Automatic Grey Water Filtration

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***Abstract*—India is facing a water crisis and by 2025 it is estimated that India's population will be suffering from severe water scarcity. Water scarcity leads problems such as food shortage, regional water conflicts and environmental degradation. As the industries with population are growing day by day the load on effluent treatment and disposal is also increasing. Now the condition is getting very worst so new treatment and new techniques are needed to be discovered for grey water treatment [1]. Reusing grey water by applying automatic water treatment is an effective procedure for getting the fresh water demand for Daily uses in house, Construction, Cleaning, Washing, Irrigation and Households purpose. Greywater (sullage) is the component of domestic waste water which does not contain the toilet effluent. This study aims at treatment of greywater for potable purpose, focusing on a non-biological treatment technology which is simple, cheap and of portable in nature which is having minimum maintenance [1]. Characterization of mixed domestic sullage was done as an initial part of the study. The COD, BOD, TSS, Oil & Grease, Alkalinity, Acidity, pH and Turbidity concentration was found out. The main reason for these is to be due to high concentration of cooking oil and detergents in the water. Based on literature serve, a grey water treatment system consisting of coagulation followed by sedimentation, adsorption, filtration and ion exchange and also automatic technology of flow of water and providing heat automatically is proposed so as to bring the concentration of contaminants up to potable standards.**

***Index Terms*—Adsorption, Auto-flow and heat technology, Reuse, Sullage, Sedimentation, Filtration, UV rays, Background**

I. INTRODUCTION

The India's Population will have expanded by 1,425,775,850 at the end of 2023, where 1.2 billion people by 2025. Water demands is also been rising at more than three times of population growth. In most of the state's human population are growing while water availability is not. It has been found that 1/3rd India is suffering from water shortages. Increasing demand for water with rapidly growing rate of population, inadequate, rainfall, uncontrolled use of water and climate change are some of the reasons behind it. The UN estimations suggest- 'While 1.2 billion people, or almost one-fifth of the world's population, live in areas of physical scarcity, 500 million people are nearing this situation. Another 1.6 billion people, or almost one quarter of the world's population, face economic water shortage (where countries lack the necessary infrastructure to take water from rivers and aquifers) [2].

It is because of these concerns, the agenda 21 adopted by the United Nations Conference on Environment and Development, popularly known as the "Earth Summit" of Rio de Janeiro, 1992, identified protection and management of freshwater resources from contamination as one of the priority issues, that has to be urgently dealt with to achieve global environmentally sustainable development [3].

Union Minister of India Jal Shakti, Shri Gajendra Singh Shekhawat launched the Sujalam 2.0 campaign for greywater management at a virtual event hosted by the Department of Drinking Water and Sanitation (DDWS), Ministry of Jal Shakti to mark the World Water Day, 2022 [4].

Wastewater generation has increased swiftly due to exponential growth of population and related developmental activities, including agriculture and industrial productions. The current scenario invariably points out at recycle and planned reuse of waste water. Several pioneering studies have provided the technological confidence for the safe reuse of reclaimed water for beneficial uses. Previously the emphasis was mainly on reuse for agricultural and non-potable reuses, but the recent trends prove that direct reuse after treatment is possible as soon as the waste water is generated. There are also many projects that have proved to be successful for indirect or direct potable reuse.

A. Significance

Out of the total wastewater generated, 70 % is sullage. When separately collected, sullage can be conveniently treated and restored to the original characteristics of tap water. The methods in existence for treating waste water require a large amount of space and they account for the treatment of entire sewage [5].

Thus, there is a need for developing a compact design requiring minimal maintenance that can be conveniently used by residential buildings for treating their sullage water. By disallowing sullage to mix with sewage and treating it separately, the treated water can be reused for domestic purposes such as gardening, flushing, washing clothes and utensils, cleaning floors. Greywater most easily offsets water demands for reuse. In conjunction with rainwater harvesting, it can supply most, if not all, of the landscape reuse needs of a domestic use. Greywater contains nutrients (e.g. oil, soap, salt dust, phosphorus and nitrogen from detergents).

