Decentralize the Recycling of Domestic Light Greywater as an Alternative Water Supply Option in Water Management

Ar. Niranjan Vilas Sangawar
Associate Professor, Shri Siddheshwar Shikshan Mandal's College of Architecture, Solapur

ABSTRACT

The construction industry is a critical constituent of India or any country economy but has a major impact on the environment. If we talk about size, building construction and building maintenance is one of the prime users of energy, material resources, and water, and also an alarming polluter. In a same line drinkable water is the most used material and at the same time scare material whichplays a vital role and one of the basic necessities of human being. As per the report from the United Nations has estimated that in the year 2025, about 2.6 billion people will be facing water scarcity problems which mean more than half of the population will be affected by water scarcity and even it will not be exerted to say that third world war may occur due to water.

The dearth of fresh water is one of the chief concerns for the most populous country in the worldthat is India and even the pinch can be sensed in many parts of the country particularly in summer days which compels human's more responsiveness towards the preservation of fresh water. In similar line to the world many countries are already facing fresh water crisis and many in verge to move to the club of water scarcity due their negligence towards water conversation.

The imbalance between water demand and supply has become a significant concern of human life as demand is increasing exponentially. With growing population and particularly the concentric of population due to urbanization, this imbalance has become more acute in urban areas. So, implementation of alternative water supply options has become an inevitable need for water management. Grey water and black water recycling is one of the most reliable options to reduce urban water demand. Both centralized and decentralized recycling systems are used based on available resources and facilities. But decentralized systems should be given priority as it has potential to save the save transportation costand divert the risk of getting complete failure at the same time.Our study will focus on decentralize recycling of light grey water which consist waste from bathroom, wash basin, washing machine and reuse as an alternative water supply for gardening, vehicle cleaning, flushing tank etc.

Keywords:*Grey water, Alternate water source, physico-chemical, Treatment System, Decentralize system*

1. INTRODUCTION

1.1 General

Water consumption in residential projects are approximately makes up 10% of overall water consumption, preceded only by water consumed by agricultural irrigation and water consumption by industries. Building industry practitioners like Architects, Designers, and Engineers have begun to pay consideration to scheming and controlling the ecological damage due to their activities. Particularly Architects and designers have a unique opportunity to reduce ecological impact through the accomplishment of sustainability objectives at the planning and design stage of a building plan.

Wastewater is any water that has been polluted by human use. Domestic wastewater can contain physical, chemical and biological pollutants. Broadly we can classify waste water as black water and grey water. Black water can contain feces, urine, water and toilet paper from flush toilets. Black water is distinguished from grey water, which comes from kitchen sinks, bathrooms, washing machines, and other kitchen appliances apart from toilets. Grey water can be further categorized based on the source of waste like light grey water and dark grey water. In the recent past, there is comparatively increased awareness among the governments and bodies dealing with water management to address the challenges related to water security. Measures to reduce water usage through increased awareness, installation of rainwater harvesting and grey water treatment systems are seen as promising solutions, especially in developing countries that are more vulnerable to water scarcity like India. Water is an essential part of human's life. In water shortages, three key methods: water conservation, desalination and recycling could be considered. Due to lower costs and possibility of wastewater treatment in waste production site, water recycling is much better than the other two methods. Grey water reuse is increasingly emerging as an integral part of water demand management. [1, 2]

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The need for increased water requirement for the growing population in the new century is generally assumed, without considering whether available water resources could meet these needs in a sustainable manner. The question about from where the extra water is to come, has led to this study. The study in this paper will illustrate the possibility and opportunity to reuse of light grey water in a residential building by analytical study of its parameters and its scope to reuse in the building. Also, how an architect or designer can play a vital role at design stage of building for sustainability of built environment because water is the most critical element for human beings in the environment, it is in our best interests to do whatever we can to protect our precious and fragile fresh water supply for the future.[1, 4]

1.2 Problem Statement

As per Niti Ayog study 2018, India is one of the world's most water-stressed countries, will become water-scarce with time. The per capita water available is set to decline to 1,465 cubic metres by 2025 from 1,544 m3 in 2011.If appropriate and time-bound measures are not taken, the country may have to confront a series of associated problems, ranging from health issues due to poor sanitation and conflicts over water access, to food security and climate change.

