi is 34,360 Kilo Litres per day (KLD), Cuttack and Bhubaneswar contribute 1,05,600 KLD and 2,08,624 KLD respectively. The condition of Brahmani is still worse with flow of industrial waste water, urban garbage and untreated sewage into it. Rourkela located on its bank generates waste water of 66,520 KLD with Rourkela Steel Plant (RSP) and Suidihi Distillery contributing 52,272 KLD to river water of Brahmani.

4.10.2. Sampling technique

Direct method i.e. Bucket Method was used for collection of grey water from Schools and sewers drains in the Khamar village, wherein a bucket of 40-60 liter capacity was used. Screen was put at the inlet of pipe collecting grey water from the outlet of the pipe where the bucket was kept for the collection of grey water. The sample of grey water was collected from combined outlet of flowing water from bathrooms, washings and sinks.

5. Experimental Method

5.1. Sample collection and analysis

Laboratory scale grey water treatment system was designed for 5liters capacity, restricted to five stages of physical operations such as raw grey water unit of 10 liters capacity, sedimentation unit of 10 liters capacity, first filtration unit of sand and gravel of 5liters capacity, second dual filtration unit of 5liters capacity containing granular activated carbon and zeamaize fodder and storing unit for treated grey water of 5liters capacity as shown in figure1. The easily available and natural materials were used as filter media in the filtration unit such as fine particles of sand 0-2mm, gravel of 8-10 mm and 1820 mm size, granular activated carbon, zeamaize fodder which is the waste material used for the experiment.

The bed height of each material was determined and finalized by the experimentation. The gravitational flow as used for the flow of water from raw grey water unit to the storing unit of treated grey water. The flow rate was adjusted at 20 ml/min. The samples were collected from raw water and from each stage for the analysis. These samples were analyzed by standard method at laboratory (Aery,2010; WHO,2004;OECD,2003;APHA,AWWA and WEF, 2005; Clairetal.,2003).

The parameter such as Turbidity, Total suspended solid (TSS), Total dissolved solids (TDS),Total hardness (TH), Chemical oxygen demand (COD) and Biochemical oxygen demand (BOD) and were determined of raw and treated water sample for the performance study of the grey water treatment system.

Statistical analysis

All analyses were performed in triplicates. The data were recorded as means± standard deviation and analyzed using Microsoft excel.

Chapter 6 : Results and Discussion :

Four experimental setups were performed by using low-cost materials and their performances were evaluated. The low-cost material such as sand, gravels, zea maize fodder, granular activated carbon and nylon rope were used in the filtration unit. The sample of water was taken before and after filtration with varying bed height of each filter bed at 20ml/min of water flow rate. The samples were analyzed for the physical and chemical parameters to check the quality of wastewater (raw grey water) and subsequently used the data for the selection of treatment process.

6.1. Experimental setup-I, using combination of zea maize and activated carbon (dual filter)

Table 1 shows the concentration of various selected parameters to remove load of pollutants of each stage of the Grey water treatment system. The levels of total dissolved solids (TDS) and Total suspended solids (TSS) of wastewater were 688 mg/l and 155mg/l respectively which are high and it was due to soap and dirt contaminations (organics).

The high content of Total dissolved solids and Total suspended solids were also responsible for higher chemical oxygen demand (COD) and Biochemical oxygen demand (BOD). The pH and turbidity of wastewater were 8.39 and 145NTU respectively. Grey water is typically alkaline due to the use of soap and detergents (Katell Chaillou et al., 2002). The data showed that sedimentation and filtration was decreased the quality of wastewater to be used for the filtration of sand and gravel filter and then through dual filter of zea maize fodder and activated carbon. Total suspended solids was reduced from 155mg/l to 10mg/l, total dissolved solids from 688mg/l to 645mg/l, turbidity from 145 to 13.86 NTU, total hardness reduced from 522mg/l to 273mg/l. Additionally the organic load in the form of Chemical oxygen demand (COD) reduced from 176.7mg/l to 98.23mg/l and Biochemical oxygen demand (BOD) from
56.65 to 31.74 mg/l. The applied treatment system has reduced the organic load nearly 50% 0f the original organic load.