The primary goal is to design and solve a portable treatment unit to treat sullage so that it can be used for non-potable use. To achieve this goal following objectives are identified:

- To determine the characteristics of sullage by performing standard tests – pH, Turbidity, h=hardness, COD (Chemical oxygen demand), BOD (Biological oxygen demand).
- To solve the treatment on using various characteristics after treatment provided sedimentation, adsorption using activated charcoal, ion exchange and chlorination.

II. LITARETURE REVIEW

Grey water, wrap water from showers, baths, sinks, and washing machines, constitutes a significant portion of household wastewater. Treating and reusing grey water can help conserve potable water resources and alleviate the burden on wastewater treatment plants. This literature survey reviews various methods and technologies for grey water filtration, highlighting their effectiveness, advantages, and limitations.

The grey water in normal household waste is estimated as 70% of water waste which includes kitchen waste, hand wash waste, bathroom used, washing utensils, washing cloths and cleaning waste water where grey water dose not contain any toilet waste.

The estimation is done from common houses such as it is recorded as a house of single family with 5 members according to using water for their daily uses of 1000litre of water per day in which 20% of water is used in toilet use and 10% water is used in planting and normal waste at last 70% of water is use in kitchen, bathroom, washing, cleaning and utensils wash where it is calculated as more then 600lites of water used in making grey water on the statistically count from India had 302.4 million households in 2021. The indicator recorded a year-on-year increase of 1.8% in 2021. On the bases of this the total waste per day is

600 liters X 302400000 = 18,144,000,000 liters/day

It estimated as largest water waste in India as daily uses. There are some existing solutions for grey water treatment in large scale as well as in short scale. As large-scale plants are acquiring large land space with different techniques and small scale is not providing an efficient filter of water.

Below shows the literature survey on different research that have been published and also table consist of data with only methods and disadvantages of the paper and focusing on disadvantage this our research has been taking all it as extra inputs.

Greywater treatment has been extensively studied to explore sustainable solutions for domestic water reuse. In 2015, a study titled "A Study on Grey Water Treatment Processes" examined greywater generated from households and local areas. The study attempted to evaluate the basic characteristics of greywater and its treatability, but it had limitations such as the inability to completely remove odour, maintain ideal pH (ranged between 6–9), and achieve optimal chemical oxygen demand (COD) levels.

In 2016, research on the "Use of Sullage for Non-Potable Purposes" employed conventional treatment methods such as coagulation, sedimentation, adsorption, and ion exchange. While these methods showed potential, the study lacked visual representation, such as diagrams or detailed procedures, which limited its practical applicability.

The 2019 paper titled "Grey-Water Treatment and Reuse" investigated physical, biological, and chemical treatment techniques. However, despite utilizing multiple processes, the study reported minimal improvement in essential water quality parameters like pH, turbidity, biological oxygen demand (BOD), total solids (TS), and COD.

In 2022, a paper titled "Greywater Treatment Technologies" emphasized physical and chemical methods. While physical processes proved effective in removing suspended solids, they were found to be less efficient in addressing organic pollutants, limiting their use as standalone solutions.

More recently, the 2023 study "Physical, Chemical and Biological Greywater Treatment Technologies for Effective Reuse: Critical and Comparative Analyses" provided a comparative analysis of advanced treatment technologies including microfiltration, ultrafiltration, nanofiltration, and reverse osmosis. Although these methods demonstrated high effectiveness, the study highlighted that their performance was highly dependent on variables such as pollutant concentration, adsorbent type and size, hydraulic retention time (HRT), temperature, pH level, mixing conditions, and the surface charge of the adsorbent used.

