KSCST SPONSORED PROJECT

FABRICATION OF GREY WATER FILTERS

A PROJECT REPORT

Submitted to

Visvesvaraya Technological University

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by

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in partial fulfilment of the requirements for the award of the degree of

Bachelor of Engineering

Department Of Mechanical Engineering

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SDM INSTITUTE OF TECHNOLOGY

(Affiliated to Visvesvaraya Technological University, Belagavi)

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CERTIFICATE

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Abstract

Water scarcity and the growing global population have heightened the need for sustainable water management solutions. Greywater, which refers to the wastewater generated from domestic activities excluding toilet waste, represents a significant potential source for water reuse. This study 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 and nutrients.

To enhance the purification efficiency, an advanced chemical treatment stage is implemented, incorporating techniques such as coagulation, flocculation, and disinfection. Disinfection techniques, including chlorination or ultraviolet (UV) disinfection, are employed to eliminate remaining pathogens and ensure the safety of the treated greywater.

Table Of Contents

List of Tables and List of Figures

Chapter-1
Introduction
1.1 General

Water is a basic resource for life. It is used directly or indirectly in every domain: domestic consumption, urban endeavours, industry, and agriculture. In the natural environment, the diversity and health of ecosystems depend on water. Four main drivers affect the expected growth of water shortage: population growth, urbanization, increased personal consumption due to the rising standard of living, and climatic changes. Consequently, effective and sustainable use of water resources is a global challenge that is garnering increasing attention from various international institutions. The need to save water and use water sources effectively is of particular importance in semiarid and arid regions, where water sources are scant and the precipitation volume is low. Innovative concepts and technologies are straight away needed to close the loop for water.

Greywater is gently used water from your bathroom sinks, showers, tubs, and washing machines.

In general, greywater is less polluted than the total domestic wastewater because it does not contain toilet flush wastewater or, for the most part, kitchen wastewater. In addition, the concentration of organic matter, particularly the biodegradable part, is lower in greywater relative to the total domestic wastewater. Despite the potential advantages over wastewater, the concentrations of pollutants in greywater are not always lower than the pollutant concentrations of the total domestic wastewater. The reason for this lies in the large variance between the relative volumes and flows of each greywater source.

Other pollutants, such as concentrations of detergents and sometimes even boron, are usually higher in greywater than in general sewage.

Greywater may contain traces of dirt, food, grease, hair, and certain household cleaning products. If greywater is released into rivers, lakes, or estuaries, its nutrients become pollutants, but to plants, they are valuable fertilizer. Aside from the obvious benefits of saving water (and money on your water bill), reusing your greywater keeps it out of the sewer or septic system, thereby reducing the chance that it will pollute local water bodies. Reusing Greywater for irrigation reconnects urban residents and our backyard gardens to the natural water cycle.

Greywater reuse has been considered as a reliable method of ensuring water security as compared to other methods of water capture such as rainwater harvesting which is dependent on hydrological conditions. The amount of greywater produced in a household can vary greatly ranging from as low as 15 L per person per day for poor areas to several hundred per person per day.

Greywater accounts for up to 75% of the wastewater volume produced by households, and this can increase to about 90% if dry toilets are used. It has also been estimated that greywater produced accounts for about 69% of domestic water consumption.

Greywater reuse is one of the main alternatives for reducing potable water consumption in households, industries and commercial buildings.

1.2 Sources of Grey Water

Most domestic water consumption is for the purpose of cleaning or rinsing (such as bathing, washing dishes, and laundry). Each water flow resulting from rinsing that is discharged into the wastewater collection system has different characteristics. The method of consumption of each stream is different, and hence the level of pollution it produces is also different. It is worth noting that the quantities of greywater contributed by modern washing machines and even more so by modern dishwashers have fallen sharply in the last decade. This implies that in the future as existing appliances are gradually replaced by new ones, their contribution is expected to further decrease. In addition, the introduction of water- efficient fittings, such as faucet aerators, into extensive use may also decrease the volume of the water.

1.2.1 Washing Machine

Washing machines are the most significant contributor of pollutants to greywater. Washing machine has approximately 4–5 cleaning stages, each of which produces greywater of different quality. Most of the contamination is released in the first two cleaning phases, and the level of pollutants then decreases sharply with each stage.

1.2.2 Baths and Showers

Water consumption for washing differs between people and cultures. A survey found that the average. In a survey, it was found that water consumption in baths was 61.4 L/use and 42.3 L/use in showers.

1.2.3 Wash Basins

The water consumption of handbasins (washbasins) is widely varied depending on the nature of its use. A washbasin contributes about 15% of greywater's total volume and mostly has low concentrations of pollutants.