Efficiency and performance of each stage of the treatment system of dual filter

The data showed that in sedimentation and filtration, there was maximum decrease in the total suspended solids (TSS) and turbidity levels. Due to sedimentation, the course size and fine solid particles were settled down by gravitational force and only clear water flew towards sand and gravel filter of treatment system and found that 87% of TSS was removed in the sedimentation unit, 37% by sand and gravel filter and 18% by dual media filter, (filter contain zea maize fodder and activated carbon).77% turbidity was removed by sedimentation unit, 42% was removed by sand and gravel and 27% was removed by dual media filter. In efficiency and performance at each stage of the treatment system, the results showed that, dual media filter which was combination of zea maize fodder and activated carbon filter beds did not give much better performance to remove the pollutants. Figure 2 explains the removal of pollutants from grey water in each stage of the grey water treatment system.

6.2. Experimental setup-II, using activated carbon

The Total dissolved solids (TDS) and Total suspended solids (TSS) of waste water were found to be 752.31mg/l and 163.20mg/l respectively. Large quantity of suspended solids in wastewater could affect wastewater treatment processes in several ways. Suspended solids can interfere with the flow of water in transport pipes, distribution components, and soil pores. The pH and turbidity of wastewater was 8.31 and 160.49NTU respectively. The natural materials such as sand, gravels and activated carbon were used as medium in the filtration unit. Grey water was passed through a sedimentation tank. The sedimentation tank was designed to stabilize the flowing water or water is allowed to flow at a very low velocity. The heavier inorganic impurities settled at the bottom of tank and the lighter inorganic impurities float on the surface of liquid. It was observed that plain sedimentation tank removed about 60% of suspended matter and about 75% of bacterial load from water (Eriksson et al., 2002). Table 2 shows the concentration of various selected parameters to remove load of pollutants from each stage of the treatment system. The data has showed that sedimentation and filtration improved the quality of wastewater after passing through sand and gravel filter media and then through activated carbon. pH was reduced from 8.38 to 7.65. TSS from 163.20mg/l to 14.31mg/l, TDS from 752.31mg/l to 611mg/l, turbidity from 160.49 to 29.30 NTU.TH reduced from 562.60 to 265.6mg/l. Additional parameters like COD reduced from 183.7mg/l to 74.60mg/l with BOD from 59.24mg/l to 20.56 mg/l.

Efficiency and performance of each stage of the treatment system of activated carbon filter

Figure 3 indicates the removal of pollutants in each stage of the grey water treatment system. Due to sedimentation, the course size and fine solid particles are settled down by gravitational force and only clear water flew towards sand and gravel filters removing 82% of TSS in the sedimentation unit, 38% was removed by sand and gravel filter and 22% was removed by activated carbon filter. 66% turbidity was removed by sedimentation unit, 37% was removed by sand and gravel and 13% was removed by activated carbon filter. The result showed that activated carbon filter beds which were used instead of dual media filter did not give better performance to remove the selected parameters of grey water.

6.3. Experimental setup-III, using Zea maize fodder

The data revealed that the water is alkaline in nature. The average conductivity value was 1240 µS/cm. The TDS and TSS of wastewater were also high and it was due to soap and dirt contaminations. The turbidity of grey water was 167.58 NTU. Table 3 shows the reduction in concentration levels of various selected parameters in each stage of the treatment system of activated carbon. The data showed that filtration through zea maize fodder did not much improve the quality of waste water. pH was reduced from 8.10 to 7.89. TSS from 132.20mg/l to 12.02mg/l, TDS from 868mg/l to 854.20mg/l, turbidity from 167.58 to 20.20 NTU. Total hardness reduced from 576.86mg/l to 311.01mg/l. The parameters like COD, reduced from 165.47mg/l to 58.52mg/l, whereas BOD from 48.27mg/l to 18.71mg/l. Total nitrogen was reduced from 53.44mg/l to 18.22mg/l.

Efficiency and Performance of each stage of the treatment system of Zea maize fodder filter

Figure 4 presents the removal of pollutants in each stage of the grey water treatment system. Due to sedimentation, the course size and fine solid particles were settled down by gravitational force and only clear water did flow towards sand and gravel filter of treatment system and found 68% of TSS reduction in the sedimentation unit, 51% in sand and gravel filter and 51% in zea maize fodder filter.68% turbidity was removed in sedimentation unit, 29% in sand and gravel and 51% by activated carbon filter media. The result showed that activated carbon filter beds which were used instead of dual media filter did not give better performance to remove the selected parameters of grey water.

