B.Tech Project on

Grey Water Treatment

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A Project Report Submitted by Utkarsh Gupta (B21CH034)

in partial fulfillment of the requirements for the award of the degree of
Bachelor in Technology

Declaration

I hereby declare that the work presented in this Project Report titled "**Grey Water Treatment**" submitted to the Indian Institute of Technology Jodhpur in partial fulfillment of the requirements for the award of the degree of B. Tech, is a bonafide record of the research work carried out under the supervision of **Professor Pradip Kumar Tewari**. The contents of this Project Report in full or in parts, have not been submitted to, and will not be submitted by us to, any other Institute or University in India or abroad for the award of any degree or diploma

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Contents

Introduction

There is a significant amount of freshwater on Earth overall, but it is not readily available for direct human use and is being strained by growing demand. About 97% of Earth's total water resources are found in seas, and they are mostly salty. Freshwater makes up only around 3% of the planet's water, and the majority of it is essentially inaccessible due to its lockup in glaciers, ice caps, or deep subterranean aquifers. About one-hundredth of the total freshwater resources are thought to be accessible freshwater, which makes up a small portion of the 3% total. The limited availability of water resources exacerbates existing inequalities both in time and space. Some regions are deprived of water while others have plenty, creating imbalances that can potentially develop serious social and economic challenges. The main reasons for the global use of freshwater include biological necessities such as drinking and sanitation and uses like industry, domestic consumption, and agricultural irrigation.

Water stress – wherein demand surpasses available supply for a considerable timeframe – already impacts about 800 million individuals, and this demographic is predicted to rise to almost 3 billion people by the year 2025 as a result of urbanization, industrialization, and population increase. Given this increase in demand, another important question arises: can the limited and already compromised supplies of freshwater on Earth sustain the requirements in the coming years? And most importantly, where will that extra supplies of water necessary for the human activities that are already increasing, come from, especially considering that shifts in climate are already changing rainfall patterns and reducing the freshwater supply in certain regions?

In turning this challenge into an opportunity, it is necessary to use a combination of new and imaginative approaches and solutions, one of which is the reuse of greywater. Greywater, that is the wastewater from domestic uses other than the toilet, including sinks, showers, and laundries, is a largely untapped resource. If only it can be treated and reused efficiently, it could cut down on the reliance of potable water sources.

Literature Review

The literature review shows that all types of grey water have good biodegradability. The bathroom and the laundry grey water are deficient in both nitrogen and phosphors. The kitchen grey water has a balanced COD: N: P ratio. The review also reveals that physical processes alone are not sufficient to guarantee an adequate reduction of the organics, nutrients and surfactants. The chemical processes can efficiently remove the suspended solids, organic materials and surfactants in the low strength grey water. The combination of aerobic biological process with physical filtration and disinfection is considered to be the most economical and feasible solution for grey water recycling.

Grey Water generation rates are mostly influenced by lifestyle, types of fixtures used and climatic conditions. Contaminants found in greywater are largely associated with the type of detergent used and influenced by other household practices. Many of the treatment systems reviewed were unable to provide total treatment as each system has its unique strength in removing a group of targeted pollutants. There has been technological advancement in treating greywater using biological, chemical and membrane filtration methods which allow for reusing the greywater for non edible purposes like irrigation, flushing toilets and even in some industrial activities. This helps to alleviate the pressure on fresh water supply while at the same time reduces the energy and environmental consequences of the traditional methods of extracting, treating and distributing water. This is where a cursory look at greywater reuse is worthwhile.

Greywater

It refers to domestic wastewater generated in households or office buildings without any contributions from toilet water. It includes water from sinks, showers, baths, washing machines, and dishwashers, excluding wastewater with fecal contamination.

The composition of greywater varies and depends on the lifestyle, fixtures and climatic conditions. In water stressed areas, reuse of greywater has been an old practice, and it is still being done. It helps reduce the over-reliance on freshwater resources and reduce the pollution caused by discharge of untreated greywater into freshwater resources. It can also be a supplementary source to existing water sources in areas where there is acute water crisis or in arid climatic regions. For different water-demanding activities that include potable and non-potable uses (such as toilet flushing and agriculture), recycled greywater can be used. The major concerns with greywater reuse have been issues with public health perceptions and inappropriate technology for the reuse option.

Greywater treatment methods vary based on site conditions and greywater characteristics. The design of a greywater treatment system primarily depends on water quality, the quantity to be treated, and the reuse applications. A wide range of greywater treatment technologies have been applied and examined and they produce effluents with different qualities.

Grey water categories

Wastewater from the bathroom, including showers and tubs, is termed light greywater. Greywater that includes more contaminated waste and from laundry facilities, dishwashers and, in some instances, kitchen sinks is called dark greywater. Some greywater sources and their constituents are presented below.