1.2.4 Kitchen sinks/ Dishwashers

The kitchen sink produces about 26% of domestic greywater and it is reported that a single use consumes, on average, about 12 L of water. Kitchen sink water contains a high load of pollutants. Kitchen sink stream constitutes about 58% of suspended volatile solids, 42% of the general COD, 48% of the BOD5, 43% of total fats, and 40% of anionic surfactants in greywater.

1.3 Grey Water Characteristic

Greywater inherently contains traces of the materials that were used within the household premises such as soaps, salts, cosmetic ingredients (e.g., face creams and makeup), food, spices, oils, and minerals. Therefore, in examining the characteristics of greywater, it is appropriate to search for common household products and other such relevant materials. The variables that characterize greywater can be divided into physical, chemical categories.

1.3.1 Physical Characteristics

The main physical characteristics that affect the quality of greywater and its treatment are temperature, color, odor, turbidity, suspended solids, and salinity.

Temperature: Greywater temperature is influenced by the surrounding temperature and that of the water source. In many cases, greywater will have a higher temperature than the ambient temperature since it is sourced from warm bathing, washing, laundry, and rinsing water. When greywater is collected in a storage or balancing container, temperature variability will be smaller, and the water temperature will be similar to the ambient temperature (or only slightly higher). It should be noted that in some cold climate areas, it may be feasible to harvest the heat of the greywater via heat exchangers. High temperatures, above 30°C–40°C, which is characteristic of greywater, may lead to the development of bacteria and encourage the accumulation of residues (limescale) in collecting containers and piping. However, it may also accelerate biological treatment processes and make them more efficient.

Color: Greywater is named because of its color, which in many cases is a shade of grey. The source of the color is mostly coloring

substances that are added to products such as soaps and detergents. The color of the water can be measured in several ways. It should be noted that the method has to be adapted to the nature and source of the color (from humic substances, other color materials, metals, etc.). However, these techniques are of limited efficiency, and their relationship to the quality of the solution is limited. Usually, color does not cause significant problems in treating and reusing greywater.

Odor: The source of the odor in raw greywater is usually household chemicals, such as detergents and other cleaning agents. However, when raw greywater is stored for an extended period of time in a tank or equalization basin, the concentration of dissolved oxygen decreases within hours, and anaerobic decomposition processes begin to take place. The formation of odors is one reason that some treatment systems do not store the greywater.

1.3.2 Chemical Characteristics

pH: The appropriate pH for unlimited irrigation ranges from 6.5 to 8.5. The pH of most greywater sources is low, ranging from 7 to 8 and the pH of laundry greywater is even more basic ranging from 7.5 to 10. This is because laundry powders and liquids are made up of basic materials containing hydroxide OH^- ions, which raise the ph.

Chapter-2

Literature Survey and Objective

2.1 General Introduction

A literature survey is a fundamental practice, to understand and develop the idea. A literature survey not only summarizes the knowledge of the area or field but also gives us an idea of what had to be done. In the following section, we discuss the issues and works related to water quality and testing.

2.2 Literature Survey

2.2.1 Piyush Gupta in the year 2016 performed "Design and Performance Evaluation of a Greywater Treatment System for Residential Complexes in India". This research paper focuses on the design and performance evaluation of a greywater treatment system specifically tailored for residential complexes in India. It discusses the system's design considerations, such as space requirements, treatment processes, and operational parameters. The article also presents the results of a case study evaluating the system's performance.

2.2.2 Keshav Mohan in the year 2021 performed Greywater Recycling for Domestic Use in India. This review article explores the opportunities, challenges, and perspectives of greywater recycling for domestic use in India. It discusses the socio-economic and environmental benefits of greywater recycling and addresses the barriers and potential solutions for its implementation in Indian households. The paper also highlights successful case studies and policy recommendations.

2.2.3 Shashwat G. Mishra in the year 2018 did the task on Assessment of Greywater Treatment Technologies for Urban India. This study assesses different greywater treatment technologies for urban India. It compares the performance, cost-effectiveness, and sustainability of various treatment options, including constructed wetlands, sand filters, and membrane-based systems. The article provides insights into the feasibility of implementing greywater treatment in an Indian urban context.

2.2.4 Neha Gupta in the year 2019 performed the task on Design and Development of a Low-Cost Greywater Treatment System for Indian Households. This research article presents the design and development of a low-cost greywater treatment system suitable for Indian households. It discusses the system's components, such as sedimentation tanks, filtration units, and disinfection methods. The paper also includes the results of a field study evaluating the performance of the system.