III. MATERIALS AND METHODS

A. Collection of samples

To determine the composition of grey water, the percentage composition of leaks and toilet is not considered, and modified composition is found out of 1000 liters:

- Kicthen use – 15%
- Bathroom use – 25%
- Cloths wash – 20%
- Cleaning – 10%
- Other domestic – 10%

Therefore, to prepare 100 liters of greywater approximate volumes of the components were collected, which are as follows:

- Kicthen use –20 litre/day
- Bathroom use –35 liter/day
- Cloths wash –25 liter/day
- Cleaning –10 liter/day
- Other domestic – 10liter/day

The above-mentioned volumes of different components were obtained from different households. The cleaning water from utensils (along with some settled food particles) was collected from the kitchen sink. Used cooking oil (25 mL) was added to this sample. The bathroom effluent was collected by blocking the drain trap. This sample was mixed with the waste water from floor cleaning in a ratio of 1:1. The laundry effluent was obtained by soaking and washing clothes in a bucket and thereafter collecting the wash water. Hand and mouth washing was done in a large vessel for providing the basin effluent. All the above samples were mixed in a 100-liter plastic bucket by continuous shaking so as to form the final household grey water sample.

B. Characteristics of grey water

Grey water has properties which are unitability for most types of reuses (for same daily use) therefore it required improvements. The main characteristics that the greywater needs to be checked for are- pH, turbidity, total hardness, suspended and dissolved solids, COD, BOD, DO, hardness, alkalinity, oil and grease content. The final sample collected as mentioned above was used directly to the treatment.

C. Treatment provided

Here are some steps where the treatment taking place as follows:

- Screening
- Coagulation :(Primary & Secondary)
- Sedimentation
- Adsorption
- Ion exchange
- Biological Treatment
- Water flow and heat are automated

1)Screening: The screening of the water is primary treatment to clean the contaminated particles and visible particle from water. Screening is a very basic steps to filter the greywater. The screening done by piping system where 1inch of pipe with filter wholes on it which is covered by 4inch cylindrical bottle like pipe with single opening on top end. The following figure shows the mechanism of screening. The following figure shows the structural view of screening with grey water inlet from the top. The conteminated grey water later moves into main chamber. The screening is done with vertically 4inch cylindrical bottle in that 1inch filter pipe which make to reduce the speed of water from inlet and make the grey water free from visible particals moving from outlet of 1inch pipe which has one open ending at down where upper one will be closed. This function release the water surface from down open of pipe with help of L-bow and sprinkling water tap. Where sprinkling of water tap is use to release grey water in all the direction so that water can avoid flowing at only one point. The below figure show screening method :

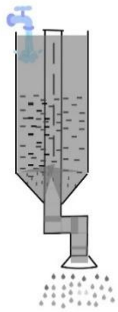


Fig 3.1: Screening with top inlet and down out to further

2) Coagulation:

Coagulant process is second and very important process of filtration of grey water after screening in Grey water filtration process. It consists of two different procedure Primary and Secoundary Process. Where both the process dependents on different steps and material used.

A. Primary Coagulation:

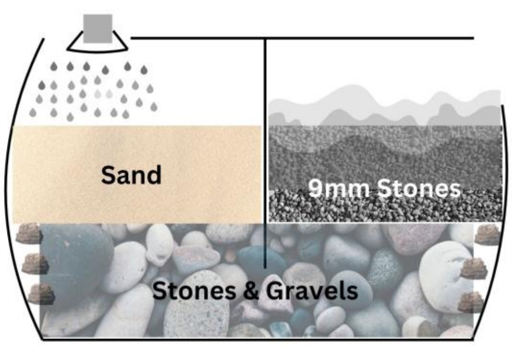


Fig 3.2: Primary Coagulation

After screening coagulation in primary system different materials to use for basic filtration of grey water which filter the water at 10%. The systematic arrangement and separation of Silica Sand, Gravel's, Stones, Bricks breaks and 9mm stones. The coagulation process starts in horizontal cylinder which has different chamber in which one of the chambers is for primary coagulation which starts the process of filtration with the inlet of grey water from screening cylinder. The process of dividing the cylindrical chamber one. The chamber itself is divided into 2 parts at exactly center of chamber one but it should be open from down and attracted from top as shown in figure (2). Chamber one is of 12 X 12 inches with length and width. Chamber has two short opens one at left top for inlet from outer side and another inside the cylinder in partition for next chamber. The chamber itself is divided into 2 parts of 6 inches each with partition of 9inches plane stop wall which is attracted at top and open at bottom as shown in figure. Material used inside the chamber is Silica sand, Gravels, Stones, Bricks breaks & Stones 9mm.