1.3 Study Objective

The research objectives for this paper are as follows:

1) To study the physico-chemical parameters of case study building.

2) Propose alow-cost treatment system for treatment of light grey water in case study building.

1.4 Current Scenario of Urban waste generation and treatment

As per study by by Central Pollution Control Board (CPCB) in 2022, In India, the sewage generation in the urban centerswas 72,368 Million Litres per Day (MLD) for the year 2020-21. Currently, the installed sewage treatment capacity is 31,841 MLD, but the operational capacity is 26,869 MLD, which are much lower than the load generated. Out of the total urban sewage generated, only 28% (20,236 MLD) was the actual quantity of wastewater treated. This implies that 72% of the wastewater remains untreated and is disposed of in rivers/lakes/groundwater. There are some increases in infrastructure e.g., another 4,827 MLD sewage treatment capacity, has been proposed. If this is added to the existing installed capacity, even then, there is a gap of 35,700 MLD (i.e., 49%) between the wastewater generated and the capacity available for treatment as per CPCB report 2021.

Looking more closely at the city-scale wastewater generation, the estimated wastewater generation from Class I cities and Class II towns (as per the 2001 census) is 29,129 MLD, which is expected to be 33,212 MLD at present, assuming a 30% decadal growth in urban population. Against this, the installed sewage treatment capacity is only 6,190 MLD. There remains a gap of 79% (22,939 MLD) between sewage generation and installed sewage treatment capacity.

Another 1742.6 MLD wastewater treatment capacity is under the planning or construction stage. If this is added to the existing capacity, there still is a gap of 21,196 MLD (equal to 73%) in sewage treatment capacity as per CPCB report 2021.

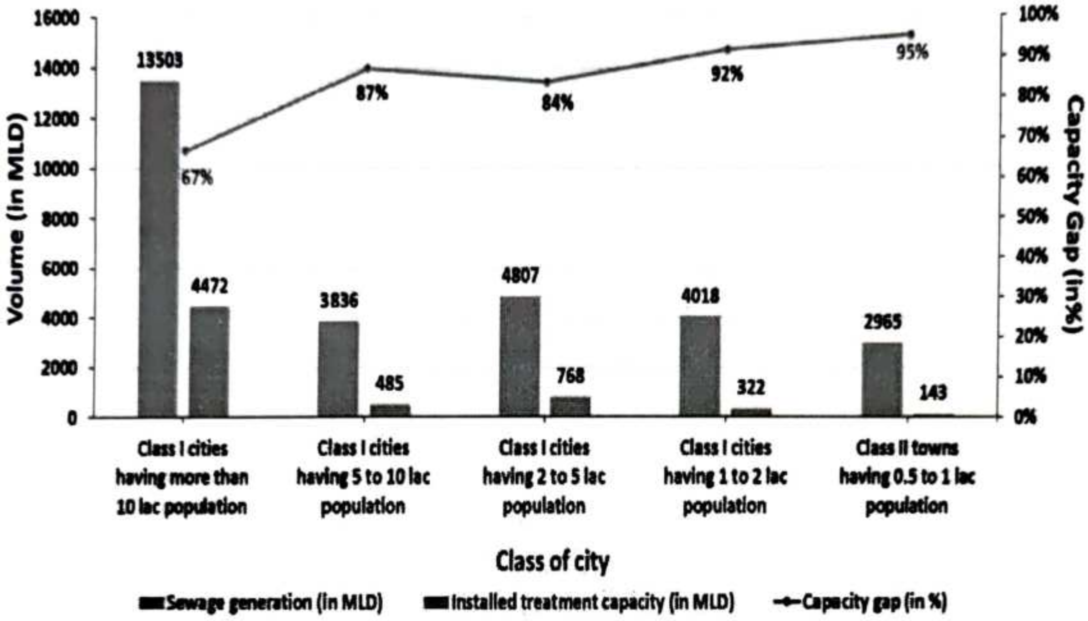

Figure No. 1: Wastewater generation and treatment capacity gap at city level in India (CPCB, 2022)

2. LITERATURE REVIEW

A detail literature review to examine the background on what has been explored on the topic so far. An extensive literature review provides background information on current knowledge related to the research topic. The literature review is divided in two segments that is the characteristics of grey water effluent and Various approaches to reuse of Grey Water Treatment System from various published research papers.