2.2.5 Himanshu Joshi in the year 2017 performed the Evaluation of Low-Cost Greywater Treatment Systems for Urban Areas in India. This research article evaluates the performance of low-cost greywater treatment systems suitable for urban areas in India. It compares different treatment technologies, including biofiltration, chemical coagulation, and disinfection methods. The paper provides insights into the efficiency and feasibility of implementing such systems in an Indian urban context.

2.2.6 Anjali Deshpande and Maitreyee Nigudkar in the year 2015 performed the Design and Optimization of Greywater Treatment Systems for Indian Rural Communities. This study focuses on the design and optimization of greywater treatment systems for Indian rural communities. It discusses the challenges specific to rural areas, such as limited resources and infrastructure. The article presents different treatment options and suggests strategies for optimizing the performance of greywater treatment systems in rural India.

2.2.7 Manish Kumar in the year 2020 gave information about Technologies for Greywater Treatment and Reuse in Indian Residential Complexes. This research paper explores the technologies available for greywater treatment and reuse in Indian residential complexes. It discusses the treatment processes, system configurations, and operational considerations for greywater reuse. The article also addresses the socio-economic and environmental benefits of implementing greywater treatment systems in residential complexes.

2.2.8 Anindita Dasgupta in the year 2019 performed the Assessment of Greywater Treatment Technologies for Sustainable Urban Development in India. This study assesses greywater treatment technologies for sustainable urban development in India. It evaluates different treatment options based on their performance, cost-effectiveness, and sustainability. The article also discusses the potential integration of greywater treatment systems into the existing urban infrastructure in India.

2.3 Problem Statement

India is a semiarid region with water scarcity and a strong pressure on water sources caused by the rapid increase of population and industrialization. In this region, rain water harvesting alone is not enough to meet water supply demands due to the irregular distribution of rainfall in time and space. Integrating rainwater harvesting with grey water reuseresulted in a more feasible and reliable strategy than thosestrategies based only on rainwater harvesting.

2.4 Objectives

The principal objective of reusing grey water is to allow the less usage of fresh water. By treating and reusing greywater for flushing, gardening, washing garages and vehicles, etc. Grey water includes household waste liquid from baths, showers, kitchen sinks, wash basins and washing machines which is mostly disposed in sewers creating a lot of loads on sewage treatment plant. No danger to human health or unacceptable damage to the natural environment is expected.

- Physical, chemical and biological characterization of domestic grey water samples from the kitchen, baths, etc.
- Comparison with the prescribed standards.
- Design of treatment plant.

Chapter-3

Components Used

3.1 Components required for Bio filter:

3.1.1 Fine Sand: Fine sand in the purification of greywater offers enhanced physical filtration. It provides increased surface area for better contact between greywater and sand, improving filtration efficiency and adsorption capacity. Fine sand also supports a higher population of beneficial microorganisms, aiding in the biological breakdown of organic matter. It is a valuable filtration medium for effectively removing contaminants from greywater.

Fig 3.1. Fine Sand

3.1.2 Gravels and Pebbles: Gravel and pebbles in greywater purification provide coarse filtration, acting as a pre-filter to remove larger debris. They support the sand filtration layer, ensuring stable flow distribution. These materials promote oxygenation and provide a habitat for beneficial microorganisms. Together, they contribute to effective purification of greywater.

Fig 3.2 Gravels and Pebbles

3.1.3 Charcoal: Charcoal, particularly activated charcoal or activated carbon, plays a crucial role in the purification of greywater. It has a high adsorption capacity and can effectively remove contaminants, odors, and color from the water. Charcoal also aids in reducing chlorine and disinfection by-products, improving overall water quality.

Fig 3.3 Charcoal

3.1.4 Coconut Husk: Coconut husk, specifically coconut coir, is a valuable component in the purification of greywater. It serves as a filtration medium, effectively removing solids and larger particles. Coconut husk helps to improve water quality and reduce odors. It has the ability to retain and release nutrients, making it useful for irrigation purposes. Additionally, coconut husk contributes to pH regulation in greywater treatment systems. Its natural properties make it an eco-friendly option for enhancing the purification of greywater.

Fig 3.4 Coconut Husks

3.1.5 Booster Pump: A booster pump is a type of pump that increases the pressure of a fluid, typically water, in a plumbing or irrigation system to overcome low water pressure or friction loss in pipes.

Fig 3.5 Booster Pump

3.2 Components used for Post cleaning Process

3.2.1 Sedimentation Filter: Sediment is any particulate matter that can be transported by fluid flow and which eventually is deposited as a layer of solid particles on the bed or bottom of a body of water or other liquid.

Fig 3.6 Sediment Filter

3.2.2 Pre Carbon-Filter: A pre-carbon filter is an essential component of water treatment systems, used to remove larger particles, sediment, and organic matter from water before it reaches the main filtration or purification stage. It improves water clarity, taste, and odor, while also extending the lifespan and efficiency of the entire water treatment system. A pre-carbon filter plays a crucial role in pre-treating greywater by removing suspended solids and reducing organic matter, ensuring that the water is suitable for reuse in non-potable applications.

