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Design Optimization for Grey Water Treatment

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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. Although India occupies only 3.29 million km^2 of the geographical area which forms 2.4% of the world's land area, it supports over 15% of the world's population with only 4% of the world's water resources. With increased population growth and development, there is a need to critically look at alternative approaches to ensure water availability. The scarcity of water is soon going to incapacitate the entire world and therefore the sooner newer methods are devised to utilize water in all its possible forms the better for mankind. Ground water and surface water are rapidly getting contaminated by pollutants and hence cannot be utilized for irrigation purposes. Thus, an alternative water source, i.e. grey water comes into play. Grey water is easily available and through an inexpensive laboratory-scale treatment method like ours it can be purified so that it can serve for irrigation and household purposes. Five liters of grey water was treated by physical, chemical, and biological aided treatment procedures which were divided into three main methods namely primary, secondary and tertiary treatment. These alternative resources include rainwater and the bulk of water used in the household will emerge as grey water and contain some minerals, and organic waste materials dissolved and suspended in it. When this is allowed to flow out this will join the sewage and be bacteriologically contaminated, resulting in a sewage stream. It is possible to intercept this grey water, at the household level, and treat it so that it can be recycled for garden washing and flushing purposes as well.
Keywords: Greywater treatment, Scarcity, Recycled, Irrigation, Inexpensive, Sources.

I. INTRODUCTION

Greywater is specifically washed water generated from baths, showers, hand basins, washing machines, laundries, and kitchen sinks. The main objective is the optimization of greywater treatment system to provide a better way for greywater disposal, and issues of greywater treatment odors around the treatment plants. When properly managed, greywater can be a valuable resource that horticultural and agricultural growers as well as home gardeners can benefit from [1]. It can also be valuable to landscape planners, builders, developers, and contractors because of the design and landscaping advantages of on-site greywater treatment/management. It is, after all, the same phosphorous, potassium, and nitrogen making greywater a source of pollution for lakes, rivers, and groundwater which are excellent nutrient sources for vegetation when this form of wastewater is made available for irrigation [2]. Non-potable reuse applications include industrial, irrigation, toilet flushing, and laundry washing dependent on the technologies utilized in the treatment process. In this investigation, the distinctive treatment strategies for greywater reuse are dictated by inspecting the distributed written works. Wastewater treatment these days has turned out to be more typical as a result of a shortage in numerous parts of the world and causes well-being effects [4]. The present study focuses on the theoretical and modeling aspects of the developed design and investigates the performance of this design in removing organics, and separating nutrients from grey water [3].

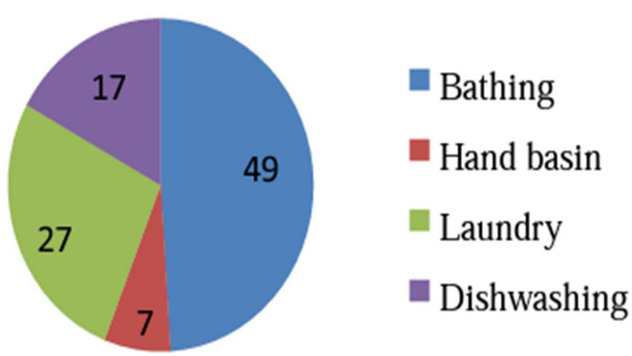

Figure 1: Grey Water Generation Chart

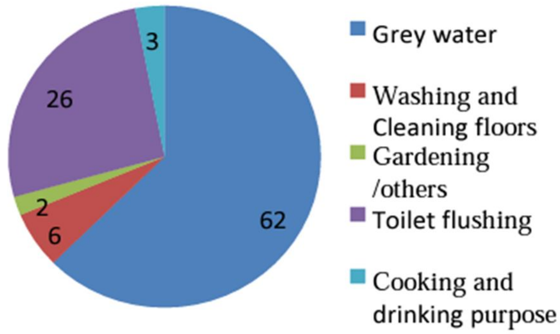

Figure 2: Total Water Consumption [5]

II. CHARACTERSTICS OF GREYWATER

The qualities of family unit grey water can change contingent upon the number of family tenants, their age, well-being status, tap water sources, water utilization examples, and household items utilized, (for example, Soaps, Shampoos, Detergents, Mouthwash, Tooth glue, hair, Shaving cream, and body oils) [6].

COMPOSITION OF GREYWATER

S.No	Parameters	Unit	Ranges
1	Suspended solids	mg/L	45-350
2	Turbidity	NTU	22-220
3	BOD_5	mg/L	90-290
4	COD	mg/L	280-800
5	Oil &Grease	mg/L	37-78
6	Coli form	Cu/100ml	0-500-10000
7	Total Dissolved Solids	mg/L	126-175
8	Temperature	˚C	18-38
9	Nitrite	mg/L	<0.1-0.8
10	Ammonia	mg/L	<0.1-25.4
11	Total Kjeldahl Nitrogen	mg/L	2.1-31.5
12	Total phosphorous	mg/L	0.6-27.3
13	Ph	-----	6.6-8.7
14	Conductivity	µs/cm	1.4-2.9mS/m
15	Sodium	mg/L	29-230

Table 1:Composition of Greywater

Grey water attributes are profoundly affected by social and social conduct of the home, accessibility of water utilization isolating dark water from dark water lessens the risk causes by the pathogens.[7]