Table No. 1: Characteristics of Laundry effluent from Various Research Paper

Sr. No.	Tittle	Year of Publication	Remarks	
			Characteristics of Laundry Effluent	Value
1.	Commercial Laundry Water Characterization by J. K. Braga and M. B. A. Varesche	2018	pH	5.6
			Total Alkalinity	25.9
			COD	1710
			TSS	80
			Nitrate	8.4
			Nitrite	2.1

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			Sulphate	21.1
			Sulphide	0.2
2.	Characterization of domestic gray water from point source to determine the potential for urban residential reuse by Golda A. Edwin Et. al	2019	pH	9.1
			EC	641.6
			Hardness	721
			BOD_5	186.5
			COD	1545.8
			DO	N.D
			TS	586
			TSS	141.2
			Nitrate	0.3
			Nitrite	0.2
3.	Study of physico-chemical characteristics of domestic Wastewater in Vishnupuri, Nanded, India by Sonune NA Et. al	2020	pH	7 – 8
			BOD	56 – 96
			COD	180 – 300
			Ammonical Nitrogen	129 – 146
			Nitrate	74 – 181
			Phosphate	0.4 – 2.1
			TDS	1228 – 1440
			TSS	43 – 65.43
4	Qualitative Characterization of Grey water from a Residential Complex in Bengaluru City, Karnataka, India by Parameshwara Murthy Et. al	2021	pH	5.7
			BOD	35-138
			COD	123 - 540
			Nitrate	0.67 – 2.3
			Phosphate	6 – 12.8
			TDS	144 - 212
			TSS	86 - 300
5.	A Study on Characterization & Treatment of Laundry Effluent By Prof Dr K N Sheth Mittal Patel	2021	Temperature	30 – 34
			pH	7.88 – 10.32
			COD	376 – 910
			BOD	230 – 625
			SS	445 – 1550
			TDS	640 - 1455
			Oil & Grease	3 - 6
6	Characteristics and Treatment of Grey water – A Review	2022	pH	7 -7.3
			BOD	155 - 205
			COD	386 - 587
			Total N	6.6 – 10.4
			Total P	0.69 – 1.1
			TDS	215 - 279
			TSS	153 - 259

Table No. 2: Various approaches to reuse of Grey Water Treatment System from Various Research Paper

Sr. No.	Tittle	Year of Publication	Characteristics of Treatment System
1.	The Design Of Wastewater Treatment System In Tall Residential Building Using Phytorid By Komal Hemant Malpani	2017	• Decentralized biological wastewater treatment system. • Suitable for Tall Building. • Using a patented 'Phytorid' technology. • This technology uses no electricity, requires minimal manpower and uses natural plants. • Reused for landscape and gardening.
2.	Water filter-based MBR unit in laundry effluent treatment M A Islam Et. al	2019	• An aerobic membrane bioreactor (MBR) system with filter. • Suitable for group of Buildings. • Efficient to remove flux, COD.
3.	Laundry wastewater treatment using coagulation and membrane filtration By S. Šostar Turk Et. al	2019	• Precipitation/coagulation and the flocculation process with adsorption on granular-activated carbon (GAC) – No scope or possibility of selection of parameters. • Precipitation/coagulation and the flocculation process with ultrafiltration (UF). • Precipitation/coagulation and the flocculation process with reverse osmosis. - possibility of selection
4.	Design and Treatability Studies of Low Cost Grey Water Treatment with Respect to Recycle and Reuse in Rural Areas By Vijaya V. Shegokar Et al.	2020	• Laboratory scale grey water treatment system. • Five stages of physical operations of raw grey water unit. • Suitable for physico-chemical characterization of grey water.
5.	Greywater Reuse System Design and Economic Analysis for Residential Buildings in Taiwan By Yi-Kai Juan	2020	• Applicable for the family unit (size of 4 to 6 persons). • Interior Customized Greywater System (ICGS). • This system has a minimum payback period of 4 years.
6.	Domestic Waste Water Treatment Using Fly Ash Alone or in Combined Form By Dr. Pankaj Singh Et al.	2021	• Use of fly ash for the treatment of domestic laundry waste water. • Different ratios with wood ash for the treatment of domestic laundry waste water. • Dosage of 40g/L is recommended.