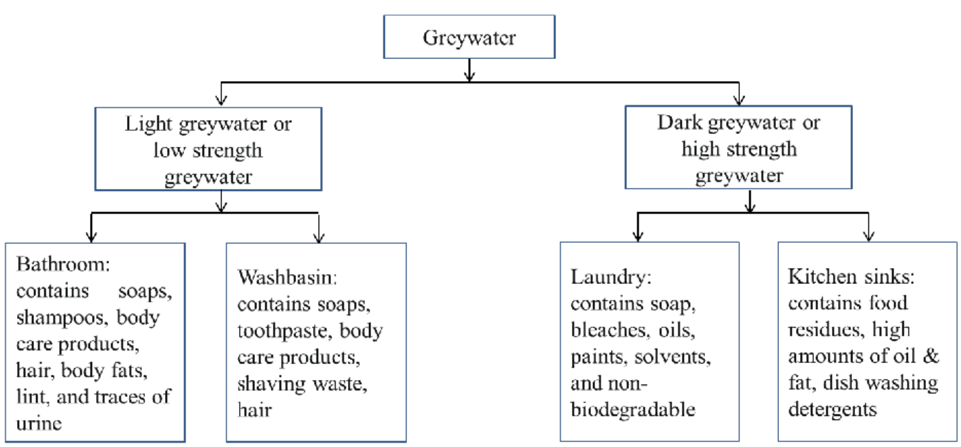


Figure 1. Classification of Greywater

Quantity of Grey water

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. Factors that account for such huge disparities are mostly attributed to geographical location, lifestyle, climatic conditions, type of infrastructure, culture and habits, among others.

The distribution of greywater sources indicates that about 27% of greywater originates from the kitchen sink and dishwasher, 47% originates from the wash basin, bathroom, and shower, and 26% originates from laundry and the washing machine.

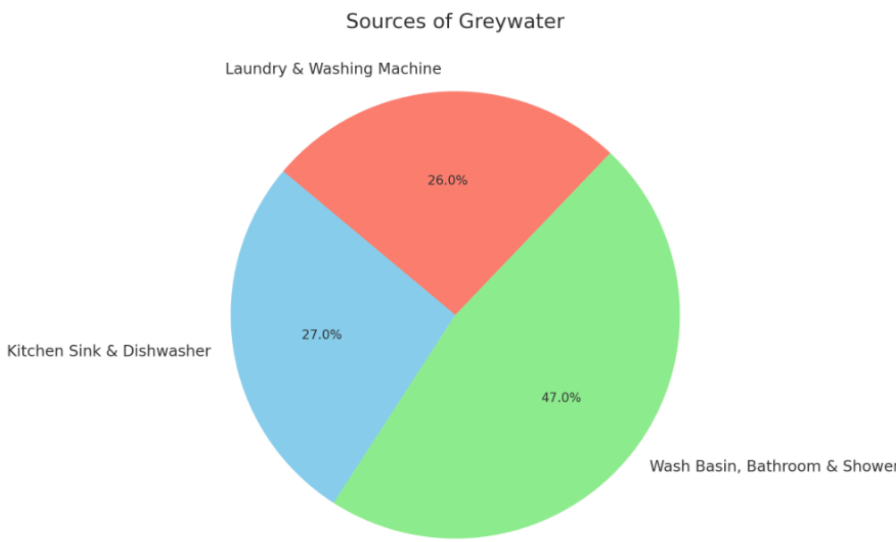


Figure 2. Composition of greywater from different sources

Water consumption always depends on the quality of life standards and availability of resources. The quantity of greywater generation depends on the total water consumption, living standard, population structures (i.e., age, gender), resident habits, and water installations of a given population. Therefore, greywater varies from 50% to 80% of the wastewater volume produced by households, and over 90% if vacuum toilets are installed. The typical volume of greywater varies from 90 to 120 l/p/d, however the volume of greywater in low income countries that experience chronic water shortages can be as low as 20–30 l/p/d. The quantity of greywater also varies between urban and rural area, as shown

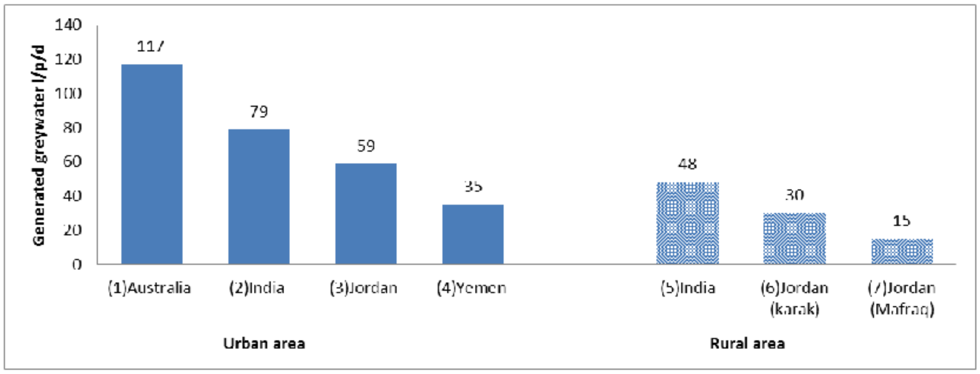


Figure 3. Volume of Grey Water Generated in Urban and Rural areas

Grey water Composition

-The composition of greywater varies, and it is largely a reflection of the lifestyle and the type and choice of chemicals used for laundry, cleaning and bathing. The quality of the water supply and the type of distribution network also affect the characteristics of greywater. There are significant variations in the composition of greywater in both place and time due to variations in water usage in relation to the discharged quantity. The composition may also be affected by chemical and biological degradations of some compounds within the transportation and storage network.

-Generally, greywater contains high concentrations of easily biodegradable organic materials and some basic constituents which are largely generated from households. These include nutrients such as nitrates and all its derivatives, phosphorus and its derivatives and biological microbes such as faecal coliforms, salmonella and general hydrochemical constituents.