III. METHODOLOGY

A. Optimized Model for Treatment of Grey Water

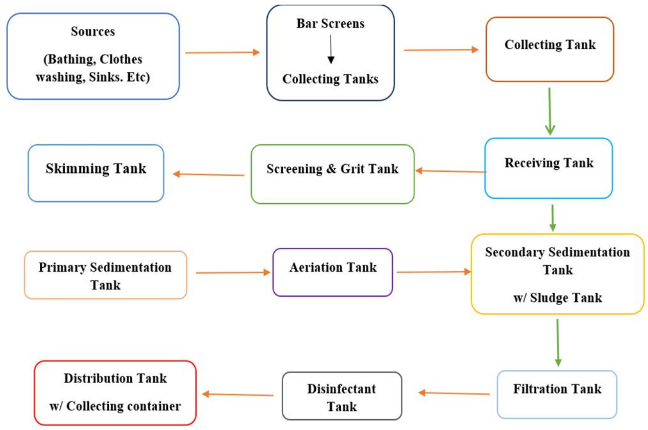

Figure 3:Flowchart of Grey water treatment using the optimized model

B. Technologies for Treatment of Grey Water

Greywater treatment includes physical, chemical, and biological processes, followed by pre-treatment and disinfection, respectively. Coarse sand, soil, and membrane filtrations are the commonly applied physical processes. Greywater treatment is essentially required to reduce the organic load, nutrients, and pathogenic microorganisms. Untreated greywater discharged into any ecosystem is unsafe and hence proper treatment is required for the safe discharge of greywater. The advancements perplexing for treating grey water incorporate physical, compound, and organic frameworks. Grey water reuse should progressively turn out to be a piece of an arrangement of incorporated activities towards the normal utilization of water, since this kind of profluent speaks to a substitute hotspot for non-versatile utilizations, with widely materialness not just in private, business, and mechanical structures. A large portion of the advances is gone before by a pre-treatment technique for strong fluid division and taken after by post-treatment as sanitization. To stay away from stopping up of the ensuing treatment, the pre-medications, for example, screens, channel packs, and channels are connected to diminish the measure of particles and oil and slick substance. The cleansing advance is utilized to meet the microbiological prerequisites.

1) Physical Treatment

The primary advances predominantly began with physical treatment choices, for example, coarse filtration or films post-treatment with purification [15]. Grey water is dealt with by a moderate sand channel. The outcome found that lessening in suspended solids and turbidity are 72.8% and 67% separately. COD outlet is an average of 45.86 mg/l. The most extreme expulsion effectiveness of 75.85 % was ingested for COD and 89% for BOD. Some straightforward methods are two-phase filtration and synthetic sterilization evacuating cold frames however stay high in turbidity and natural contamination. The smaller scale filtration film demonstrates powerful evacuation of shading, COD, turbidity expulsion, and suspended strong cleansing framework and evacuation proficiency was 71.8% in COD,5% in SS, and the effectiveness was extremely successful contrasted with moderate sand filter.[16] Using the channel segments made out of two indistinguishable misty uPVC sections stuffed with rock layer, media grains, and smashed igneous rock and silica sand, the COD, TSS, and oil and oil fixation were diminished by 48%, 65%, and 67% after settling of dark water for 1 hour in the blending holder. The fixation of E. coli in settled dark water added up to 6.9*107(±2.4*107) CFU (100ml)-1 [17]. The exploratory setup for this grey water treatment framework incorporates a gathering tank, a pumping gadget, a filtration framework, and a UV cleansing unit treatment productivity of expulsion of solids and natural issues is to a great extent accomplished by the channel, while the sterilization unit is chiefly in charge of the microbiological lessening. pH isn't influenced by comparable incentives when treatment. Lessening of 16-39% [18]. Grey water has a much lower oxygen request than black water [8] [9]. Grey water is separated from black water by natural material and supplements introduce [10]. The grey water attributes are affected by occupants, and water accessibility [11]. The pH was in the range of 6.3 to 8.1. The clothing water will have a greater amount of antacid nature yet on blending with a nearly high volume of showering water and kitchen water, the pH comes to the above range [12].

Contrasting and different species generally coagulates recommend that the crashes in grey water apply a moderately low charge request to the water per unit of natural material [13]. Putting away grey water for 48 hours at 19 to 26degreesC deteriorates its quality and organic debasement delivers a terrible smell causing a stylish issue, pathogens rearing, and mosquito reproducing which are a wellbeing problem [14].

a) *Sand and Gravel Filter:* The wastewater moves through a channel medium – sand or rock in low-tech greywater channels. The fundamental treatment process involves the maintenance of particles by channel material and a cleaning process because of natural action in the biofilm on the sand and rock.
b) *Cabinet Compacted Sand Filter:* The Drawer Compacted Sand Filter (DCSF) is an adjusted plan for a sand channel in which the sand layer is separated into a few layers, every one of which is 10cm high and set in a versatile cabinet isolated by a 10cm space. A lab-scale DCSF was outlined and worked for 330 days nourished by engineered grey water. Results demonstrated that DCSF could evacuate >90% of the natural issue and aggregate suspend solids for all measurements. No noteworthy distinction was seen as far as general channel proficiency between heaps of all parameters [19]. It diminishes the issue, for example, obstructing, causing awful odor [20].
c) *Filter Using Marble Chips:* The grain estimate conveyance for marble chips ranges from 4.75 to 20 mm. The most extreme evacuation got for turbidity, COD and aggregate solids were 75.6%, 59.4%, and 43.16% separately at 8-hour maintenance time. In the sand channel the expulsion effectiveness of turbidity has been recorded up to 81.89% [21].
d) *Filter Using Jute Coir:* In this media the expulsion of COD proficiency is 59.03% out of 8-hour maintenance time. The permeable structure in this media serves to develop the thick matt of particles and lessens the COD [21].

2) *Chemical Treatment:* Chlorine sterilization of grey water by adding up to coli shape inactivation disease. The viability of cleansing was almost enjoyed with molecule estimate. Bigger molecules protected whole coli shapes from inactivation and sterilization adequacy diminished with expanding molecule measure. The chlorine sanitization discloses that up to 91% of aggregate cold frames in chlorinated grey water were molecule associated [16]. The synthetic process connected for dark water treatment incorporates coagulation, photograph synergist oxidation, particle trade, granular enacted carbon, and so forth. Coagulation with aluminum salt lessened the COD, the BOD, the turbidity, TN, and PO43. The attractive particle trade gum process neglected to decrease the scope of turbidity and the BOD to the level for both limited reuses [22]. Hydrogen peroxide goes about as the best disinfectant, the expulsion of BOD and COD was substantially more powerful with the grey water [23].

a) *Normal Coagulants:* Normal coagulants assume an imperative part in the expulsion of turbidity and contaminants. Normal coagulants, for example, concentrates of miniaturized scale living beings or plant starting points (illustrations: Narmali seeds, Moringa seeds, Okra seeds, Cassava seeds, Dutchuslabla, Broad beans, Flava beans, Watermelon) [24].
b) *Artificial Coagulants:* Manufactured coagulants incorporate Aluminum sulfate, Aluminum chloride and Sodium aluminate, Ferric sulfate, Ferrous sulfate, de and Ferric chloride sulphate [24].
c) *Electro-Coagulation:* Electro-coagulation is the strategy with stainless steel cathode as the anode in the arrangement of bipolar association. In the examination of treated wastewater, it demonstrates that the greatest evacuation of BOD, COD, and Suspended Solids were 92.71%, 88.76%, and 93.1% respectively [26].
d) *Alum Treatment:* The water is dealt with by alum filtration through a glass segment with medium measured quartz sand and cotton fleece plunged at the base [27]. The alum is included with crude water responds with bicarbonate alkalinities the floc draws in fine molecule and suspended molecule.