3. METHODOLOGY

This section of research paper will explore the process of carrying out research work in systematic way as shown in Figure 2.

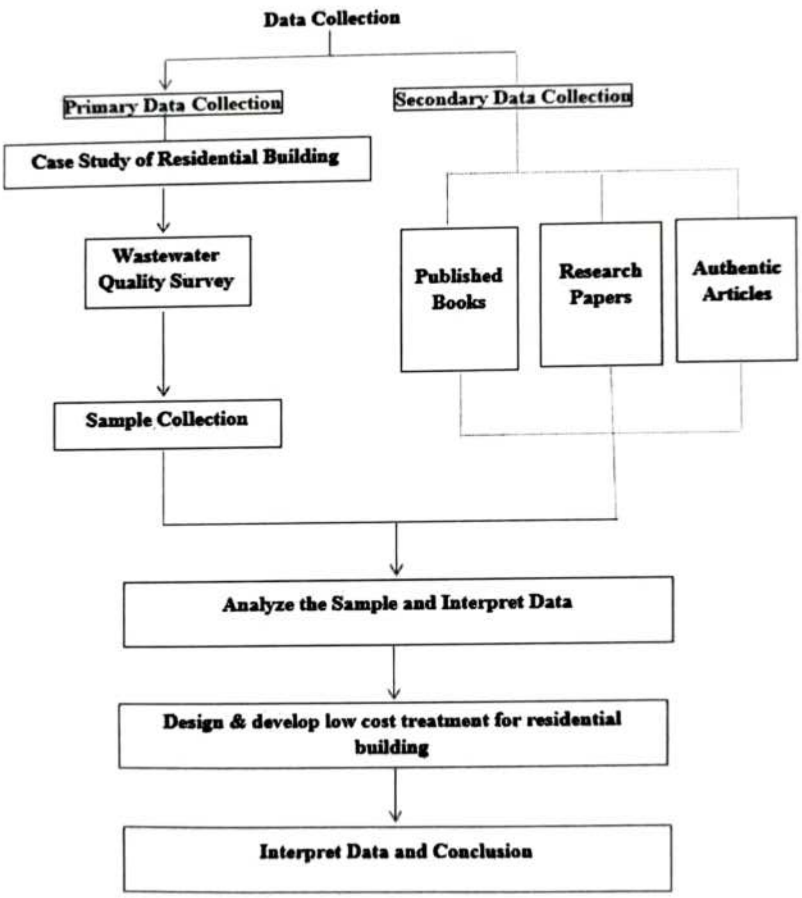

Figure No. 2: Detail Methodology for Research Work

4. CASE STUDY

4.1 Case Study Brief

Building Name	Muktai Aangan Phase 3
Address	Bopkhel, Vishrantwadi, Pune - 411031
Total No of flats	16
Number of Flats Taken for Study	14
Data Collection Period	April 2022

4.2 Collection of Sample

To carry out the analytical assessment in smooth and effective way, the samples are collected and kept in ice till the reaching of labs before assessment.