Silica sand: It is used in 4 inches of thickness at the left side of the chamber at top layer to create a net like cage to grey water where all large and visible components will stop there itself. Where silica sand has life span of 3-7 year where need not requires to change in every treatment [6].

Gravels, Stones and Bricks breaks: Is also used as to reduce the speed of grey water to get at the constant and stones, gravels and bricks are used to attract the Oily and dust particle from water. And Stones, Bricks & Gravels also has a life span to attract the dust till 2 years. It is used in complete horizontal chamber of 12 inches and vertically it is filled till 4inches.

9mm Stone: It is used to take standby to release water from first chamber which is also used to attract the particles and it's is filled opposite side of the silica sand at 3inches as shown in the figure (2).

B. Secondary coagulation:

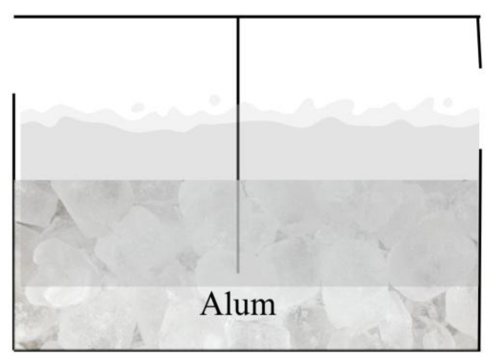


Fig 3.3: Secondary coagulation using Alum

As shown in the figure (3) there Secondary coagulation is the third procedure to filter the water the filtration is done here at 25% of grey water where it makes clear the water from COD, pH and Turbidity. Where here in this process the Alum as is added as filtration material to destroy dissolve soap and oil from water [14]. Alum its functionality depends to attract dissolve thing from water as in this method, where alum react with both oil as well as dissolve soap. After destroying the contaminated thing from water, it helps to separate the particle according to their weights where light weighted goes top at the water level and heavy weighted will settle down where the middle level of water is filtered. To overcome with this alum is add in second chamber. Where the second chamber is of 12 inches in length and 12 inches in width with the equal dividing portion as same as primary coagulation. Before this chamber one small 4 inches in length 12 inches in height with two opening in upper level as a mediator to reduce some more speed of flow of water. The second chamber is divided into two equal parts and the alum filled at 3.5inches in both the side. This chamber as on top opening for air and two internal opening inside the chamber one is for inlet from mediator and another is for outlet to next chamber.

Alum requires monthly change maintenance to it because it has only one month life span in water.

Secondary coagulation can also be done be using Moringa powder or liquid and also by using PAC Poly Aluminum Chloride both the materials are used for filtration of water and also gives the same results as alum it is used only because to avoid alum for people who has elegy by alum and also Moringa is most use full and healthy for humans. The below show how the moringa powder and liquid is mixed with contaminated water to filter water. This process is totally option for the user and has less accuracy as compare alum.

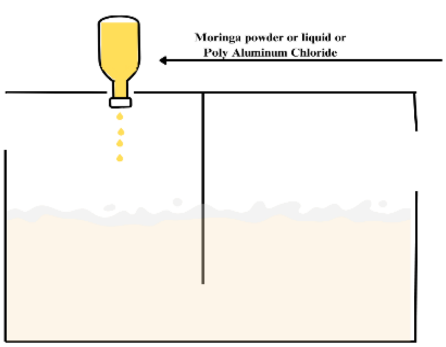


Fig 3.4: Secondary coagulation using Moringa or PAC

3) Sedimentation: Sedimentation is another process to filter the water at 10% in third chamber which is used to remove oily particles from water. Here it's also consisting of 12 X12 inches of length as well as width with filling of charcoal which is used to attract the oily particles from water. This process not require more techniques because it provides more rest to water to sedimentation and settlement of particles. As shown in the figure (5).