3) *Biological Treatment*

Propelled oxidation techniques, for example, moving bed bio-film reactor were utilized for the expulsion of colors [28]. For strong fluid partition, the film bioreactor joins biodegradation with layer filtration because of its procedure, security, and its capacity to expel pathogens, COD and BOD are about high in go [23]. 100% aggregate coli form evacuated in the film bioreactor. Pivoting natural contractors can productively treat dim water with the evacuation of BOD and TSS efficiencies of 93-96% and 84-95% [29].

a) *Moving Bed Bio-Film Layer Reactor:* It evacuates hair shading by 80% effectiveness, and it expends vitality under 1.3 kWh/m3 grey water with various loadings and fluctuating encompassing temperature [30].
b) *Submerged Sequential Bunch Reactor:* Grey water treated with SBR is utilized with the end goal of vehicle washing, latrine flushing, fire protection, and so on. This framework expels 94.57% of BOD, 84.85% of COD, 89.73% of SS and 63.89% of TSS [30].

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c) *Vermifilter:* The examination was done in a vermifilter pack that contains rock with a layer of dark cotton soil to finish everything. It shapes the term filter bed. It has the arrangement to gather separated water at the base of the accumulation chamber which opens out through a pipe fitted with a tap. For vermifilter dark cotton soil having pH 7 is utilized. The bottommost layer is made of rock of size 20mm, and it topped off to the profundity of 40mm. Over this is the total of 10mm size topped off to a profundity of 30mm. On the highest point of this is sand going through 2.36mm IS Sieves were topped off to a profundity of 30mm. The highest layer of soil blended with cow excrement in 1:3 extent up to a profundity of 120mm in which the night crawlers are discharged. The rate lessening in the convergence of COD in vermifilter ranges from 74 to 80 and BOD ranges from 85 to 93 [31].

IV. MECHANICAL DESIGN & DEVELOPMENT

This whole project has been developed and 3D designed in **Autodesk™ Fusion360 (Prototype)** and there is each module/component adds a factor to the whole process of the design optimization of the grey water treatment process.

V. COMPONENTS USED

Figure 4: Front View of the "Greywater Treatment Plant"

S. No	Component/System Used	Quantity
1.	Collecting Tank	2
2.	Receiving Tank	1
3.	Screening & Grit Tank	1
4.	Skimming Tank w/ Oil Filter	1
5.	Primary Sedimentation Tank	1
6.	Aeriation Tank	1
7.	Secondary Sedimentary Tank w/ Sludge Tank	1 w/ 2
8.	Filtration Tank	1
9.	Disinfectant Tank	1
10.	Distribution Tank w/ Chamber	1
	Miscellaneous	As mentioned below
11.	Connector PVC pipes/ Bar racks	3- Día 100mm and lengths varying of (6 ft, 10ft, 15ft)
12.	Aquarium Pump	1
13.	Filter Candle	2
14.	Wire Gauges	2- Porous & Fine
15.	Container Tank	1

Table 2:Represents BOM (Bill of Materials) for Grey Water

There are several important components which has its each and own functionality in Treatment of Grey Water Plant.

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VI. FUNCTIONALITY OF COMPONENTS (GREY WATER SYSTEM)

Several technologies have been applied for greywater treatment worldwide varying in both complexity and performance. The following in general greywater systems considered: -

1) *Primary Treatment*: pre-treatment to secondary treatment: -

1. Screening 2. Equalization

2) *Secondary Treatment:*

1. Gravel filtration 2. Sand filtration 3. Chlorination

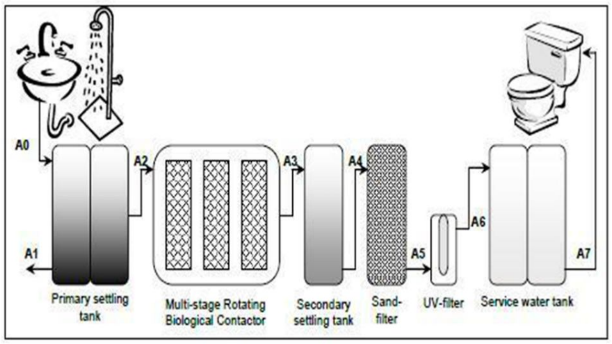

Figure 5: Process of Grey Water System.

A. Components

(*Are as follows*):

1) *Collecting Tank:* Drainpipes from bathrooms and kitchens are extended to an underground collection tank via a strainer and this collecting tank sends to strainer traps particulate matter, hair, and other contaminants lager than 0.3 mm. The tank is sized as per the water required per day (excess water if collected is drained). There are 2 collecting tanks each having capacity of 5L, additional of h= 80mm.

(l x b x h = 200 x 250 x 100 mm) all in mm.

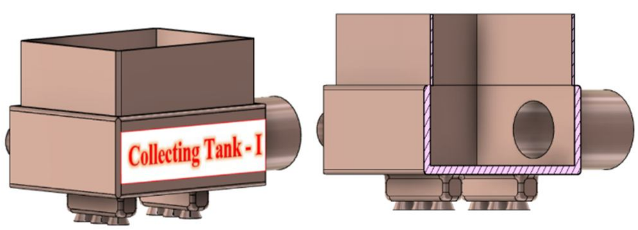

Figure 6: On left: Isometric View; On Right: Cross sectional View of Collecting

2) *Receiving Tank:* This is like Collecting tank but, instead of collecting the direct Greywater from different places such as (Houses, Industries…etc.), it will receive through some certain stages and will let go one this grey water for treatment plant (Same capacity as collecting tank).