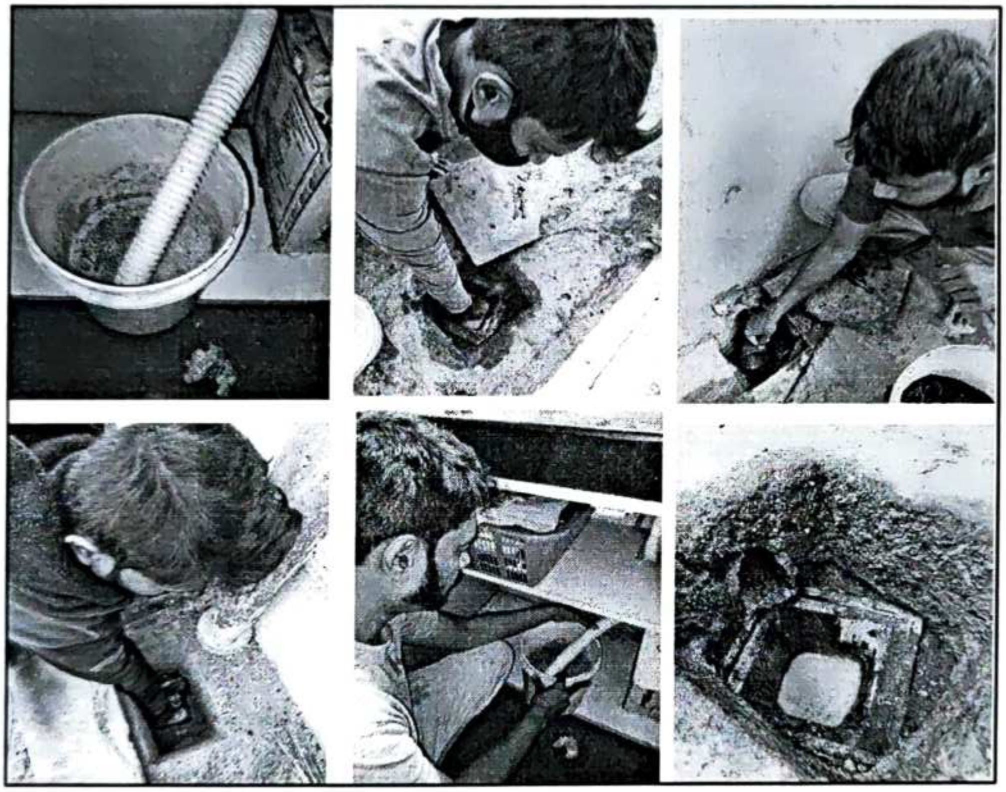

Figure 3: Photos While Collecting Light Greywater at Source

4.3 Transportation and Testing

The physicochemical composition of light greywater effluent samples was statistically analyzed in April 2022 and the results are presented in the form of acceptability or class of the parameter based on Water recycle/reuse standards based on protection of human health and the environment and suitability for the intended reuse application in below section.

Table No. 3: Washing machine Quality Classification based on Recycle/Reuse Standards

Sr. No.	Analysis Parameters	Mean Value	Acceptability
01	pH	9.1	Above the permissible limit
02	COD	1549.0	Above the permissible limit
03	BOD	180.6	Above the permissible limit
04	Oil and Grease	2.0	Doubtful

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05	Turbidity	108.7	Above the permissible limit
06	Conductivity	640.0	Doubtful
07	TDS	722.9	Within Permissible limit
08	Total Hardness	621.4	Above the permissible limit
09	Calcium	4.1	Within Permissible limit
10	Magnesium	1.3	Within Permissible limit
11	Total Alkalinity	37.2	Doubtful
12	Sulphate	25.8	Within Permissible limit
13	Iron	0.8	Within Permissible limit
14	Lead	<0.003	Within Permissible limit
15	Zinc	<0.01	Within Permissible limit
16	Dissolved Oxygen	ND	Insufficient to be in permissible limit
17	Nitrate	0.2	Within Permissible limit