-In studies, we can find pharmaceuticals, health and beauty products, aerosols, pigments and toxic heavy metals such as Pb, Ni Cd, Cu, Hg and Cr in appreciable concentrations in greywater. The presence of these contaminants in greywater is an indication of the gradual increase in the level of complexity in the composition of greywater.

Physical Constituents

These include temperature, turbidity, electrical conductivity and suspended solids, among others.

-Greywater normally has a temperature range of between 18 and 35 °C, and high temperature of grey water is due to warm water used for personal hygiene and cooking activities. High temperatures may favor microbiological growth and may also cause precipitation of certain carbonates such as CaCO3 and other inorganic salts which become less soluble at high temperatures.

-The concentration of total suspended solids in greywater is within 190–537 mg/L. Greywater originating from the kitchen and laundry accounts for the relatively high values of total suspended solids (TSS), and this is due to washing of clothes, shoes, vegetables, fruits, tubers and many others which may contain sand, clay and other materials that could increase TSS.

-The range for electrical conductivity in greywater is between 14 and 3000 μS/cm. Groundwater sources and water scarce areas have high electrical conductivity due to dissolved materials. Poor or old plumbing materials also contribute to the increase in electrical conductivity due to leaching into greywater sources.

-The range of turbidity recorded for greywater is between 19 and 444 NTU. Greywater from the kitchen and laundry is more turbid due to the presence of suspended matter.

Chemical Contaminants

-Significant chemical constituents in greywater are from chemicals used for cleaning, cooking and bathing purposes.

-The pH in greywater mainly depends on the pH and alkalinity in the water supply. It is normally within the range of 5–9. Laundry Greywater exhibit high pH due to the presence of alkaline materials used in detergents. Surfactant is the major chemical constituent found in greywater which is generated as a result of cleaning or washing activities. It is the main active agent in most cleaning products. They are either cationic or anionic in nature. The majority of cleaning and laundry products are anionic. Cationic surfactants are generally salt based, and they constitute a source of ammonium in the greywater.

-Sodium is the other constituent which is also from cooking and preservation activities in the kitchen. It can be found in appreciable levels. Sodium-based soaps is the main reason for high sodium in greywater. Other additives such as builders control water hardness in detergents and also serve as the main source of phosphate contaminants in greywater.

-Nutrients such as N and P are associated with kitchen and laundry activities. Greywater sources with high nutrient concentrations are mostly made up of a high fraction of kitchen and laundry sources. Kitchen waste are the primary source of nitrogen in greywater (range between 4 and 74 mg/L) while washing detergents are the primary source of phosphates found in greywater (range between 4 and 14 mg/L).

-The conventional wastewater parameters such as biochemical oxygen demand BOD and chemical oxygen demand (COD) always show a dominance of COD over BOD. The biodegradability of greywater is determined by the BOD/COD ratios. The ratio determines the ease with which bacteria can decompose the organic matter in the greywater. The average BOD/COD ratios in greywater have ranged between 0.31 and 0.71 The dominance of COD to BOD has largely been due to the presence of XOCs that increase COD. XOCs are synthetic organic compounds that are present in household chemicals and pharmaceuticals such as bleaches, surfactants, softeners and builders and beauty products.

Biological Characteristics

Greywater contains microorganisms such as bacteria, protozoa and helminths which are introduced into it by body contact. Inappropriate food handling in the kitchen and direct handling of contaminated food have been identified as sources of enteric pathogenic bacteria such as *Salmonella* and *Campylobacter* into greywater . Fecal contamination is also common in greywater and is largely associated with poor personal hygiene and disposal of greywater which contains washed nappies. Pathogenic *Escherichia coli* and enteric viruses have been detected in greywater with the majority of the water originating from laundry sources. The most common indicators are coliform bacteria and *E. coli*. A number of pathogens are also found in greywater such as *Pseudomonas* , *Legionella* , *Giardia*, *Cryptosporidium* and *Staphylococcus aureus*.

Objectives of Greywater treatment

- Protection of groundwater and surface water
- Protection of land and vegetation
- Prevention of a public health risk
- Protection of the community against possible disease transmission arising from improper greywater reuse and

Nitrates

Nitrate is a chemical compound that includes nitrogen and oxygen. Nitrates are used as fertilizers in agriculture. High levels of nitrate occur here because of the heavy use of fertilizers.

The World Health Organisation (WHO) has defined the maximum nitrate level of a contaminant in drinking water as 50 mg/L. As per the Indian situation, 45 mg/L is recommended by the Bureau of Indian Standards (BIS) as the permissible level of NO3− in drinking water. As a result of the prolonged ingestion of groundwater nitrate, serious health issues are encountered in the different parts of the world. Thus, nitrate exposure-related health risk assessment research is extensively studied in different countries

Adverse effects of High Level Nitrates in water on ecosystem:

- High nitrate lowers the total chlorophyll content and reduces the photosynthetic efficiency of plants.
- Low levels of dissolved oxygen, also known as hypoxia
- Unsightly algae scums on the water's surface
- Fish kills
- Blue Baby syndrome to human beings.

Denitrification Using Managed Aquifer Recharge(MAR) Technique

Managed Aquifer Recharge (MAR) is an adopted approach to replenish groundwater resources by intentionally directing water into aquifers. An aquifer is a body of rock or sediment that holds groundwater. This process solves issues such as water scarcity, increase of height water demand, and impacts from climate change. The recharged water contains pollutants like nitrate (NO_3^-), a highly contaminant in agricultural and urban runoff. High nitrate levels cause risks to human health and hamper the ecosystem, making nitrate removal a critical objective in MAR projects. To enhance nitrate removal via microbial denitrification , the potential of carbon-rich permeable reactive barriers (PRBs) – specifically, wood chips and biochar is high.