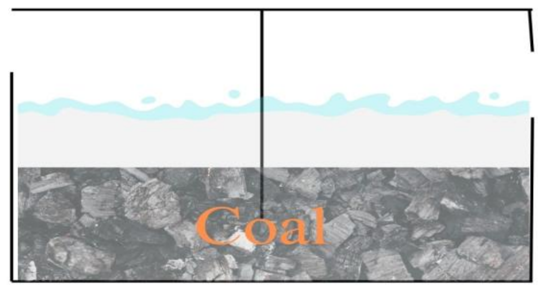


Fig 3.5: Sedimentation using Charcoal

4) Adsorption:

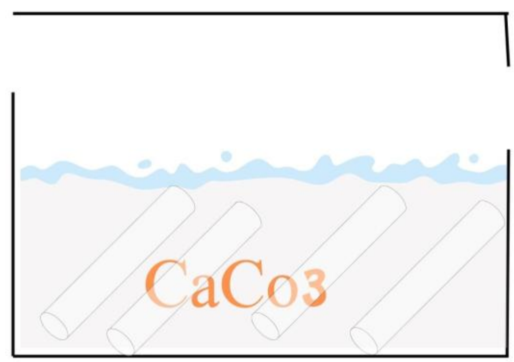


Fig 3.6: Adsorption using CaCo3

As shown in above figure (6) this is another step for filtration of water for which helps to clear the water form COD as well as alkalinity where this process takes place in 4th chamber of water filtration. In this chamber the chlorine carbonate is used to reduce the value of COD and alkalinity. This chamber is divided into two equal parts at same level as same as second chamber but here outlet and inlet position are different as outlet position is down & as inlet position is also down compared to last one. Here in this process CaCo3 is added to adsorb all the deadly organic particles present in water. CaCo3 is used as chalk where it also requires weekly maintenance of exchanging or washing and putting into same chamber. In this process the water is filter at 15%.

5) Ion Exchange: This process is the last second process of exchanginging the ion from water by providing heat at 100°c to 120°c where it is used to kill all the organic particles and make it as more pure at

10% more. This process is also helpful to check the clearity of water. As it is present in last chamber of water filtration when the water is filled at the given range its start heating water where water heater will swicthed on automatically. After heating at boiling temprature for 5 -10min it will automatically turned off then the water is released from that chamber by using 7 net layers. B The outlet of water is connected to tap where the filter water is been stored. As shown in the below figure (7) the ion exchange will takes place.

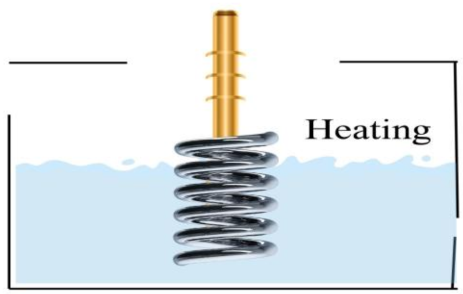


Fig 3.7: Ion Exchange by using automated technology with heating coil

6) Biological Treatment: This treatment is us to kill the biological organisms like pathogens by using UV - Rays in felt cylindrical chamber by applying UV Light in center transparent glass tube and closed with Steel/ Plastic/ Fiber covering on it which helps to emit the light inside the chamber only [8][9] & [10]. Figure 7 shows the UV rays to use the filtration system.

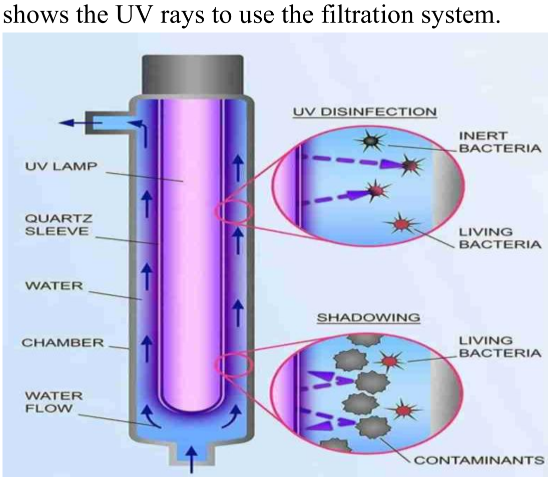


Fig 3.8: UV-rays biological treatment

7) Automatic flow control of water and heat transfer: This process is the last process which is used in all common chambers. This is the process of controlling flow of water and also to check the given time for heat. It used with relay module, wireless water level indicator, Arduino uno, ESP8266 and sensors.