Fig 3.7 Pre carbon Filter

3.2.3 Post Carbon Filter: A post-carbon filter, also known as a carbon block filter, is an important component in greywater purification systems. The filter removes residual chemicals, odors, tastes, and organic compounds, resulting in cleaner and better-tasting water. It also provides some microbial control and acts as a final polishing step before greywater is reused for non-potable purposes.

Fig 3.8 Post Carbon Filter

3.2.4 Mineral Cartridge Filter: A mineral cartridge filter is a type of water filter that contains minerals or mineral-rich media. It is used to improve the taste and quality of drinking water by adding beneficial minerals while removing certain impurities. The minerals, such as calcium, magnesium, and potassium, dissolve into the water as it passes through the filter, enhancing its taste and providing potential health benefits.

Fig 3.9 Mineral Cartridge Filter

3.2.5 Reverse Osmosis (RO): RO filters, or reverse osmosis filters, are commonly used for water purification. They utilize a semi-permeable membrane to remove dissolved solids and contaminants from water. While they can play a role in greywater purification, they are typically not the primary method. RO filters are often used as a secondary treatment step to further reduce dissolved salts and minerals in greywater.

Fig 3.10 RO Filter

3.2.6 Ultraviolet Filter: UV disinfection plays a crucial role in greywater purification by effectively eliminating harmful microorganisms. UV systems use UV light to inactivate the DNA of bacteria, viruses, and parasites, rendering them harmless. It is typically used as a final step after primary and secondary treatment processes. UV disinfection is safe, environmentally friendly, and does not alter the taste or chemical composition of the water.

Fig 3.11 UV Filter

3.2.7 Hose Pipes: Hosepipe is a flexible tube that are used to pass the water from one point and to spread it over a large area.

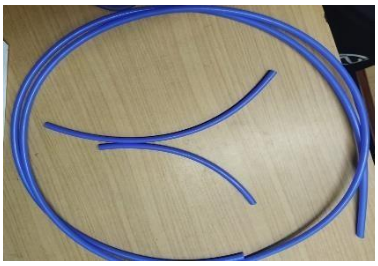

Fig 3.12 Hose Pipes

3.2.8 Sponge: Sponges are used to absorb large components like pebbles, tiny rocks, soil content etc. It also allows the water to pass through its porous holes without clogging.

Fig 3.13 Sponge

3.3 Measuring the pH value

3.3.1 pH meter: The "pH" stands for "potential of hydrogen," and a pH meter is a device used to measure the acidity or alkalinity of a solution. It measures the concentration of hydrogen ions in a solution and provides a numerical value known as the pH level.

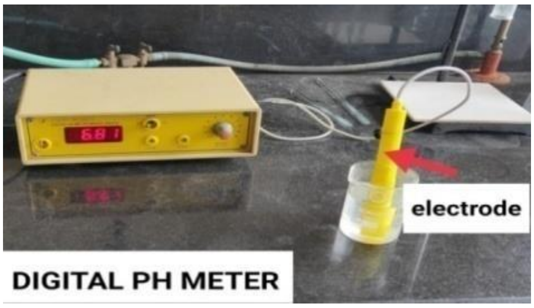

Fig 3.14 pH Meter

Chapter-4

METHODOLOGY

4.1 Methodology for measurement of pH value

(ELECTRONIC METHODS)

PRINCIPLE

The pH value is found by measurement of the electromotive force generated in a cell. It is made up of an indicator electrode which is reactive to hydrogen ions such as a glass electrode. When it is immersed in the test solution the contact between reference electrode (usually mercury/calomel electrode), and the test solution the electromotive force is measured. A pH meter, that is, a high impedance voltmeter is marked in terms of Varieties of electrodes have been suggested for the determination of pH. The hydrogen gas electrode is the primary standard. Glass electrode in coordination with calomel electrode is generally used with reference potential provided by saturated calomel electrode. The glass electrode system is based on the theory that a change, of 1 pH unit produces an electrical change of 59.1 mV at 25°C. The membrane of the glass forms a partition between two liquids of differing hydrogen ion concentration thus a potential is produced between the two sides of the membrane which is proportional to the difference in pH between the liquids.

The apparatus used are:

1. pH meter - With glass and reference electrode (saturated calomel),
2. preferably with temperature compensation.
3. Thermometer - With least Count of 0.5°C.