Figure 7:On left: Isometric View; On Right: Connector Pipe for 2 Collecting tanks

3) *Screening and Grit Tank:* The Greywater passes through a screen to remove rags and large debris. The screening system washes and dewaters the debris before discharging it into a garbage can. The screened greywater then flows to an aerated grit chamber that facilitates the sedimentation of heavier inorganic materials, such as sand and grit, by reducing the velocity of the greywater. The grit chamber is aerated to increase the dissolved oxygen content of the wastewater, which supports the aerobic biological process used later in the treatment system. The material collected at the bottom of the grit vessel is removed by an auger and mixed with biosolids generated during the treatment process. Dimensions of tank (l x b x h = 200 x 250 x 100 mm); 5-Screening plates: (180 x 10 x 80 mm).

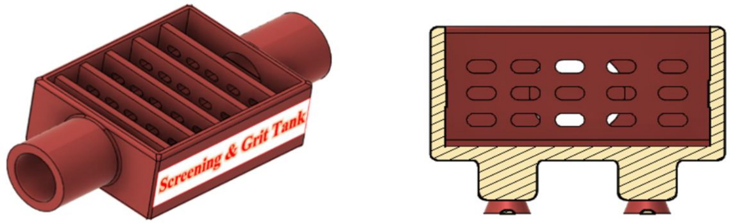

Figure 8: On left: Isometric View; On Right: Cross sectional Front View of the

4) *Skimming Tank:* A skimming tank is a chamber so arranged that the floating matter like oil, fat, grease, etc., rises and remains on the surface of the greywater (if any) until removed, while the liquid flows out continuously under partitions or baffles. It is necessary to remove the floating matter from sewage otherwise it may appear in the form of unsightly scum on the surface of the settling tanks or inter-fere with the activated sludge process of sewage treatment. It is mostly present in industrial sewage. In ordinary sanitary sewage, its amount is usually too small. So, instead replacing it with Oil filters (having that porosity can help in removing the dirt & oil floating at top and letting greywater pass into further stages). Dimensions of tank (l x b x h = 200 x 250 x 100 mm); Oil Filter: (circle dia 4mm, l x w = 90 x 220 mm).

Figure 9: On left: Isometric View; On Right: Hollow Cross sectional View of the Oil Filter w/ Skimming Tank

5) *Primary Sedimentary Tank:* The primary sedimentation process is basically a physical process utilizing gravitational forces. Settleable and suspended solids, which are the major components of sludge and are heavier than water, settle out of the sewage along with any grit carryover from the headworks. Scum, which is lighter than water, floats to the surface and is removed by skimming. Approximately 60 to 65 percent of the suspended solids will be removed by gravitational forces as part of primary sedimentation. Capacity of Tank: 2.5L to 5L; Sludge Area: 1000 mm2; 3-Screening plates: (180 x 10 x 80 mm).

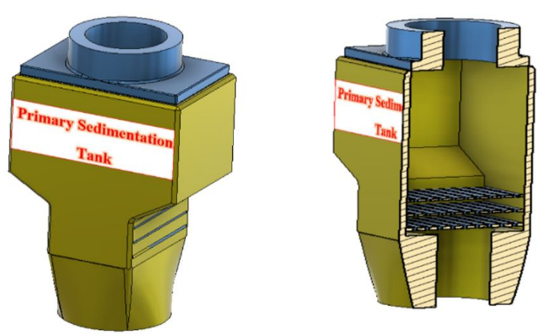

Figure 10: On left: Isometric View; On Right: Hollow Cross sectional View of the Primary Sedimentation Tank w/ Screening Tank

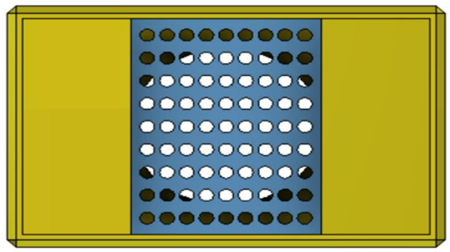

Figure 11: Top View of Primary Sedimentary Tank.

The circular primary sedimentation tanks have been installed and are arranged to operate in parallel. Either tank may be isolated for maintenance or repair purposes. The tanks are 6 feet in diameter with normal side water depths of 8 feet. Each tank has a mechanical scraper which rotates around the sloping bottom and pushes the sludge to a sludge thickening zone and a sludge sump.

6) *Aeriation Tank:* The aeration structures (basins) are designed to promote the growth of helpful bacteria which consume the nutrients in the sewage. This is called the "activated sludge" process. By injecting large amounts oxygenated air, these bacteria consume the urea, ammonia, carbohydrates, fats, etc. in the sewage and convert it into bacterial mass or "sludge." Dimensions of tank (l x b x h = 250 x 200 x 120 mm); w/ Aquarium pump so to infiltrate the aerobic process. All aeration tanks were modified with the anoxic zones and part of the MF/RO Project. Aeration in each basin is accomplished by air blowers feeding fine bubble diffusers at the bottom of each basin. Air flow is regulated by automatic dissolved oxygen (DO) control systems. The activated sludge process can be operated in several modes including complete mix or variations approaching conventional, step aeration or contact stabilization.

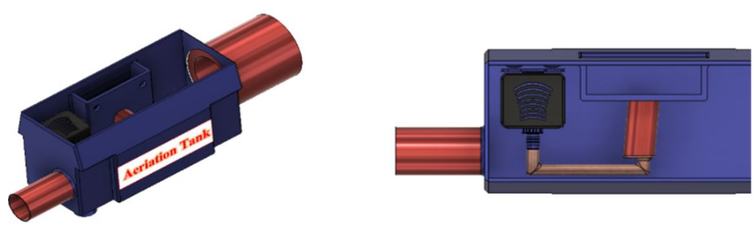

Figure 12: On left: Isometric View; On Right: Cross sectional Top View of the Aeration Tank w/ Aquarium Pump

7) *Secondary Sedimentary Tank:* Secondary Sedimentation Tank provides additional secondary sedimentation capacity during peak flows when the design maximum peak overflow rate of Tank is exceeded and provides a standby tank should Secondary Sedimentation Tank need servicing. A flap gate in each tank's wall allows floodwater inflow so the structure will not become buoyant and prevents wastewater outflow. The effluent from the Aeration tank enters each tank through the bottom, rises through the center column, and then is distributed into the sedimentation zone. Settled sludge is removed through collecting pipes located on the submerged collecting rake arms and by means of hydraulic differential flows to the sludge collection chamber near the top of the center column. Adjusting valves on the upper end of each collecting pipe can be set so the sludge removal is equalized throughout the tank. The sludge then flows back to the wet well in the Aeration tank, where it is pumped and divided into either RAS or WAS. Capacity of Tank: 2.5L to 5L; Sludge Area: 1000 mm2; 3-Screening plates: (180 x 10 x 80 mm), Sludge Tank:(50 x 40 x 80mm).