Microbial denitrification

It is an anaerobic microbial respiration process where specialized bacteria use nitrate (NO_3^-) as an alternative electron acceptor instead of oxygen (O_2) and convert nitrate to nitrogen gas (N_2). It is an important natural method for reducing nitrogen compounds in soils, wetlands, and groundwater systems and is highly beneficial in mitigating nitrate contamination. It is a multistep process that requires organic carbon as an electron donor and is effective under low-oxygen (suboxic to anoxic) conditions. PRBs, layered with organic carbon sources, can create favorable conditions for denitrifying microbes, potentially enhancing nitrate removal.

Mechanism of Denitrification

Denitrification is a microbial-mediated process of stepwise reductions from nitrate (NO_3^-) to dinitrogen gas (N_2), and includes four consecutive reductive reactions: NO_3^- → nitrite (NO_2^-) → NO → N_2O → N_2

1. Nitrate Reduction (NO_3^- to NO_2^-)
   - Enzyme Involved: Nitrate reductase (encoded by the *nar* or *nap* genes)
   - Reaction:
   - $NO_3^- + 2H^+ + 2e^- \rightarrow NO_2^- + H_2O$
2. Nitrite Reduction (NO_2^- to NO)
   - Enzyme Involved: Nitrite reductase (encoded by the *nirS* or *nirK* genes)
   - Reaction: $NO_2^- + 2H^+ + e^- \rightarrow NO + H_2O$
   - **Description**: It is considered a rate-limiting step in the denitrification pathway.
3. Nitric Oxide Reduction (NO to N_2O)
   - Enzyme Involved: Nitric oxide reductase (encoded by the *norB* and *norC* genes)
   - Reaction: $2NO + 2H^+ + 2e^- \rightarrow N_2O + H_2O$
   - Nitrous oxide escapes to the atmosphere if the process is incomplete.
4. Nitrous Oxide Reduction (N_2O to N_2)
   - Enzyme Involved: Nitrous oxide reductase (encoded by the *nosZ* gene)
   - Reaction: $N_2O + 2H^+ + 2e^- \rightarrow N_2 + H_2O$
   - Nitrogen gas (N_2) is the end product of denitrification. Nitrogen gas is released harmlessly into the atmosphere.

Factors Affecting Denitrification

1. **Oxygen Levels :** Denitrification is an anaerobic process; thus, it occurs primarily when oxygen levels are low.

2. **Organic Carbon Availability :** Organic carbon serves as the electron donor necessary for denitrifying bacteria to carry out the reduction of nitrate. Permeable reactive barriers (PRBs) i.e woodchips or biochar provide a sustained source of organic carbon.
3. **Soil Moisture and Temperature :** Higher moisture levels create more anaerobic conditions, facilitating denitrification. Denitrification rates increase with temperature, as microbial activity generally accelerates at higher temperatures.
4. **Soil pH :** Denitrification is optimal in neutral to slightly alkaline soils and extreme pH conditions inhibit the enzyme activity and reduce denitrification.

Experiment based on MAR technology:

Materials used:

1. Transparent Cylindrical Tube(70 cm length and 10 cm diameter).
2. Big storage tank(15 Litre used).
3. Pipes for the flow of water.
4. Sangwan Woodchip (size of 1mm).
5. Clay(or soil).
6. Sand.
7. Filter paper.
8. Piece of cloth(to act as a filter for big particles).
9. Collecting Vessel.
10. Grey Water.
11. Measuring Instruments(to measure the parameters of water).

Soil : Soil mimics field soil conditions and provides a medium for water infiltration.Support microbial communities for denitrification, enable control over infiltration rate and flow dynamics.

Sand : Sand filtration is used for the removal of suspended matter, as well as floating and sinkable particles as the wastewater flows vertically through a fine bed of sand. All the soap particles and other dust particles will get stuck in the sand and do not come up with water.

Selection of most suitable wood chip size:

I had wood chips of Sangwan tree, mixed of all different types of sizes. In order to study deeply the performance and to observe the difference in the denitrification impact due to the size of wood,So I used a sieve plate to separate them into various sizes of around 250 gm each: 0.6 mm (powdered form), 1 mm, 2 mm, and 4 mm.

For the test, I took two types of water.

Water 1:

Artificially prepared 1 L nitrate water having a nitrate concentration of 60 mg/L. It was prepared by adding 0.098 grams (98mg) of KNO3 to 1 Litre of Distilled water.

Afterwards, I made four samples (for four different sizes of woodchip).