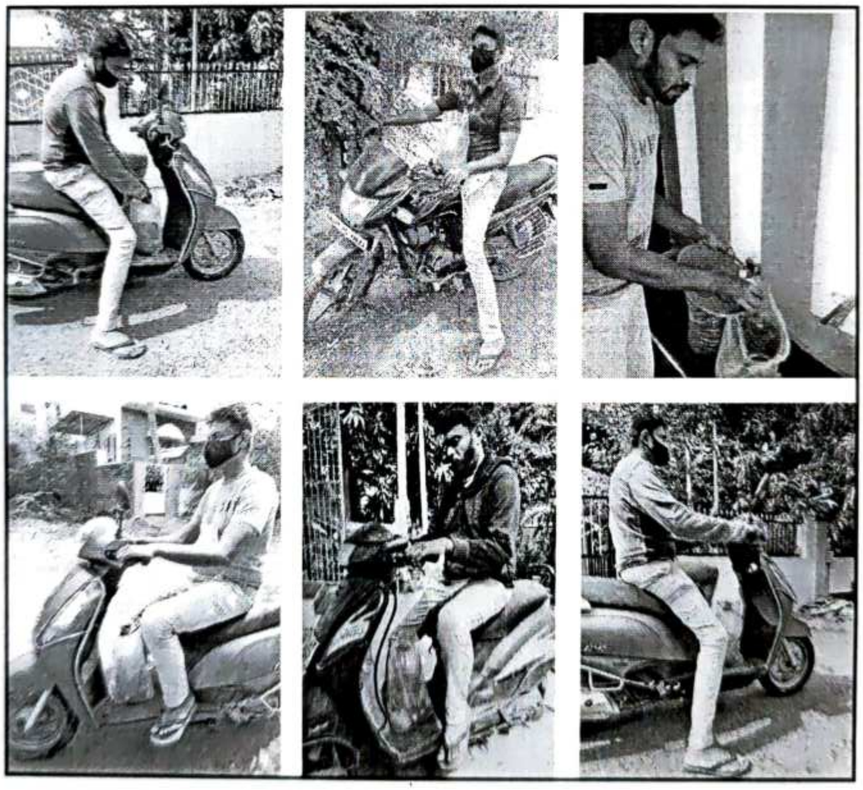

Figure No. 4: Collected Sample Transferring to Laboratory for Testing

The analysis represents the parameters have exceed the permissible limit of recycle/reuse of water like pH, COD, BOD, Turbidity, TDS, Total Hardness, DO so there is a need for an appropriate treatment system to reuse the light greywater in the case study building.

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4.4Treatment System

4.4.1 Experimental Setup

The experimental setup was performed by using low-cost materials and their performance were evaluated. The low-cost material such as sand, gravels, granular activated carbon and nylon cloth were used in the filtration unit. The sample of water was taken before and after filtration 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 light greywater collected. The filtration system consists of following four unit:

i) Influent storage Chamber

ii) Filter Media I

iii) Filter Media II

iv) Effluent storage Unit

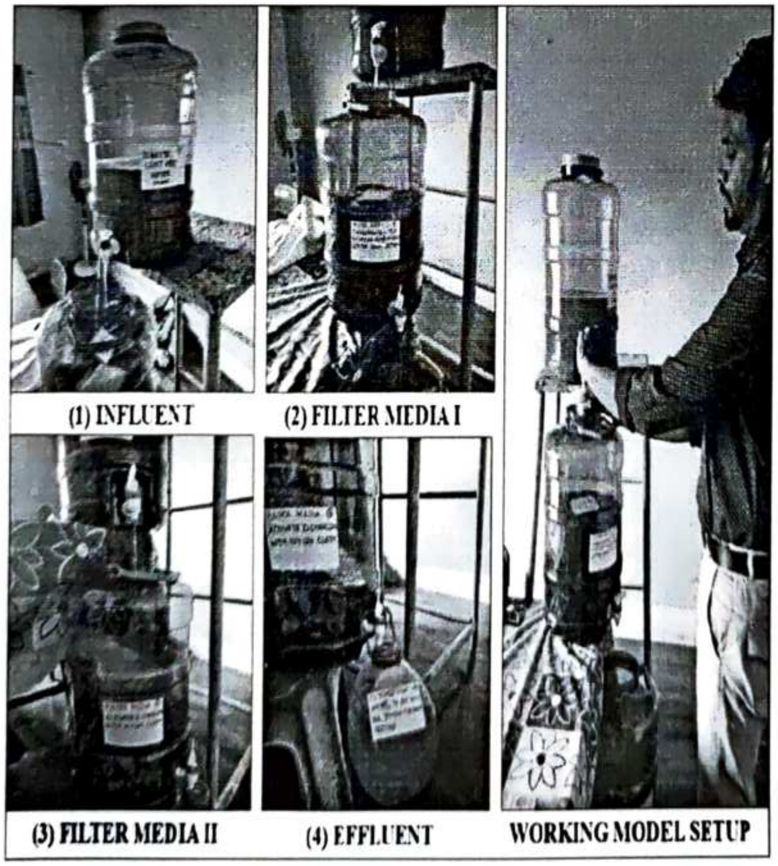

Figure No. 5: Designed and Prepared Light Greywater Treatment System

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4.4.2 Treatment System

The samples were analyzed for the parameters which are above the permissible limit as per standards in the same laboratory where the previous examination has been carried out. The pH and turbidity of wastewater was 9.1 and 171 NTU respectively which is reduced to a level of 7.61 and 28.9 NTU and become within permissible limit. The total hardness of waste water is reduced to 262.7 mg/l from 614 mg/l. Additional parameters like COD reduced from 1520 mg/l to 78.20 mg/l with BOD from 187 mg/l to 21.4 mg/l. The values are illustrated in graphical form.