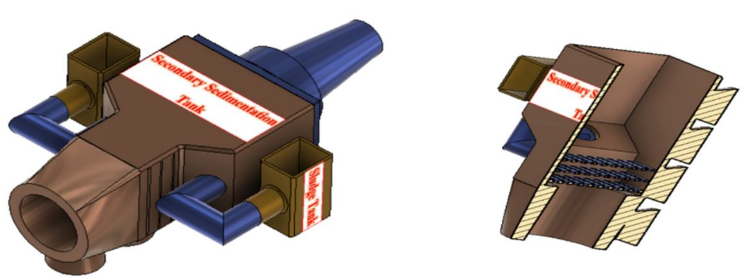

Figure 13: On left: Isometric View; On Right: Hollow Cross sectional View of the Secondary Tank w/ Screening System and Sludge Tank.

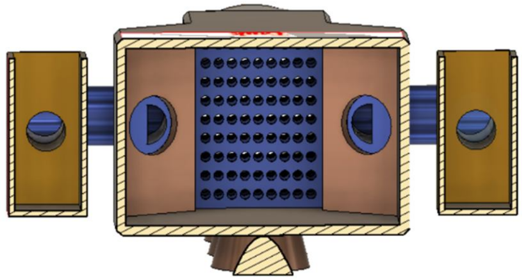

Figure 14: Cross sectional Top View of the Secondary Sedimentary Tank w/ Sludge Tank

8) *Filtration Tank:* Filtration is an important stage when treating water. Firstly, multiple methods of pre-treatment are common. This could include flocculation, coagulation, and sedimentation.

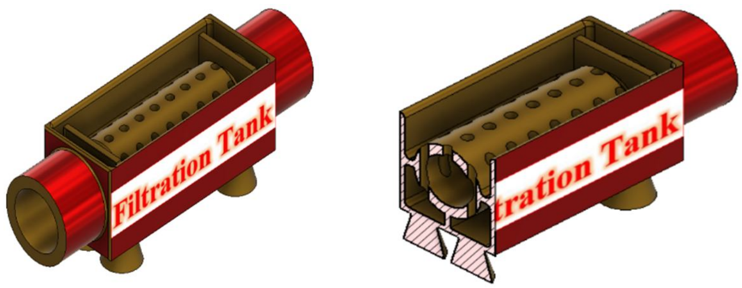

Figure 15: On left: Isometric View; On Right: Cross sectional View of the Filtration Tank w/ Filter Cartridges

Following pre-treatment, various forms of water filtration can be used**.**
For fine screening, drum filters and disc filters are common. They remove suspended solids from the water and polish effluent from wastewater treatment plants. Should media filtration be chosen, pressure gravitational filters can be used. These work by the media forming a barrier to the passage of suspended solids, absorbing some compounds contained in the liquids. Finally, membrane technologies can be used. These include ultrafiltration, microfiltration, nanofiltration, and reverse osmosis. They will retain different sizes of particles and ions, whilst allowing pure water to flow through. It is also wise to use water filter cartridges. Acting as protection barriers, they retain solids and particles upstream. Capacity of Tank: 2.5L to 5L; Sludge Area: 1000 mm2; (Filter Cartridges: Cylindrical in shape).

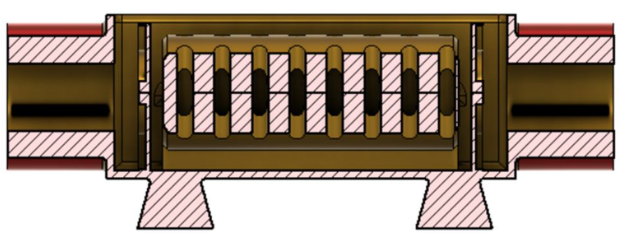

Figure 16: Front View of Filtration Tank w/ Filter Cartridges

9) *Disinfectant Tank:* Feed pump will pump the grey water from raw water tank at site through self-cleaning filters and will flow through multimedia filter followed by activated carbon filter where odor, traces of hydrocarbon etc. are removed. The exhausted multimedia and activated carbon filters are backwashed with treated grey water using backwash duty pump. The filtered grey water is thus disinfected by an appropriate automatic chlorine dosing system. Additionally, ozone/ Ultraviolet (UV) sterilizer can be integrated depending on the application requirement. Treated grey water is then transferred and stored for further use. **Capacity of Tank:** 2.5L to 5L; Sludge Area: 1000 mm2; **Dimensions: dia-240mm, 320mm**

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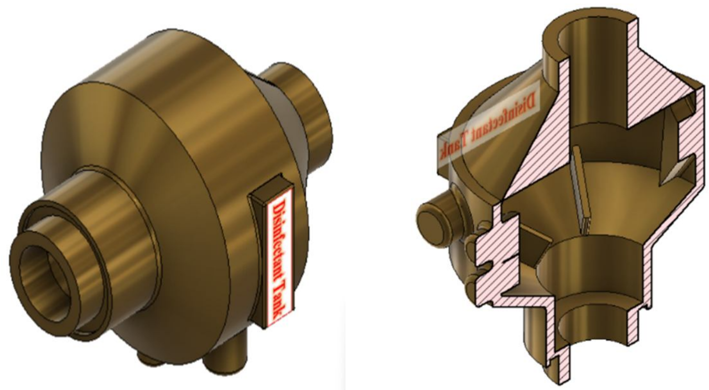

Figure 17: On left: Isometric View; On Right: Hollow Cross sectional View **of the** Disinfectant Tank w/ Rotating Drum Blades

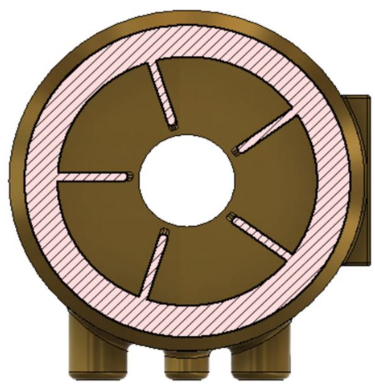

Figure18: Top View of Disinfectant Tank w/ Sludge Rotary Blades.