PROCEDURE:

The instrument is standardized after required warm-tip period. A buffer solution of pH near to that of the sample is used. The electrode is checked against at least one additional buffer of different pH value. The temperature of the water is found and if temperature compensation is available in the instruments it is adjusted. The electrodes are rinsed and gently wiped with solution. If necessary, the electrodes are immersed into the sample beaker or sample stream and stirred at a constant rate to provide homogeneity and suspension of solids. Rate of stirring is minimized and the air transfer rate at the air-water interface of the sample is noted. The sample pH and temperature is noted.

4.2 Block Diagram of Grey Water Filtration

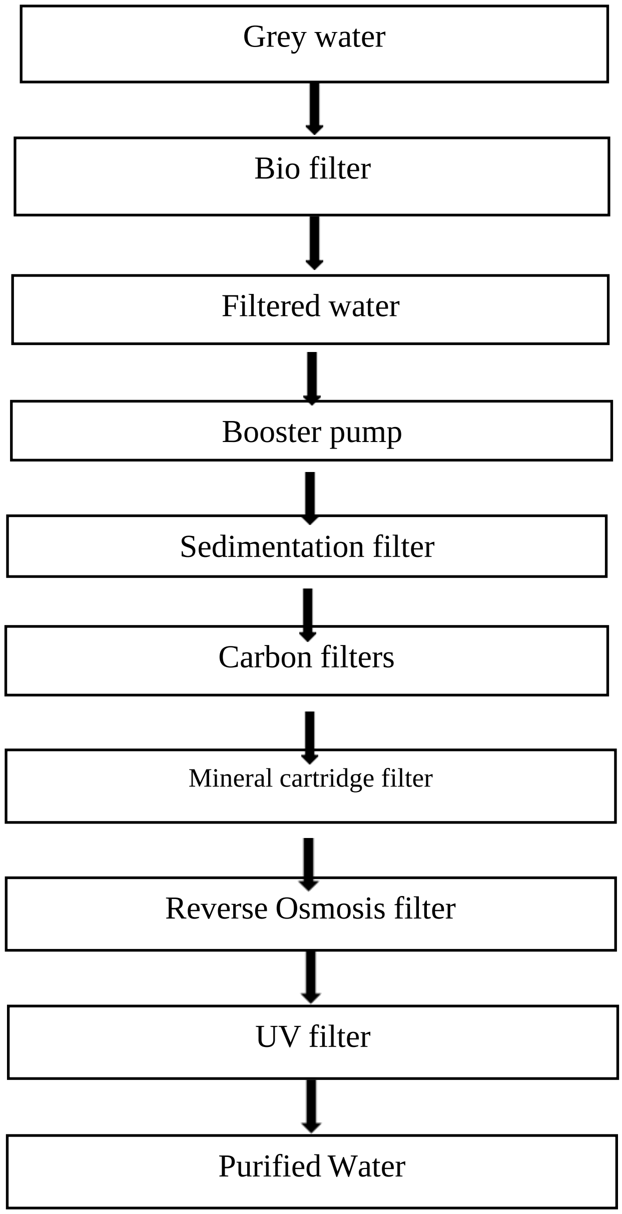

Table 4.1 Sources of Grey Water and its types

No.	Source of Grey water	Quantity/day/per person
1	Bathing	20-30
2	Kitchen	5-10
3	Washing clothes	15-20

Table 4.2 Percentage of Grey Water generated:

SR NO.	Sources	% Grey Water
1	Bathing	55
2	Laundry	20
3	Washing of house	10
4	Washing of utensils	10
5	Cooking	5
TOTAL		100