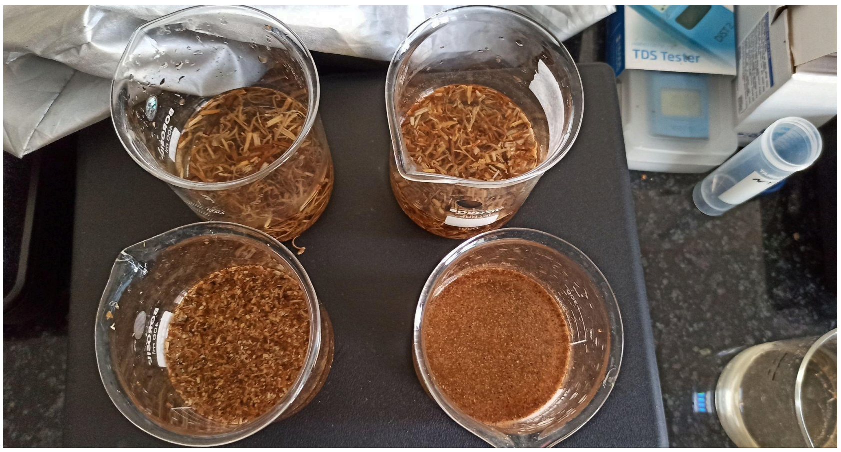


Figure 4. Test Samples for different wood chip sizes

Sample 1: 150 ml of grey water(nitrate conc 60 mg/L) mixed with 5 grams of woodchip of size 4.75mm.

Sample 2: 150 ml of grey water(nitrate conc 60 mg/L) mixed with 5 grams of woodchip of size 2mm.

Sample 3: 150 ml of grey water(nitrate conc 60 mg/L) mixed with 5 grams of woodchip of size 1mm.

Sample 4: 150 ml of grey water(nitrate conc 60 mg/L) mixed with 5 grams of woodchip of size 0.6mm.

I covered the four samples and left them for 24 hours.

After 24 hours, I checked the nitrate concentrations and below are the results:

S No.	Sample	Initial Nitrate(mg/L)	Final Nitrate(mg/L)	Δ Nitrate
1.	0.6 mm (powdered)	60 mg/L	25.2 mg/L	58.00%
2.	1mm	60 mg/L	25.6 mg/L	57.33%
3.	2mm	60 mg/L	36.9 mg/L	38.50%
4.	4.75mm	60 mg/L	50 mg/L	16.67%

Table 1. Showing nitrate removal from artificially prepared nitrate water from each of the four samples of different wood chip sizes.

- This result proved that smaller size woodchips i.e 0.6mm and 1 mm showed highest nitrate removal percent.
- It is due to their small size and provides a high area of contact for the same weight of woodchip.

Water 2:

It is laundry water. I wanted to test for TDS also along with the nitrates and to see the results on grey water cleaning apart from the artificial nitrate water (that I prepared and checked above).

Original readings of grey water : TDS**= 895 ppm** and Nitrate= **137.9 mg/L**

I again made 4 samples of it with the woodchips of four different sizes

Sample 1: 150 ml of laundry water mixed with 5 grams of woodchip of size 4.75mm.

Sample 2: 150 ml of laundry water mixed with 5 grams of woodchip of size 2mm.

Sample 3: 150 ml of laundry water mixed with 5 grams of woodchip of size 1mm.

Sample 4: 150 ml of laundry water mixed with 5 grams of woodchip of size 0.6mm.

Below are Results after 24 hours,

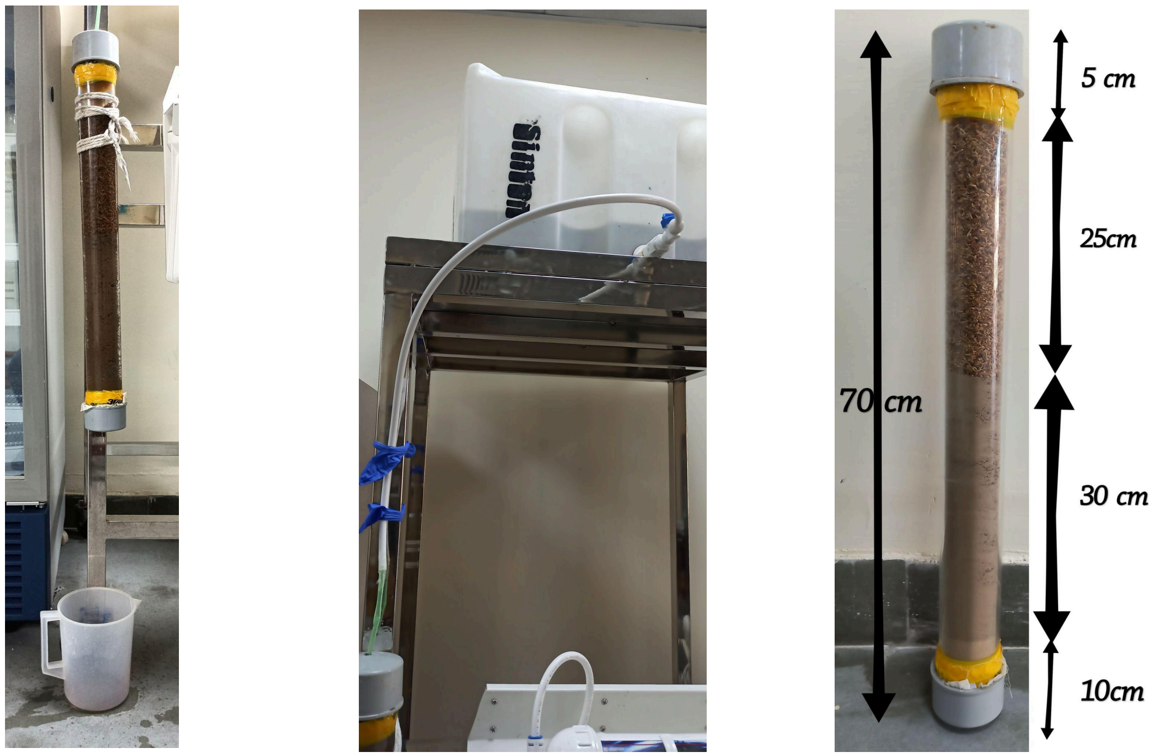
S No.	Sample	Initial Nitrate(mg/L)	Final Nitrate(mg/L)	Δ Nitrate	Initial TDS	Final TDS	Δ TDS
1.	0.6 mm	137.9 mg/L	90.2 mg/L	34.5%	895 ppm	775 ppm	13.4%
2.	1 mm	137.9 mg/L	88.3 mg/L	35.9%	895 ppm	753 ppm	15.8%
3.	2 mm	137.9 mg/L	105.0 mg/L	23.8%	895 ppm	810 ppm	9.4%
4.	4.75m	137.9 mg/L	111.5 mg/L	19.1%	895 ppm	865 ppm	3.3%