10) Distribution Tank

Treated grey water and rainwater shall be distributed by:

a) Pumping from the storage tank directly to the point of use

b) Pumping from the storage tank to intermediate storage tanks or cisterns near the point(s) of use

c) Supplying by a gravity storage tank or cistern, where feasible. Distribution systems should be designed and constructed such that the overall storage time of reclaimed water does not result in unacceptable reduction in water quality. Header tanks for toilet flushing should not be oversized. Capacity of Tank: 2.5L to 5L; Dimensions: (l x b x h = 250 x 200 x 120 mm); Distribution Plates/ Compartments: (180 x 10 x 80 mm)

Figure 19: On left: Isometric View; On Right: Cross sectional View of the Distribution Tank w/ Section planes

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11) *Connector Pipes:* There are 4 Connector pipes used and dimensions are as followed:

Figure 20: On left: Connector Pipe for Receiving Tank; On Right: For Skimming Tank.

Dimensions for Left: Diameter 90mm, l x b = 300 x 280 mm
Dimensions for Right: Diameter 90mm, l x b = 70 x 220 mm

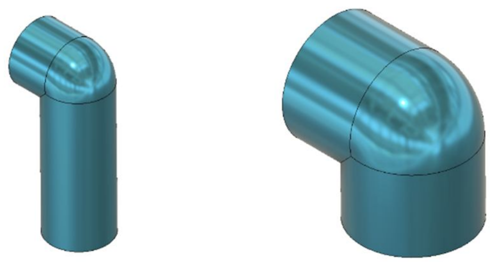


Figure 21: On left: Connector Pipe for Primary Sedimentary Tank; On Right: For Container Tank

Dimensions for Left: Diameter 90mm, l x b = 70 x 220 mm
Dimensions for Right: Diameter 90mm, l x b = 70 x 70 mm.

12) *Grey Water Treatment Plant:* Greywater systems rely on plants and natural microorganisms to treat the water to a very high standard so that it can be safely re-used. The main advantage with these types of systems is that they treat the greywater naturally and enhance the local environment because of the attractive plants used and the fauna attracted to them. There are other natural systems available to treat greywater. The type of system selected will depend on the specific application, and selection would be considered on a case-by-case basis.

Figure 22: Front View of Grey Water Treatment Plant.

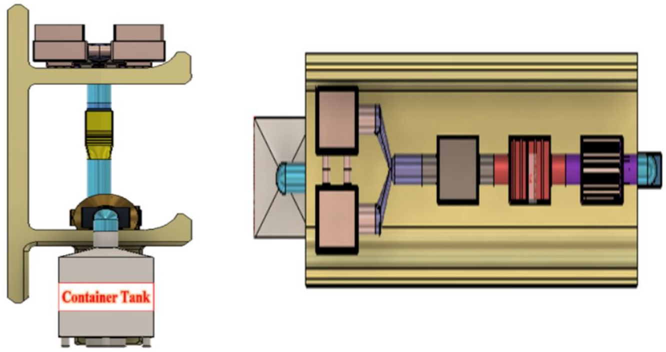


Figure 23: On Left: Side View, On Right: Top View of Grey Water Treatment Plant.

VII. EFFICIENCY

The effectiveness of the developed Optimized Model determined by carried out physio-chemical analysis on the filter-treated water samples at regular intervals of ten days. In the physic-chemical analysis, three different greywater samples were used.

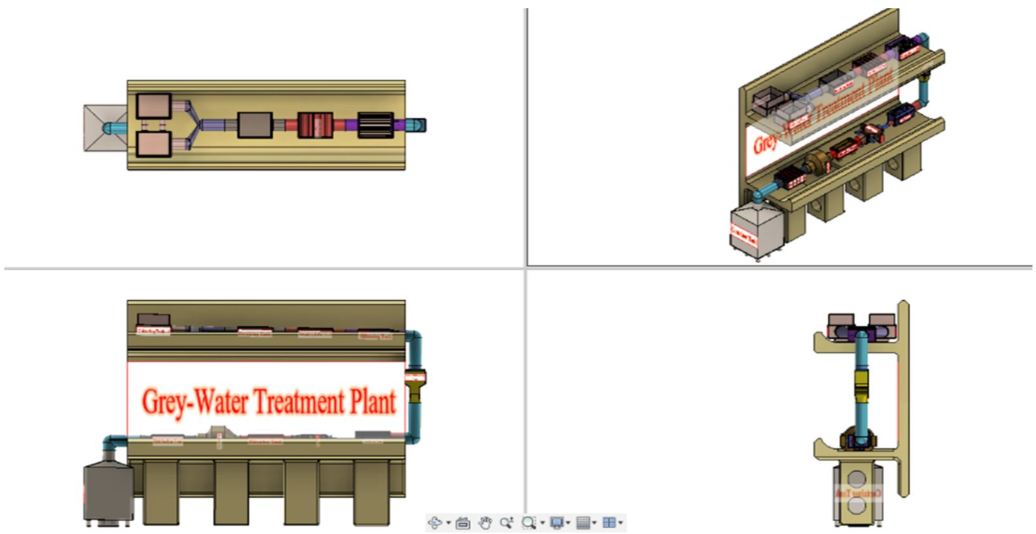
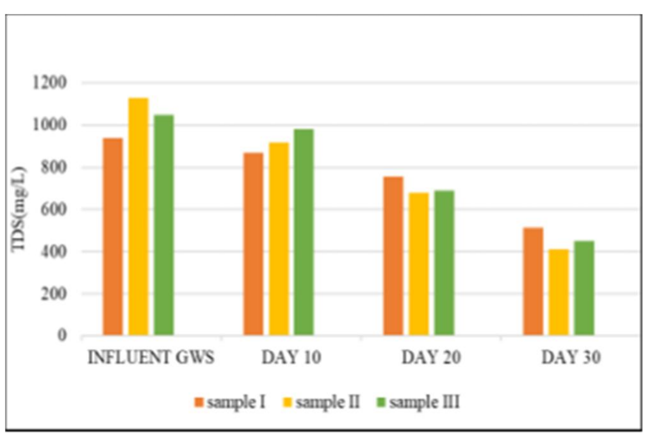


Figure 24: Final Optimized Model Views of Grey Water Treatment Plant.