6.4. Experimental setup-IV, using Nylon rope

The data revealed that the pH of grey water was alkaline in nature. The average conductivity value was 1011µS/cm. The TDS and TSS were 705.16mg/l and 165.29 mg/l respectively which were high due to soap and dirt contaminations. The turbidity of grey water was 159.88 NTU. The average value of Total hardness was found to be 445.67mg/l. Table 4 shows the concentration levels of various selected parameters to remove pollutants at each stage of the treatment system of nylon rope filter. The data showed that filtration through Nylon rope improve the quality of wastewater. pH did not vary much. Total suspended solids were reduced from 165.29mg/l to 1.2mg/l, TDS from 705.16 mg/l to 95.64mg/l, turbidity from 159.88NTU to 3.1 NTU. Total hardness reduced from 415.97mg/l to 43.12 mg/l. Additional parameters like COD reduced from 166.25mg/l to 19.1mg/l, BOD from 52.41mg/l to 5.36mg/l. Total nitrogen was reduced from 35.23mg/l to 10.32mg/l.

Efficiency and Performance at each stage of the treatment system of Nylon rope filter

Figure 5 presents the removal of pollutants at each stage of the grey water treatment system. Due to sedimentation, the course size and fine solid particles are settled down by gravitational force and only clear water did flow towards sand filter and then through Nylon rope filter. Removal was found to be 90% for TSS level in the sedimentation unit, 81% in sand and gravel filter and 63% by nylon rope filter. 78% removal was observed in turbidity level in sedimentation unit, 72% in sand and gravel and 68% by nylon rope filter. The result showed that nylon filter beds which were used instead of dual media filter and activated carbon showed better performance to remove the selected parameters of grey water.

Evaluation of Grey water Treatment system

For all pollutants removal efficiency was increased in the filtration stage. This stage was only to control the total treatment system. Hence the filtration stage was studied and performance evaluation for removal of load pollutants in grey water at each filter bed was investigated and is depicted in figures 6 and 7. The results showed that nylon rope filter media showed better performance in the filtration stage as compared to dual media filters (combination of zea maize fodder and activated carbon), and individually used as activated carbon filter and zea maize fodder.

The results presented in this study are to establish the potential applicability of the developed low-cost technological treatment system especially for the rural areas in which economics is the major constraint. This laboratory scale grey water treatment system is a combination of natural and physical operations which could be applied easily without any maintenance. All the natural and easily available low-cost materials were used for the treatment process. Economically the unit could be easily made available, the power supply, which is an important part of the operating cost of the conventional system and it is a today s major issue in India, is required minimum, because system works on the natural force for flowing of water from first stage to last stage.

The laboratory treatment system showed the better and effective performance with balances advantages and disadvantages at rural level. As per the Indian standard, the treated water could be used for toilet flushing. The benefits found are the easily applicable operation; less maintenance of the plant hence does not require the highly skilled personnel. After the investigations, it could be impressed upon that due to negligible energy demand, low operation and maintenance cost, lesser time-consuming operation, this treatment system may be applied as a significant and efficient treatment system for rural communities for treatment and reuse of grey water.

Table 3: Concentration of various parameters at each stage of treatment system of Dual filter

Sr. No.	Parameters	wastewater	edimentation tank (unit 1)	and and gravel filter (unit 2)	ual filter (unit 3)
1	Turbidity(NTU)	145.16±0.30	34.1±0.17	19.08±0.02	13.86±0.01
2	TSS(mg/l)	155.33±0.01	19.53±0.01	12.32±0.01	10.12±0.01
3	TDS(mg/l)	688.50±0.01	649.1±0.17	638.03±0.06	645.32±0.01
4	TH(mg/l)	522.37±0.54	396.96±0.99	285.5±0.61	273.5±0.06
5	COD(mg/l)	176.37±0.32	153.22±0.01	152.39±0.05	98.23±0.01
6	BOD(mg/l)	56.65±0.01	49.76±0.01	47.53±0.06	31.73±0.01

Table.2 Concentration of various parameters at each stage of treatment system of Activated carbon