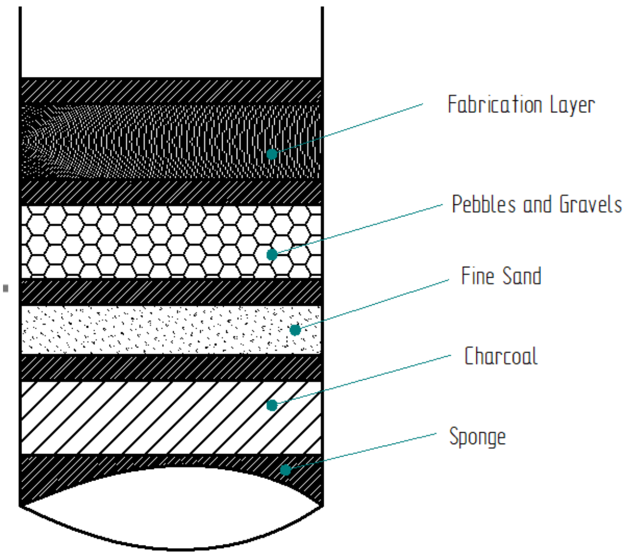

Fig 4.3 Composition of a Bio filter

Fig 4.4 Prepared Bio Filter

4.3 Experimental Procedure

- The experimental procedure of fabrication of grey water with different components and various filter for the purification process which involves several steps.
- First, we have to collect the grey water sample and necessary components like Sand, Gravels and Pebbles, Charcoal, Booster pump, Sponge, pH meter, Filters.
- Firstly, we need to prepare a Biofilter which consists of different layers of Sand, Gravels and Pebbles, Charcoal, Coconut Husks.
- Later we need to pass the collected grey water sample through each layer of bio filters.
- Later filtered water collected is collected in a tank.
- A Booster pump is used to absorb water from storage tank.
- First the absorbed water is passed through Sedimentation filter which is used for removal of sand.
- Later the water sample is passed through carbon filters which is used remove the smell from the filtered water.
- Later the water sample is passed through mineral cartridge filter which enhance nutrients in the water sample.
- Later the water sample is passed is passed through RO and UV filters where removal of bacteria's and microorganisms takes place.
- Later the pH of grey water sample, filtered water and Purified water are tested using digital pH meter.

Fig4.5 Complete Set up

4.4 Results and Discussion

Table 4.6 pH Test for different water samples

Sl. No	Sample	pH values
1	Grey Water sample	6.83
2	Fine Sand sample	5.9
3	Charcoal sample	6.97
4	Gravel sample	6.94
5	Pre sample	6.6

Table 4.7 pH Test for different combinational layered Water samples

Sl. No	Sample	pH values
1	Fine Sand & Gravel	6.85
2	Fine Sand & Charcoal	6.95
3	Charcoal & Gravel	6.99
4	Gravel & Coconut husk wood mixture	6.90
5	Charcoal & Coconut husk wood mixture	6.94