Table 2. *Showing nitrate and TDS removal from laundry grey water from each of the four samples of different wood chip sizes.*

- Still 0.6 mm and 1 mm have greater denitrification. The TDS reduction is also greater in these both cases.
- But, 1 mm wood chip is preferred over 0.6 mm because the 0.6mm size wood chips are of powdered size and hence too small. They will block the passage of MAR tube on wetting wet. On wetting wet, the water will find difficult to pass through each particle of powdered wood chip as the 0.6 mm size woodchip will stuck or will aggregate
- 1 mm has shown almost equal magnitude of nitrate removal in both types of water (artificially prepared and laundry generated). There is very little difference in Δ Nitrate values or TDS removal values. 1 mm will still provide passage to pass grey water through it as they may not stick. So, we can go with the 1 mm woodchip, which is ideal among the other sizes.

Experimental Design:

Setup Storage Tank Layers in the tube



(a) (b) (c)

Figure 5. The experimental setup showing (a)The final three layered tube, (b)Storage tank in which the grey water is stored and (c) Composition of the tube

Procedure:

1. Washed wood chips so that all its dirt and dust particles can be removed. After washing, we are left with clean wood chips which can be used in the experiment.
2. Washed the cylindrical tube, its two caps and dried it.
3. Tightly fixed the lower cap in the lower mouth of the cylindrical tube before filling the materials in the tube.
4. While inserting the lower cap, I kept Cotton cloth in the inside of the cap, to act as a filter so that sand or clay cannot come out along with water.
5. Filled Sand very firstly till the height of 10 cm.
6. Secondly, filled or inserted soil/clay. The length of soil/clay is 30 cm.
7. Above the soil, I filled the third layer i.e. woodchip of size 1 mm. The length of the woodchip column is kept 25 cm.

8. 5 cm length is left for the extra water to reside in the tube otherwise the tube may start leaking if a little flow rate is excessed.
9. Now the setup got completed. Closed the upper cap after it.
10. Tie the Column with a rope at a little height above the ground so that container can collect the treated water.
11. Filled the above storage tank with grey water.
12. After this the pipe connection is done. One end of the pipe is attached to the exit of the storage tank while the other end is going inside the tube,where the water will be treated.
13. This completes the setup.

Grey Water Treatment using the Final Setup (Made Setup)

–Treatment is done on a fresh greywater (from Laundry Centre, IIT Jodhpur). Small portion (200 ml) of greywater is kept to test the originality of the grey water by measuring the parameters. 15 L of laundry grey water is brought and filled in the storage tank. Water is allowed to flow at constant flow rate (also called infiltration rate in Managed Aquifer Recharge).

–Total 7 treated samples(each sample around 150mL) are taken after the start of treatment / experiment i.e. at the time the very first water comes from the tube, 1 hour later, 2 hour later, 3 hour later, 6 hour later, 12 hour later and finally after 24 hours after the start of experiment.

Infiltration rate= 0.0714 cm/min = 1.686 inch/hr

Parameters of original grey water:

- pH : 7.28
- Nitrate : 78.9 mg/L
- TDS : 661 ppm
- Turbidity : 61 NTU
- COD : 600 mg/L

Parameter Wise Results:

1. pH

Time	Initial	0 hr	1 hr	2 hr	3 hr	6 hr	12 hr	24 hr
pH value	7.9	7.74	7.75	7.75	7.82	7.78	7.80	7.3

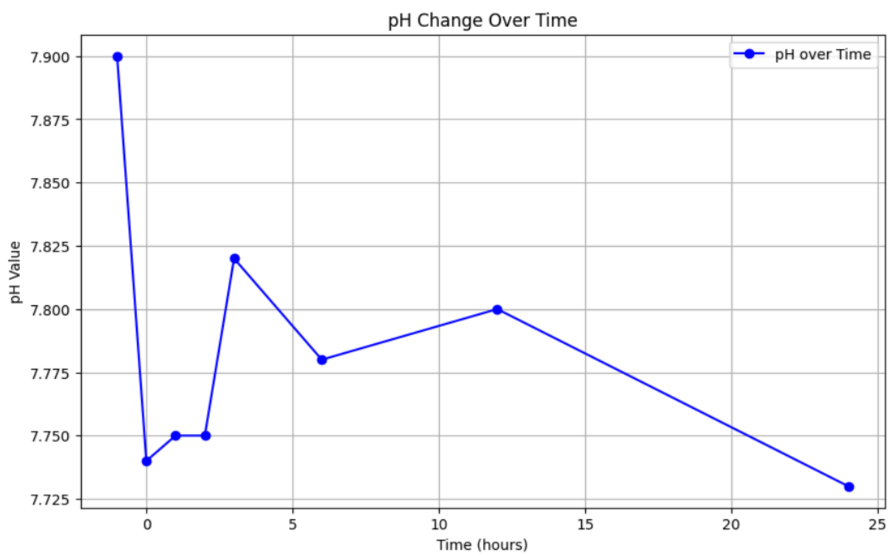


Figure 6. Plot of pH value of treated samples at different time intervals

The pH of water is slightly decreased because of organic acid which is released from decomposing wood chips. It is stable later.