Sr. No.	Parameters	wastewater	Sedimentation tank (unit 1)	Sand and gravel filter (unit 2)	Activated carbon filter (unit 3)
1	Turbidity(NTU)	160.49 ±0.49	54.32±0.56	34.17±0.06	29.30±0.26
2	TSS(mg/l)	163.20±0.18	29.31±0.02	18.31±0.01	14.31±0.01
3	TDS(mg/l)	752.31±0.10	721.31±0.01	672.60±0.01	611.60±0.01
4	TH(mg/l)	562.60±0.79	311.55±0.11	279.13±0.12	265.48±0.10
5	TN(mg/l)	30.53±0.15	21.24±0.07	18.19±0.08	15.14±0.04
6	COD(mg/l)	183.25±0.06	160.25±0.22	101.16±0.11	76.54±0.01
7	BOD(mg/l)	59.24±0.12	50.43±0.06	48.50±0.01	20.56±0.39

Table.3 Concentration of various parameters at each stage of treatment system of zea maize fodder

Sr. No.	Parameters	wastewater	edimentation tank (unit 1)	Sand and gravel filter(unit 2)	Zea maize fodder filter (unit 3)
1	Turbidity(NTU)	167.58±0.50	54.06±0.04	35.2±0.01	20.2±0.02
2	TSS(mg/l)	132.2±0.01	42.29±0.03	30.12±0.01	12.02±0.01

3	TDS(mg/l)	868±0.01	861.17±0.09	858.9±0.09	854.2±0.05
4	TH(mg/l)	576.86±0.02	389.82±0.03	324.21±0.18	311.01±0.01
5	TN(mg/l)	53.44±0.05	48.47±0.25	19.25±0.03	18.22±0.01
6	COD(mg/l)	165.47±0.20	142.4±0.07	139.17±0.05	58.52±0.03
7	BOD(mg/l)	48.27±0.10	45.46±0.04	45.12±0.46	18.71±0.13

Table.4 Concentration of various parameters at each stage of treatment system of nylon rope filter

Sr. No.	**Parameters**	**wastewater**	**Sedimentation tank (unit 1)**	**Sand and gravel filter (unit 2)**	**Nylon rope filter (unit 3)**
1	Turbidity(NTU)	159.88±0.12	35.4±0.26	9.7±0.06	3.1±0.01
2	TSS(mg/l)	165.29±0.29	17.16±0.01	3.33±0.15	1.2±0.01
3	TDS(mg/l)	705.16±0.42	526.73±0.15	205.55±0.01	`95.64±0.01
4	TH(mg/l)	445.67±0.12	415.97±0.06	122.34±0.01	43.12±0.01
5	TN(mg/l)	35.23±0.04	21.2±0.06	15.94±0.02	10.32±0.02
6	COD(mg/l)	166.25±0.03	144.65±0.02	44.65±0.02	19.1±0.06
7	BOD(mg/l)	52.41±0.01	46.02±0.01	12.88±0.02	5.33±0.03

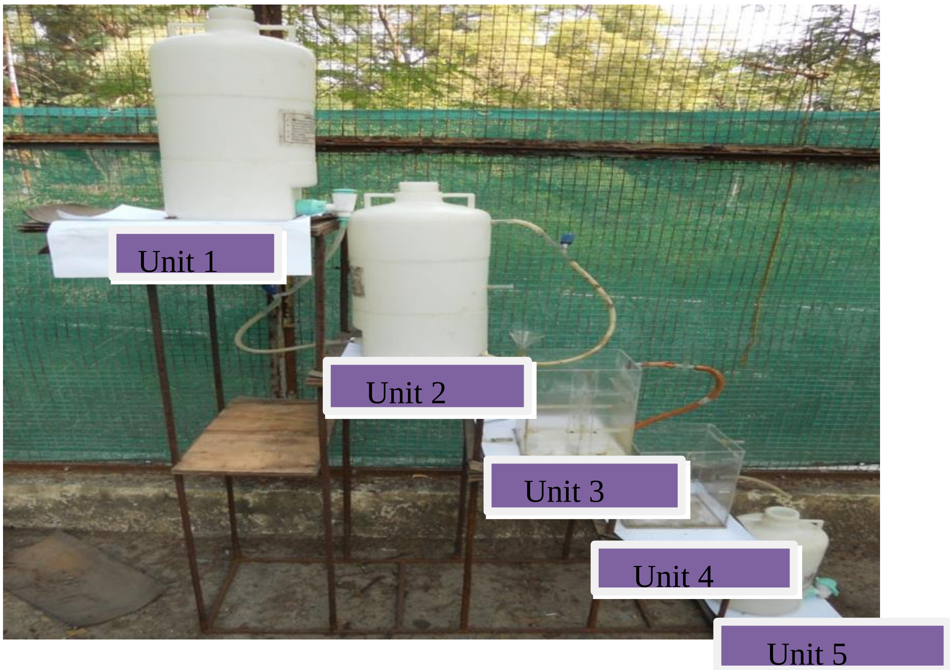

Figure.1 Experimental set up
Unit 1-raw grey water,
Unit 2-sedimentation tank
Unit 3-sand and gravel filter,
Unit 4- filtration unit
Unit 5-treated grey water