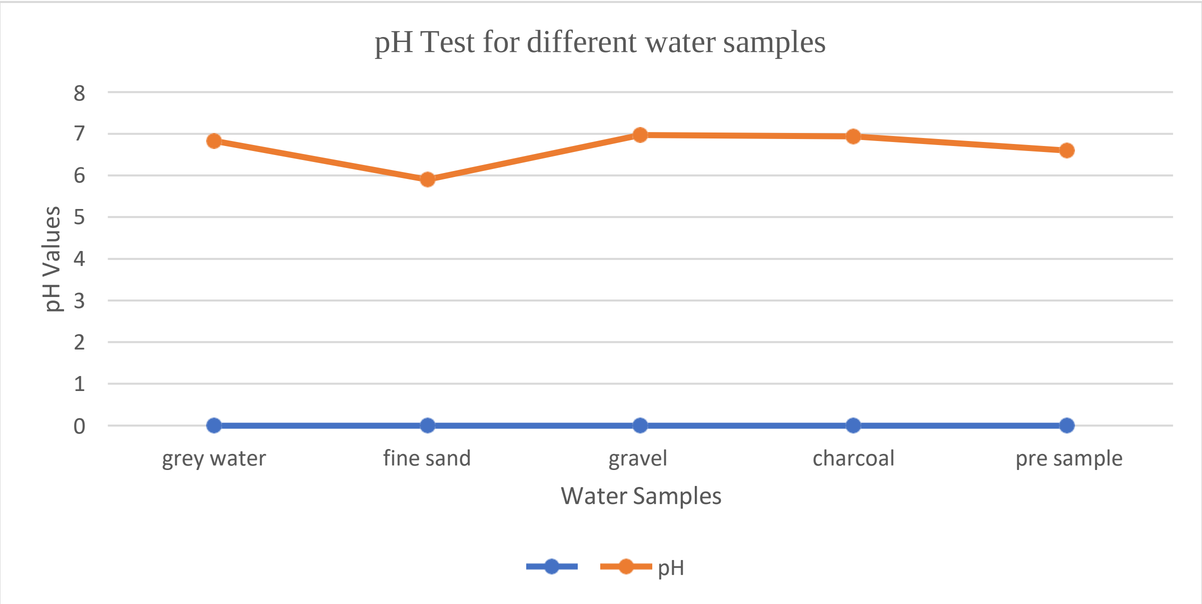

Fig 4.8 Schematic Graphical representation of different pH values

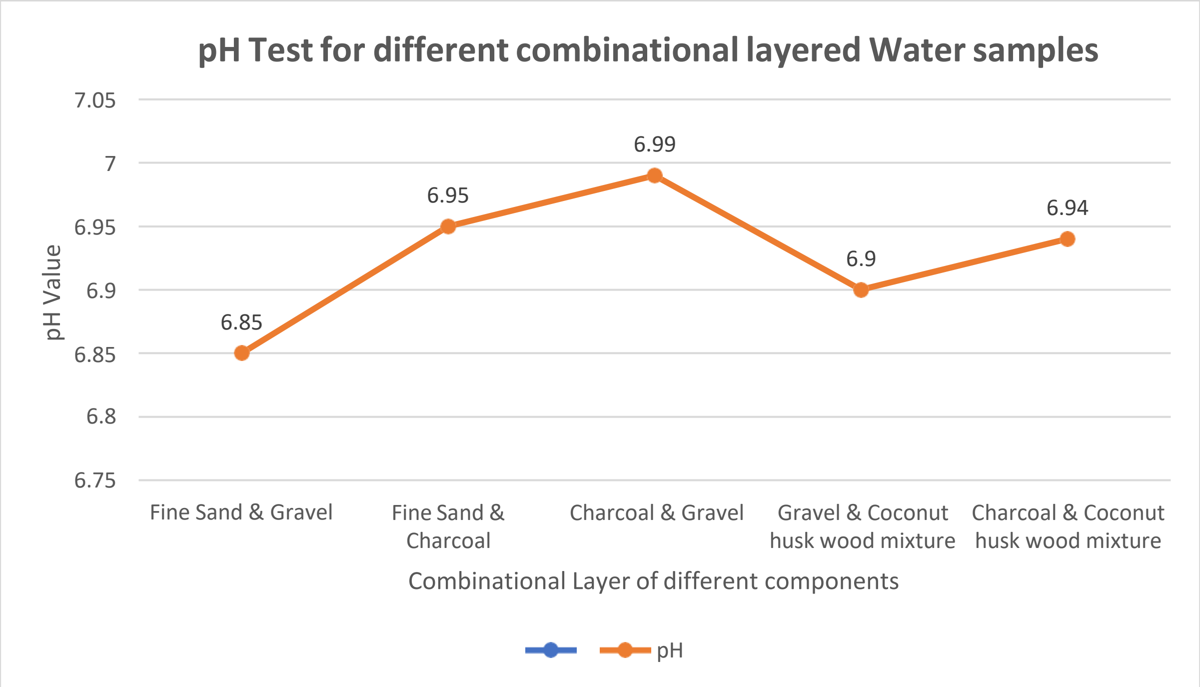

Fig 4.9 Schematic Graphical representation of different pH values of combination layers