IV. RESULTS AND DISCUSSION

The purpose of this experiment was to filter the amount contaminated thing present in water.

The turbidity of the grey water sample was found out to be exceptionally high. The high value of turbidity is observerd due to the following reasons:

1)Large amount of detergent and soaps were present in kicthen and bathroom.

2) The portion of solids in the kitchen effluent was quite high.

3)Most of water was mixed with higher level of contaminated thing.

The difference in the values is attributed to the source as well as the method of collection of grey water. In this solution a study area collecting a typical sample of grey water from household using. From this study the concentrations of the physical parameters, like TSS, TDS, pH, BOD, COD and Oil were 40 mg/L, 412 mg/L, 6.5, 1051 mg/L, 2023 mg/L and 15mg/L respectively. Hence the analysis done in this project is of primary importance to account for a factor of safety in the design of grey water treatment unit for an individual houses. General test for hardness and alkalinity is not done for grey water, but since I wanted to explore the possibility of the reusing the grey water for boiler purpose, I carried out the testing for the same.

A. Coagulation primary: The first treatment provided to the sample of grey water suspended the visible particles and solid particles from the grey water from traversing the water from silica sand, 16-20mm of stones, gravels and 9mm stone are used to sustain all the particles from grey water.

B Coagulation secondary: The second treatment of grey water sample is turbidity and suspended solids reduction through coagulant aided using optimum dose of alum ($Al_2(SO_4).18H_2O$) or Moringa or PAC . This method of coagulation with mixing causes particulate matter to flocculate. Initial turbidity of grey water sample was 1925 NTU and suspended solids as 900 mg/L. The test performed in different cylinders to test as shown in the figure [7].

The results were obtained when the range of dosage is shortened to obtain the accurate value. The optimum alum or Moringa or PAC dose was confirmed to 101mg/L and applied to the grey water sample. The turbidity and suspended solids were found to be 8.5 NTU and 345 mg/L variation in each property before and after applying alum dose.

I pH – As alkalinity is consumed on alum addition, pH drops. The carbonate shifts due to formation of carbonic acid and the water can get saturated with CO_2. The treated grey water at intermediate stage is highly acidic. In a paper dealing with treatment of cloths washing water, pH which was 8.5 in untreated of grey water, was recorded after alum addition in the range of 4.5 to 5.5. The pH drops from 7.85 to 5.07 in our case study justified.

II Total Hardness – When CO_2 is lost grey water becomes less soluble in coagulant solution and forms carbonic.

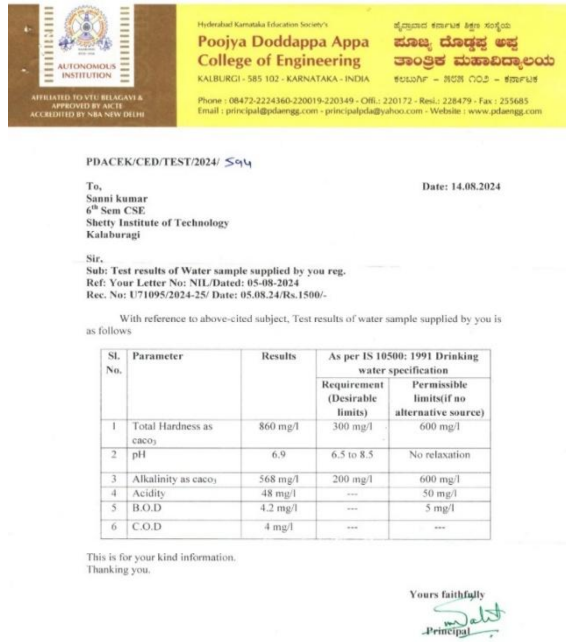
III Alkalinity – It consumed by alum to form aluminum hydroxide and hence reduced substantially from 198 to 112 mg/L.