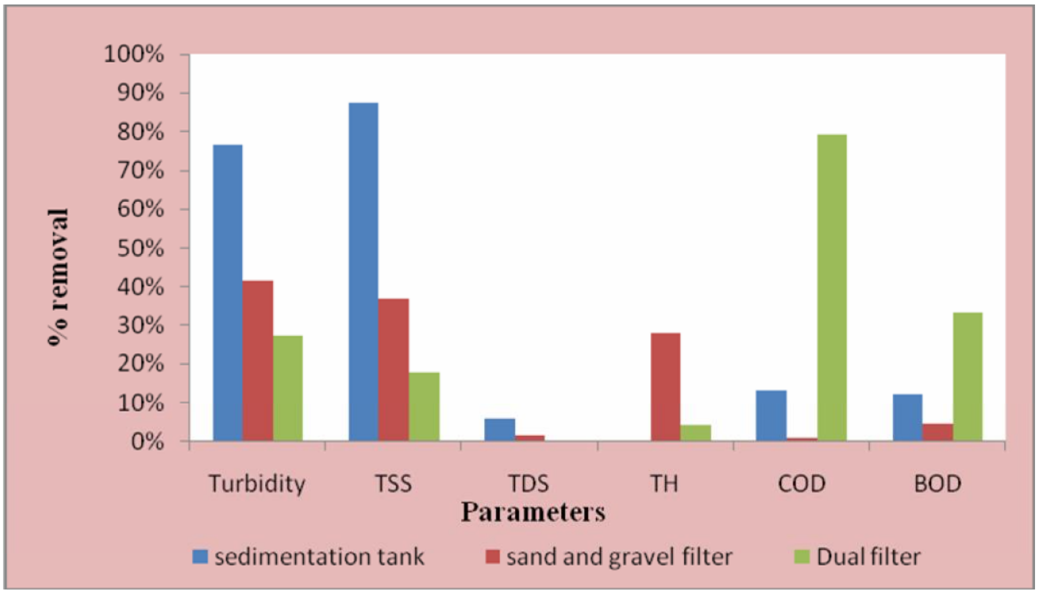

Figure.3 % Removal efficiency of various parameters in each stage of treatment system of Dual filter

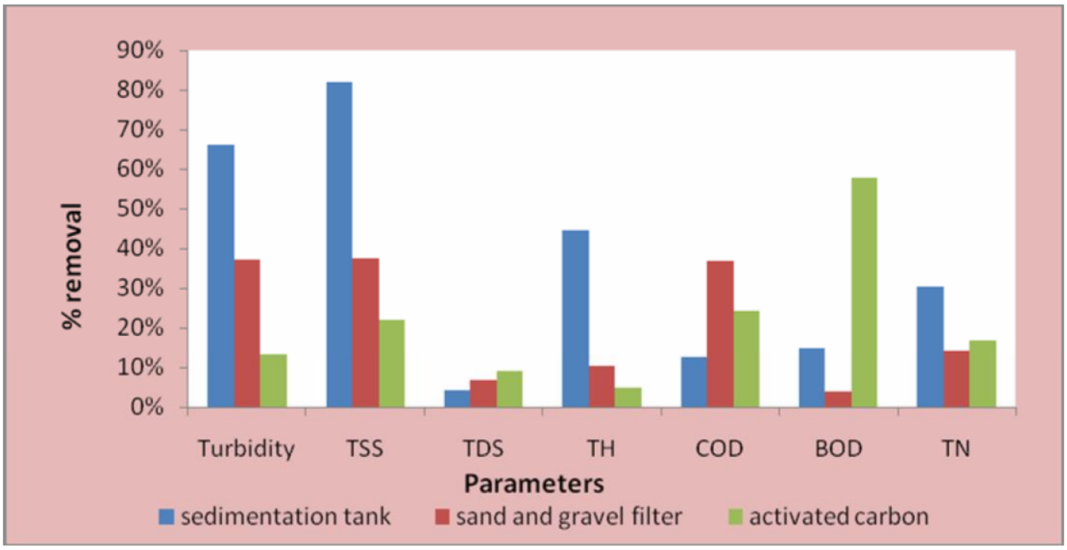

Figure.3 % Removal efficiency of various parameters in each stage of treatment System of activated carbon