Fig 4.10 Grey Water Sample

4.5 Various Water samples collected after passing through the Bio filter

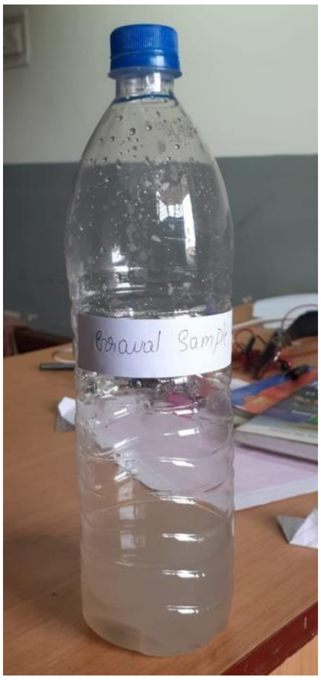

Fig 4.11 Gravel sample

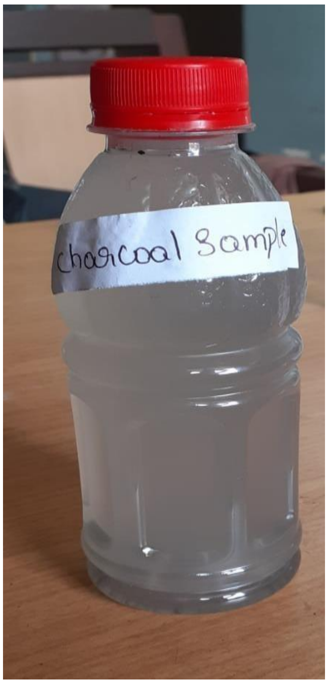

Fig 4.12 Charcoal sample

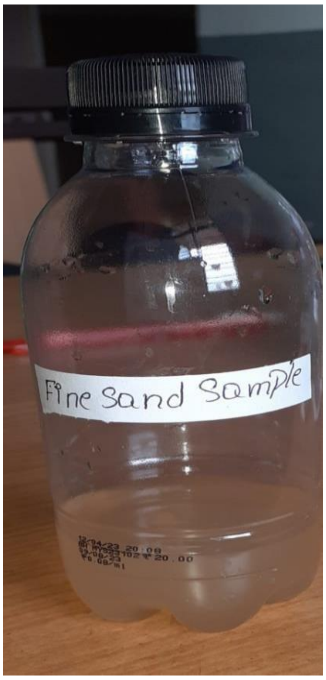

Fig 4.13 Fine Sand

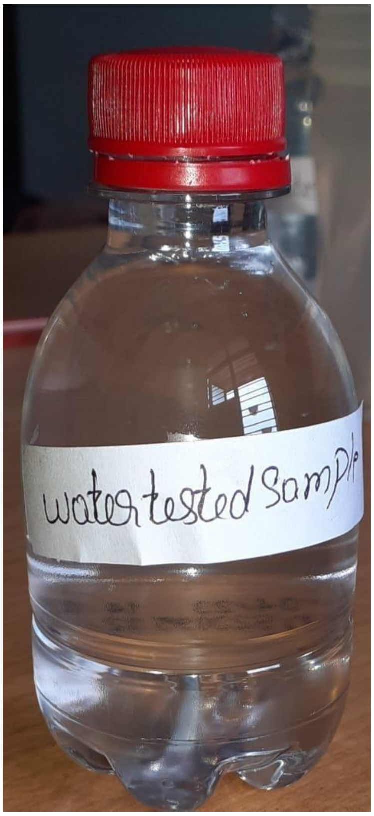

Fig 4.14 Water Sample After Purification

Chapter-5

Specifications

5.1 Booster Pump

- Voltage: 24VDC
- Open Flow: 1.8L/min
- Working Pressure: 125PSI
- Max Pressure: 90PSI
- Suction height: 2MTR
- Working current: 1A
- Max current: 1.2A
- Dimensions: 10x4x4 cm
- Weight: 1.8 Kg

5.2 Pre Carbon-Filter

- Service Life: 7500 L
- Max Flow Rate: 3LPM
- Min input water temp: 45^0C
- Activated Carbon:100%Coconut Shell

5.3 Post Carbon Filter

- Max Flow:1.00 GPM
- Max Pressure :125 PSI
- Max Temp: 100^0F
- Service Life :2500GAL

5.4 Mineral Cartridge Filter

- Ph Stone
- Red Balls
- Black Silica
- Anti-Bacterial Ball
- Carbon

Chapter-6

Applications

- **Residential buildings**: Greywater purification systems can be installed in residential buildings such as homes and apartments to treat and reuse greywater for non-potable purposes such as irrigation, toilet flushing, and laundry.
- **Commercial buildings**: Greywater purification systems can also be installed in commercial buildings such as offices, hotels, and schools to reduce water consumption and promote sustainable water use.
- **Industrial facilities**: Greywater purification can be used in industrial facilities to treat and reuse process water, which can help reduce water consumption and the discharge of pollutants.
- **Agricultural**: Greywater can be treated and reused in agricultural settings for irrigation and crop production, which can reduce water consumption and promote sustainable farming practices.
- **Water-scarce regions**: Greywater purification can be particularly useful in water-scarce regions where water resources are limited.

Chapter-7

Advantages and Disadvantages

Advantages:

- Reduces strain on freshwater resources by reusing treated greywater for non-potable purposes.
- Helps to conserve water and reduce water bills.
- Promotes sustainable water management practices.
- Can reduce the discharge of pollutants into waterways.
- Can be used in both residential and commercial purposes.
- Can be used in water-scarce regions to reduce dependence on freshwater sources.

Disadvantages:

- Requires initial investment for installation and maintenance of greywater purification system.
- Requires regular maintenance and monitoring to ensure safe and effective water reuse.
- Treated greywater may not be suitable for all non-potable uses (e.g., not suitable for drinking or cooking).
- The level of treatment required may vary depending on the intended reuse of the water.

Chapter-8

Conclusion and Scope for Future Work

8.1 Conclusion

- Greywater purification can be an effective and sustainable solution for reducing water consumption and mitigating water pollution.
- Greywater purification include filtration, sedimentation, disinfection, and reverse osmosis.
- Greywater can be treated and reused for non-potable purposes such as irrigation, toilet flushing, and laundry.
- Implementing greywater purification systems can be beneficial in both residential and commercial settings to conserve water and reduce the strain on municipalwater resources.

8.2 Scope for Future Work

Fabrication of greywater filters is a crucial aspect of sustainable water management, enabling the treatment and reuse of greywater for non-potable applications. Future work in this field can encompass various aspects, including enhancing filtration efficiency, incorporating advanced treatment technologies, designing modular and portable systems, exploring resource recovery options, implementing smart and automated features, monitoring water quality, conducting techno-economic analyses, addressing public perception, establishing policy frameworks, and integrating greywater filtration with comprehensive water management strategies. By focusing on these areas, the fabrication of greywater filters can continue to advance, contributing to water conservation efforts and promoting sustainable water reuse practices.

Chapter-9

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