2. Nitrate

Time	Initial	0 hr	1 hr	2 hr	3 hr	6 hr	12 hr	24 hr
Value mg/L	78.9	45.6	42.1	40.4	41.9	38.8	39.8	39.6

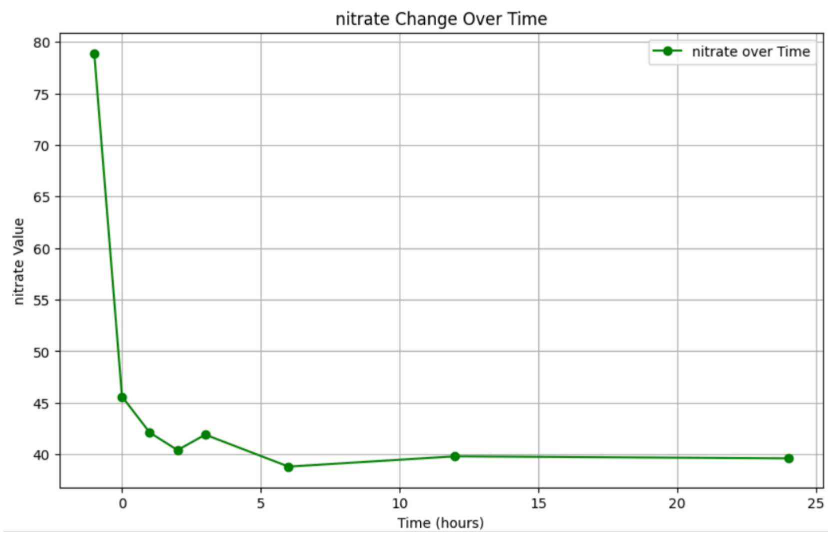


Figure 7. Plot of nitrate concentration of treated samples at different time intervals

Initially Nitrate is reduced but not much. But as Time passes, Nitrate removal improves and takes a stable value.
Nitrate reduced percentage= (78.9 - 41.17)/78.9 = **47 %**

3. TDS

Time	Initial	0 hr	1 hr	2 hr	3 hr	6 hr	12 hr	24 hr
Value ppm	661	1200	600	400	380	365	360	410

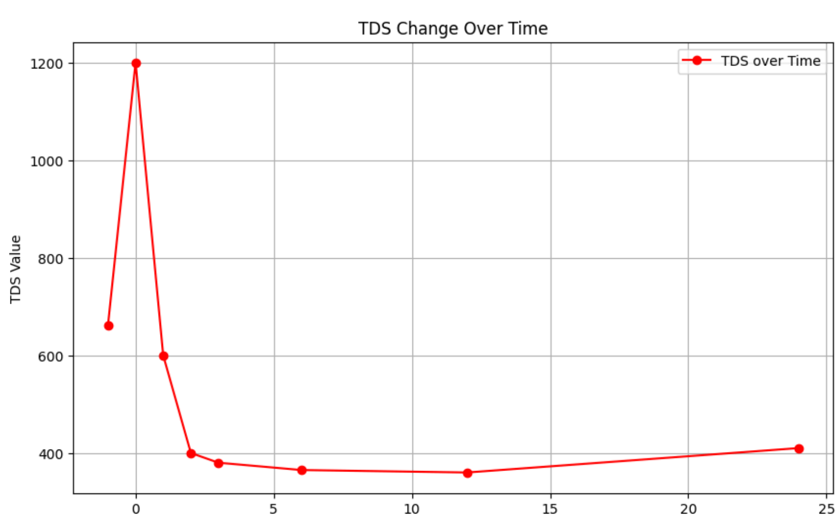


Figure 8. Plot of TDS of treated samples at different time intervals

The high TDS of 0 hr sample is maybe due to the flowing out of suspended particles ,dust particles and very fine particles with the initial water. When the water travels for the first time through the tube, it may take suspended and fine particles which were associated with woodchip, sand or clay. And after they have came out, we can see a decreased TDS value in the treated water.