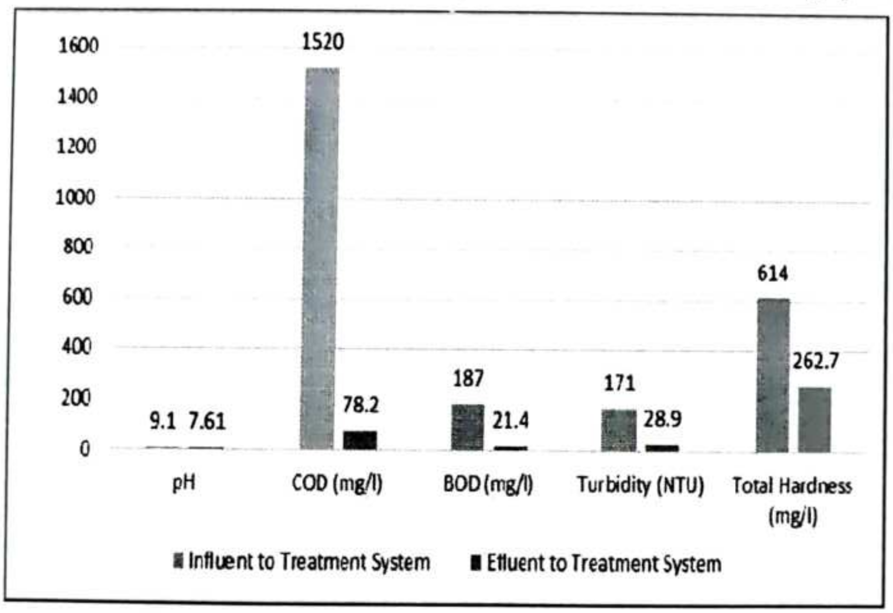

Figure No. 6: Inlet and Outlet Value Designed Filter System

4.4.3 Result Analysis

Readings indicates the removal of pollutants in 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. The result the pH has been reduced to 16.37%, were as COD and BOD has a much higher efficiency which is about 94.86% and 88.56% respectively. The turbidity and total hardness removed about 83.10% and 57.21% respectively. In following the efficiency % has been illustrated in graphical format.

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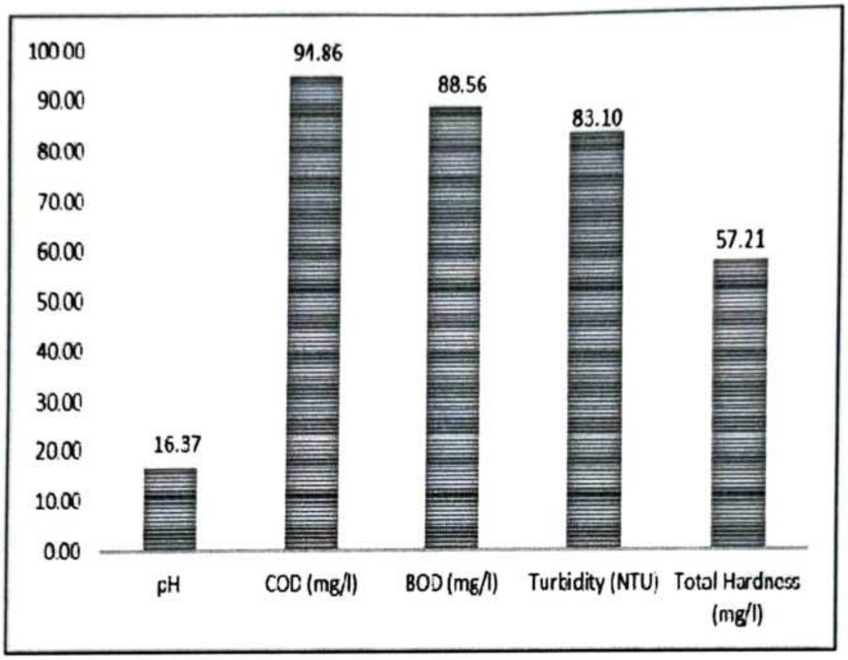

Figure No. 7: Efficiency of Designed Treatment System

Figure No. 8: Greywater Treatment System with a sample before filtration and after filtration

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5. CONCLUSION

The low-cost 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. The results presented in this study are to establish the potential applicability of the developed low-cost technological treatment system especially for the areas in which water scarcity is major constraint for particular months of calendar.

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