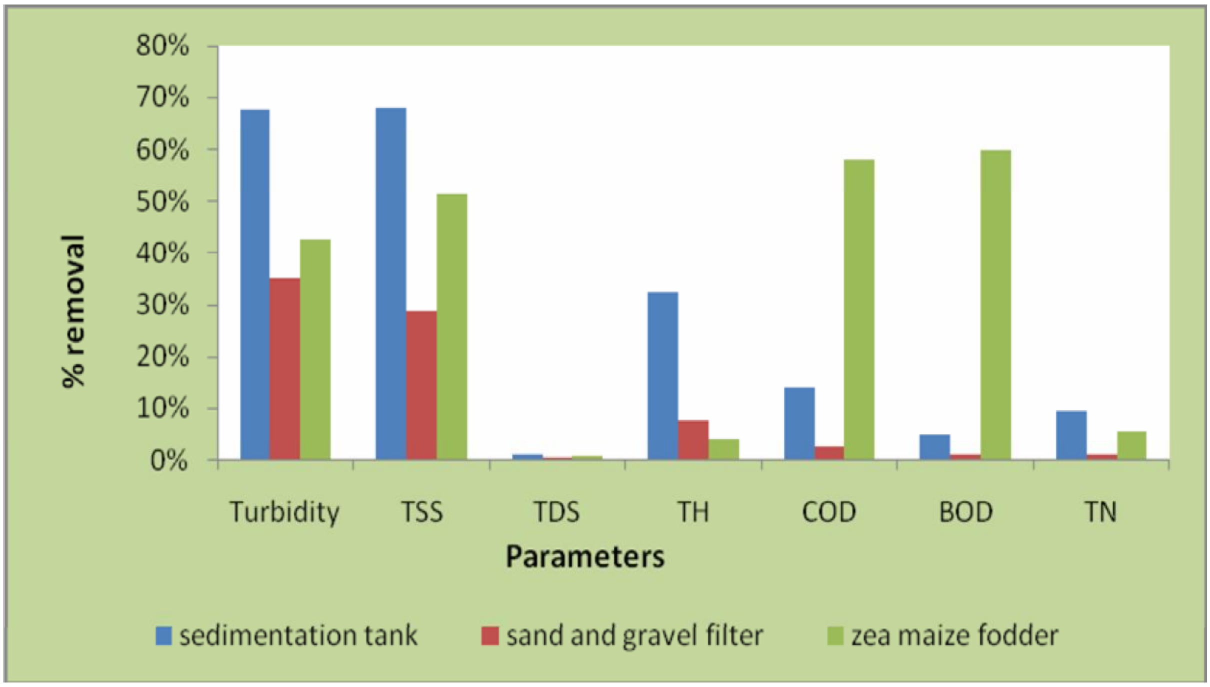

Figure.4 % Removal efficiency of various parameters in each stage of treatment system of activated carbon