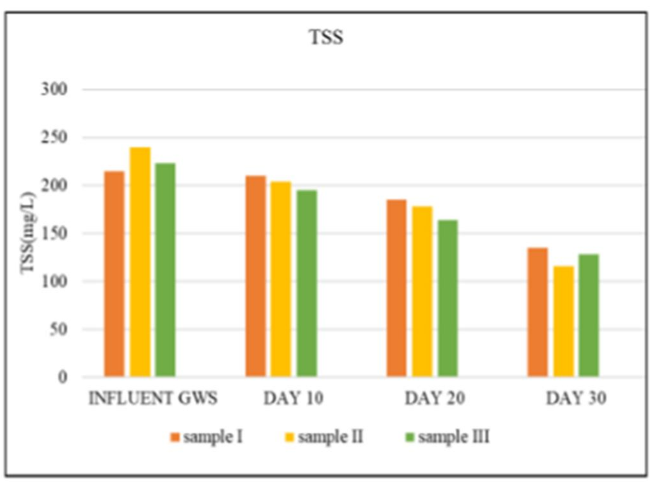
Graph 1: Variation in TDS value

Figure 12: Bio-bed filter setup process incl in Grey Water Treatment Plant.

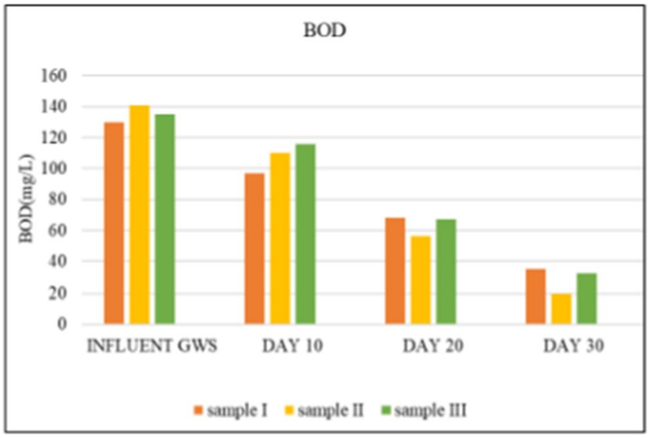
PARAMETER	UNITS	DAY 10	DAY 20	DAY 30
pH	-	8.02	7.92	7.8
EC	µS/m	950	630	540
TDS	mg/L	870	756	515
TSS	mg/L	215	185	135
BOD	mg/L	97	68	35
COD	mg/L	285	174	87.2

Table 3: Water test results after filtration

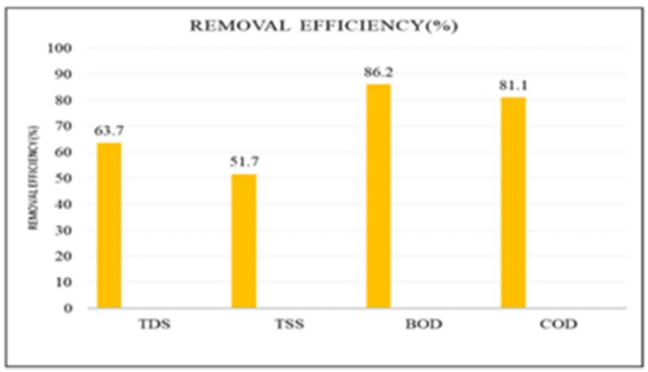
1) *Calculation of Removal Efficiency:* The removal efficiency of the following physic-chemical parameters is analyzed, and the values are tabulated below. Sample II showing the maximum removal efficiency of various parameters. Removal efficiency was found to be 63.7 % for TDS 51.7 % for TSS and in bio-bed filter. Also, the removal efficiency for BOD and COD were found to be 86.2 % and 81.1 %.



Graph 2: Variation in TSS value



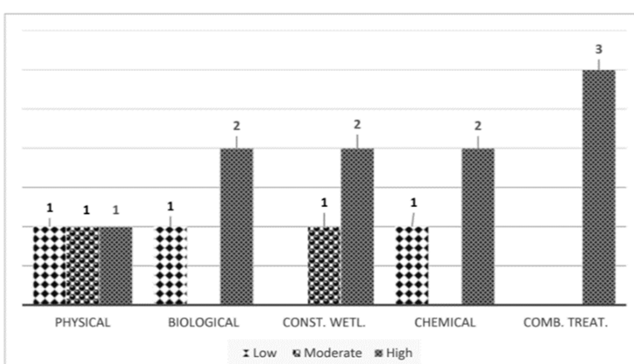
Graph 3: Variation in BOD value.