4. Turbidity

Time	Initial	0 hr	1 hr	2 hr	3 hr	6 hr	12 hr	24 hr
Value NTU	61	4.6	4.01	3.00	3.1	4.87	4.70	4.33

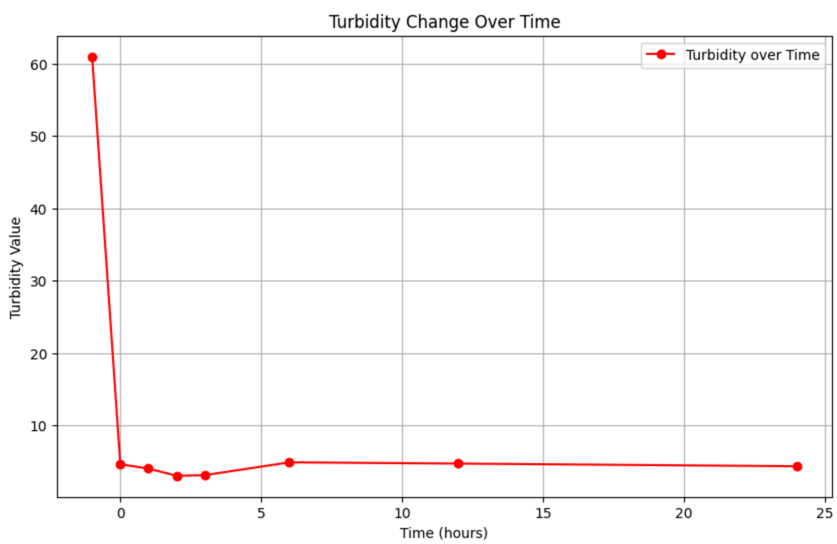


Figure 8. Plot of Turbidity in treated samples at different time intervals

Turbidity is the measure of relative clarity of a liquid. As the water is treated it becomes less dense as compared to grey water and more clear due to a less concentration of light-blocking particles, hence the turbidity of water decreases,

5. COD(chemical oxygen demand)

Time	Initial	0 hr	1 hr	2 hr	3 hr	6 hr	12 hr	24 hr
Value mg/L	600	620	712	660	603	591	559	611

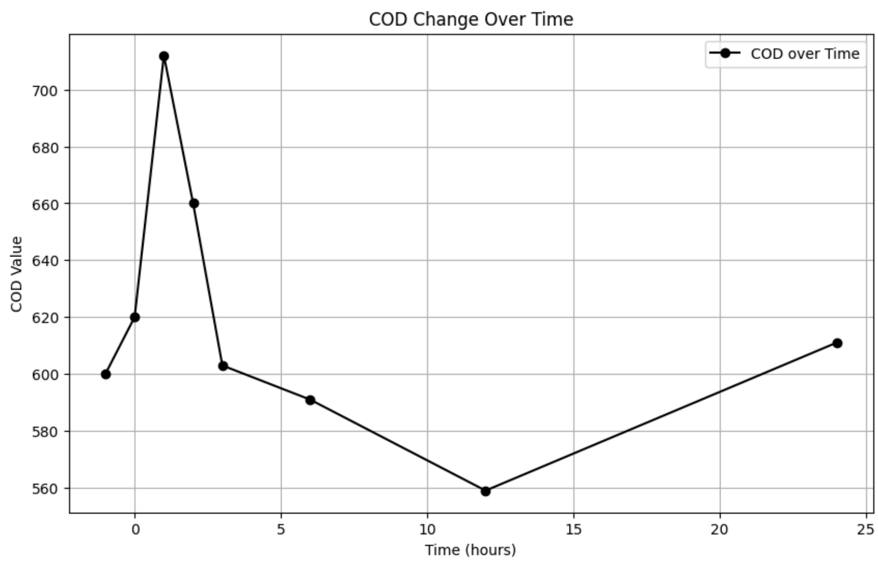


Figure 8. Plot of COD of treated samples at different time intervals

COD is increased because Woodchips release organic carbon. COD can stabilize over time because microbial uptake increases.

Results of above discussions:

- The setup is able to treat greywater efficiently.
- It not only reduces nitrates, but also the TDS, turbidity, etc in a good amount.

Conclusion:

- The project works on the principle that woodchips enhance denitrification and give favorable conditions for it.
- This project's idea is feasible for all people and places and it can be implemented at every house level. It teaches us how to use local resources and use them effectively.
- Future research will include the study of the combined use of woodchips and biochar, by combining the sustained carbon release of woodchips with adsorption properties of biochar.
- Greywater installations do not harm the environment, or cause a nuisance, and are appropriately sited and maintained according to a regulatory standard.

References

https://www.researchgate.net/publication/307866723_REVIEW_OF_THE_GREYWATER_AND_PROPOSED_GREYWATER_RECYCLING_SCHEME_FOR_AGRICULTURAL_IRRIGATION_REUSES

https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/denitrification#:~:text=Denitrification%20is%20a%20microbial%2Dmediated,1982%3B%20Zumft%2C%201997).

https://www.researchgate.net/publication/229448067_Greywater_treatment_as_an_option_for_effective_wastewater_management_in_small_communities

https://www.researchgate.net/publication/229448067_Greywater_treatment_as_an_option_for_effective_wastewater_management_in_small_communities

https://pubs.acs.org/doi/abs/10.1021/acs.est.9b01191

https://websites.pmc.ucsc.edu/~afisher/CVpubs/pubs/Gorski2020_STE_DeNO3-InfiltColumns.pdf

https://www.sciencedirect.com/science/article/pii/S266649842300042X

https://www.researchgate.net/publication/235442595_Characteristics_and_treatment_of_greywater-A_review

https://www.researchgate.net/publication/24145844_Review_of_the_technological_approaches_for_grey_water_treatment_and_reuses

https://www.researchgate.net/publication/326432835_Greywater_Characteristics_Treatment_Systems_Reuse_Strategies_and_User_Perception-a_Review

https://www.mdpi.com/2071-1050/14/2/665

https://www.ijraset.com/research-paper/design-optimization-for-grey-water-treatment