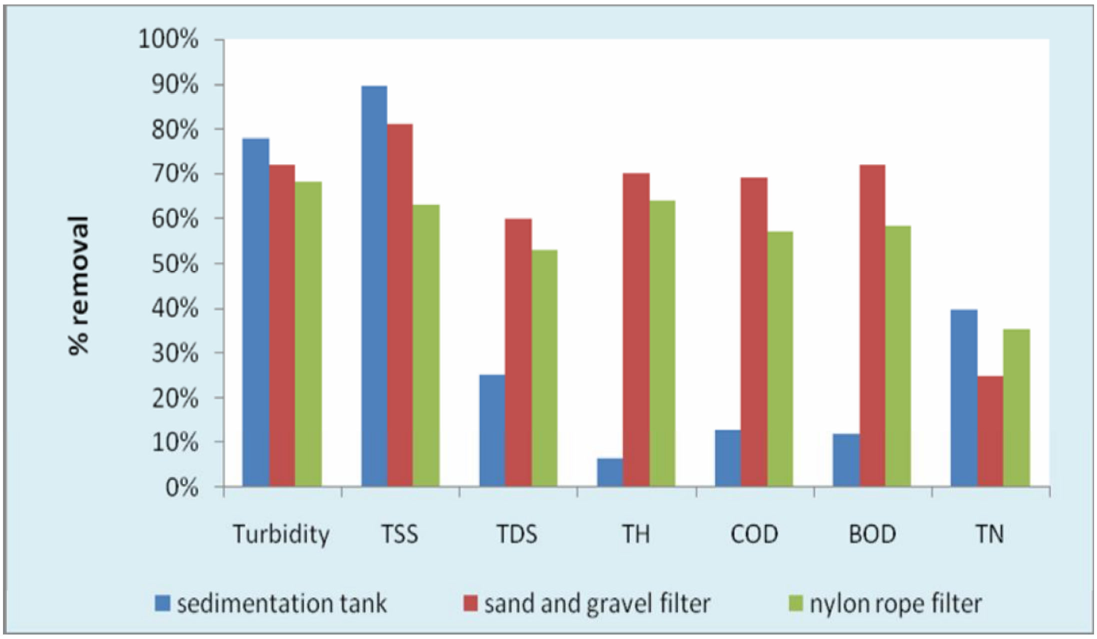

Figure.5 % Removal efficiency of various parameters in each stage of treatment system of nylon rope filter.

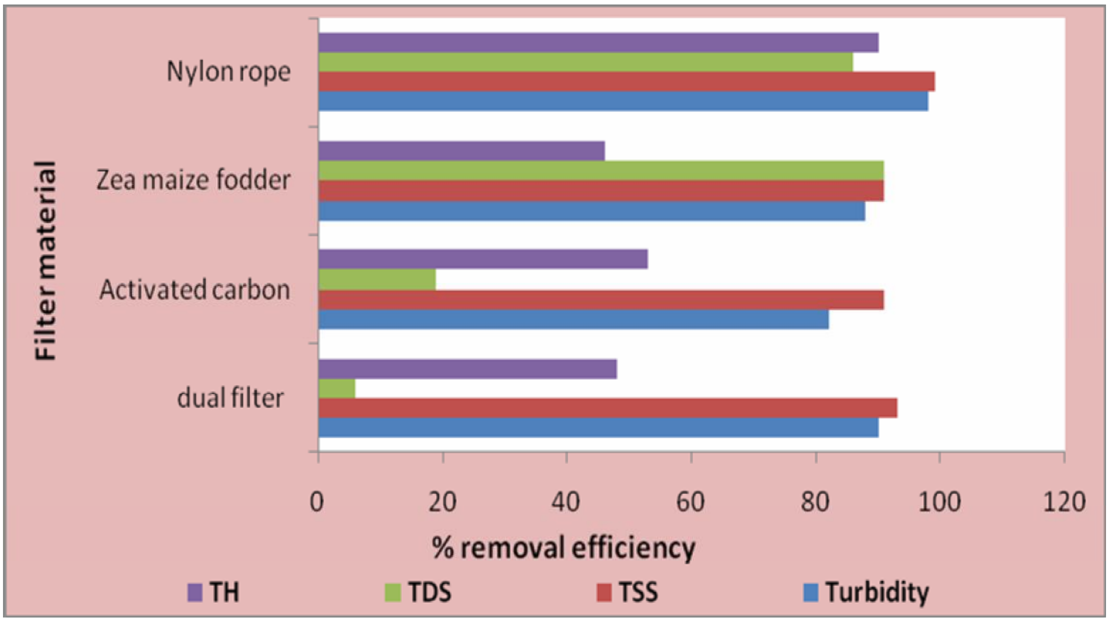

Figure.6 % Removal of pollutants (TH, TDS, TSS, and Turbidity) by each filter bed in the filtration operation