IV BOD &COD reduction: It's observed that BOD & COD is caused by suspended solids rather than dissolved solids. The removal of suspended solids in cylinder test caused removed of higher amount of BOD and COD since a large amount of the organics settle, the oxygen demand reduces.

Table 1: All required parameter test to check the purity of water

Sr.no	Parameters	Before	After
1	Turbidity	17	9.89
2	pH	5.4	6.9
3	Total solids	1036	1238.8
4	Total Hardness	1200	860
5	COD	8	4.2
6	BOD	8.9	4
7	Alkalinity	956	568

The Report test with filtered water sample which is taken from Poojya Doddappa Appa College of Engineering with the respective parameters.



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PDACEK/CED/TEST/2024/ 594

Date: 14.08.2024

To,
Sanni kumar
6th Sem CSE
Shetty Institute of Technology
Kalaburagi

Sir,
Sub: Test results of Water sample supplied by you reg.
Ref: Your Letter No: NIL/Dated: 05-08-2024
Rec. No: U71095/2024-25/ Date: 05.08.24/Rs.1500/-

With reference to above-cited subject, Test results of water sample supplied by you is as follows

Sl. No.	Parameter	Results	As per IS 10500: 1991 Drinking water specification	
			Requirement (Desirable limits)	Permissible limits(if no alternative source)
1	Total Hardness as $caco_3$	860 mg/l	300 mg/l	600 mg/l
2	pH	6.9	6.5 to 8.5	No relaxation
3	Alkalinity as $caco_3$	568 mg/l	200 mg/l	600 mg/l
4	Acidity	48 mg/l	---	50 mg/l
5	B.O.D	4.2 mg/l	---	5 mg/l
6	C.O.D	4 mg/l	---	---

This is for your kind information.
Thanking you.

Yours faithfully

Principal

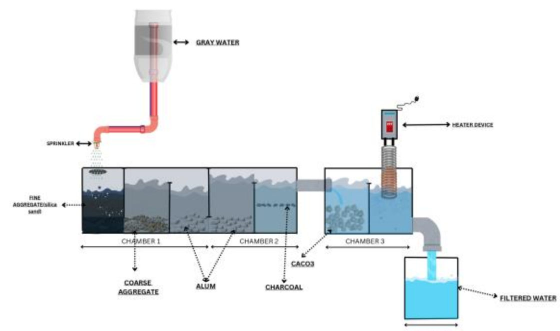

Fig 8: Grey water filtration System

a. Sedimentation: After the treatment of alum, the sample of grey water provide with contact time of 30 – 40min with varying doses of Granulated charcoal. The obtained grey water sample were filtered through multiple net cloth which help to flow only water and stop contamined thing as well as charcoal. Activated charcoal adsorbs the disovled solid and oil particles which are organic in nature and this causes the reduction in COD were it observed probably due to over dose of activated carbon.

b. Adsorption: After sedimentation the water is treated with $CaCO_3$ which helps to adsorpe the organic particles from the grey water. Calium is not even harmfull to human being and which is use as chalk.

c. Ion exchange: After all the treatment of grey water at last the grey water is bolied at 100˙-120˙c for 10min and after that cool that water from hot till room temprature then we can observe that all the particles is settled down and above remaining water is clear and filtered.

V CONCLUSIONS

After all kind of water treatment, the grey water is filtered and it can be used again in the same process as daily use. The water is filtered at all the parameters of Alkalinity, Acidity, pH, COD, BOD and Total hardness to make water it reuseable. The filtered water is existing same as normal water. By treating with all the treatment, the dose not contain any dust particles, soap, oil, & organic particles. The solution is very cost efficient and less maintenance and with long time use.

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