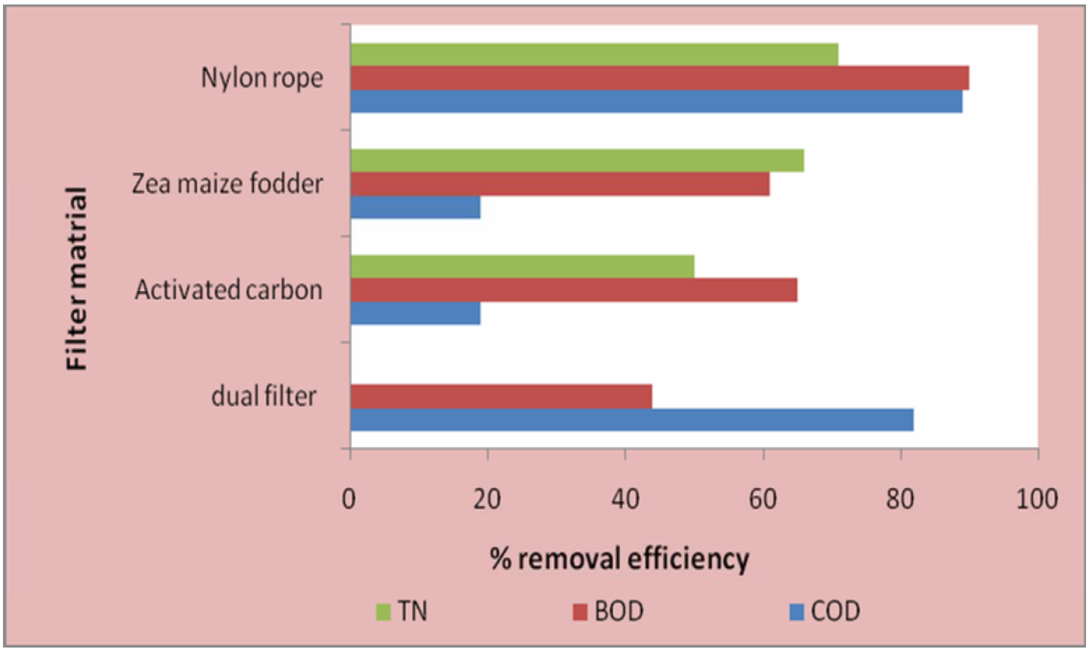

Figure.7 % Removal of pollutants (TN, COD and BOD) by each filter bed in the filtration operation

REFERENCE

1. A.D. Mande, B. R. Kavathekar, A. S. Langade, N. G. Lasankute, S. H. Patle (2018), Low-Cost Household Water Treatment Systems: A Review, International Journal of Engineering Research & Technology (IJERT), Vol. 7, pp. 425-427.
2. Ahmed Salah Eldin Shiba, Mohamed N. Ali (2020), Grey water treatment, reused and benefit of the heat capacity of water to improve the environmental performance of internal space, Journal of Xi'an

University of Architecture & Technology, Volume XII,Page No: 983.
3. Assayed A, Chenoweth J, Pedley S (2015) Assessing the efficiency of an innovative method for onsite greywater treatment: Drawer compacted sand filter – A case study. Ecological Engineering, Volume 81, Pages 525-533.
4. Batool H. Ibraheem, Musa Habib Alshammari, Husam H. Alwan (2019), Evaluation of grey water treatment with pilot filter for irrigation purposes, International Conference on Engineering Sciences, Materials Science and Engineering 671.
5. Deepika mandel, Pawan Labhasetwar, Shankar dhone, Ajay Shankar dubey, gagadhar shinde, satish wate. (2011) Water conservation due to greywater treatment and reuse in urban setting with specific context to developing countries". Asian Journal of Science and Applied Technology, Volume 8, Issue 1, PP 5-9
6. Dilip M Ghaitidak, Kunwar D Yadav (2014) Characteristics and treatment of greywater--a review, Environmental science and pollution research International, Volume :2 pp. 795-809.
7. Farah Naemah Mohd Saad, Siti Zaharatul Akmal Jamaludin (2021), Investigation of using sand filter in treating grey water, International Conference on Civil and Environmental Engineering, Earth and Environmental Science 646.
8. Francis W. Kariuki, Kiplagat Kotut, Victor G. Ngángá (2011), The Potential of a Low-Cost Technology for The Greywater Treatment, The Open Environmental Engineering Journal, Volume 4, pp. 32-39.
9. Hassane, M. K, Hegazy, M. H, Hussein, H. M, and Sabry T. I. (2022), Grey Water Treatment Using Sand Filtration," International Research Journal of Advanced Engineering and Science, Volume 7, Issue 2, pp. 232-238.
10. Indranil Guin, Susheel Kumar Gupta, (2017) LowCost Methods of treatment of water for domestic purposes in Rural Areas, International Journal for Scientific Research & Development, Vol. 4. pp 251-255
11. The Pioneer of India.