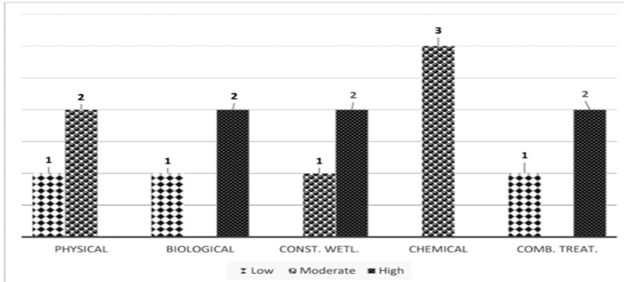
Graph 4: Variation in removal efficiency

VIII. COMPARING ANALYSIS OF GREYWATER TREATMENT TECHNOLOGIES FOR REUSE

Treatment methods investigated to treat GW may be categorized as physical, biological, chemical, constructed wetlands and combined treatment. Various studies have been examined to develop an understanding on the treatment of GW and BOD and COD removal to compare the treatment efficacy of these technologies. Removal has been categorized as low: < 61%, Moderate: 61–80%, High: >80% for ease of understanding in Graph 5 and Graph 6 showing BOD and COD removal respectively. After a detailed literature review, only those type of studies has been considered which provide comparative data for removal of both BOD and COD. It is seen from the figures that BOD removal by Physical method is low while for biological, constructed wetland and chemical method, it is low to moderate. Highest degree of BOD removal can be achieved by combining various individual treatment methods to form a treatment scheme. However, for highest level of COD removal is achieved by chemical methods while rest all methods can successfully remove low to moderate level of COD.



Graph 5: Variation in BOD removal using different technologies.



Graph 6: Variation in COD removal using different technologies

IX. APPLICATIONS OF GREY WATER

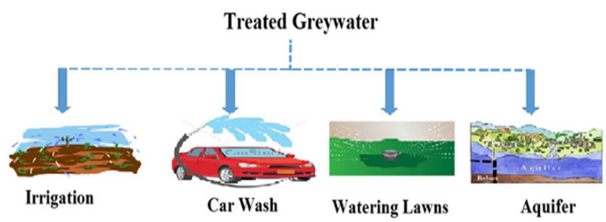


Figure 13: Applications of treated greywater.

This study motivates a new outlook toward the large-scale benefit, i.e., the rate of water scarcity could be reduced, and sustains the water for future generations, since the available freshwater in Kuwait is very limited and considered as a strategic reserve. The treatment unit is user-friendly and can be installed in every house, and the treated greywater is suitable for car washing, irrigation, watering lawns, and recharge of aquifers (Fig. 2). Finally, the study illustrates that the gravity-governed filtration is eco-friendly, economically viable and as effective as other existing expensive methods.

1) Greywater includes water from showers, bathtubs, sinks, kitchen, dishwashers, laundry tubs, and washing machines.
2) The major ingredients of gray water are soap, shampoo, grease, toothpaste, food residuals, cooking oils, detergents, hair etc. In terms of volume, gray water is the largest constituent of total wastewater flow from households.
3) In a typical household, 50-80% of wastewater is gray water, out of which laundry washing accounts for as much as 30% of the average household water use.
4) The key difference between gray water and sewage (or black water) is the organic loading. Sewage has a much larger organic loading compared to gray water.
5) In applications which do not need drinking water quality such as industrial, irrigation, toilet flushing and laundry washing. This will, in turn, reduce freshwater consumption, apart from wastewater generation.
6) Community benefit in reducing demands on public water supply.

A. Advantages

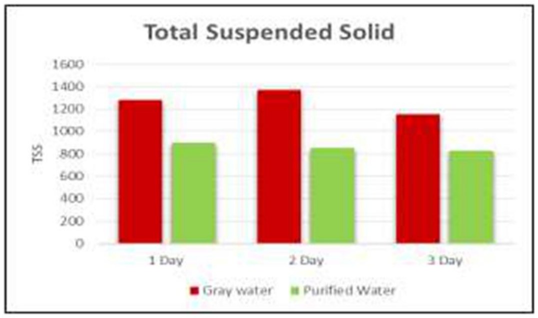
1) *Demand Outpacing Supply:* Cities like Hyderabad, Chennai has a supply for three million people; however, demand is equivalent to 8 million people.
2) *Water Contamination:* Bacteriological, nutrients, chlorides limiting supply.
3) *Industry Expansion:* States around great lakes using availability of water to attract industry.
4) *Save Money:* Mumbai uses 15 percent of energy for water/wastewater and the price of water increasing.
5) *Environmental Responsibility:* It is the right thing to do
6) *An average Indian uses about 160 gallons of water each day and 25 percent of the water entering the home is used to flush toilets:* An ideal use for treated greywater.
7) *Up to 50 Percent of all Water is used for Irrigation:* Another ideal use for treated greywater.

B. Disadvantages

1) Dual plumbing is required to accommodate reuse and source separation (greywater/blackwater).
2) Must prevent inappropriate substances going down the drain.
3) Health risks — avoid potential for contact and/or ingestion.
4) Environmental risks are not easily evaluated — minimize cumulative impacts.

X. RESULTS

1) Total Suspended Solids

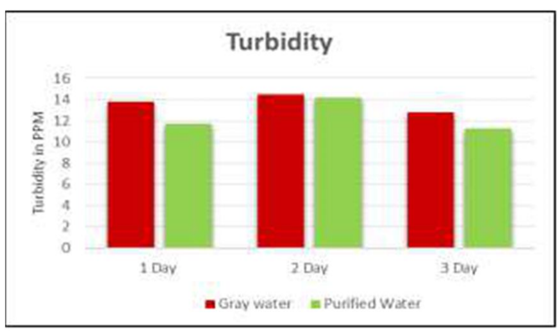


Graph 7: Total Suspended Solid.

Sr.No.	Sample Of Grey Water	Total Suspended Solid	
		Gray water	Purified Water
1	1 Day	1280	900
2	2 Day	1372	850
3	3 Day	1150	825

Table 4: Total Suspended Solid

2) Turbidity

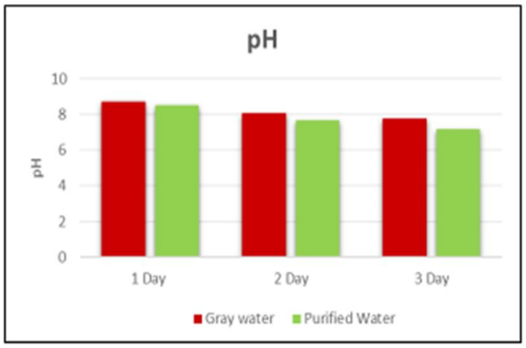


Graph 8: Turbidity

Sr.No.	sample of grey water	Turbidity	
		Gray water	Purified Water
1	1 Day	13.8	11.7
2	2 Day	14.5	14.18
3	3 Day	12.8	11.25

Table 5: Turbidity

3) pH Determination

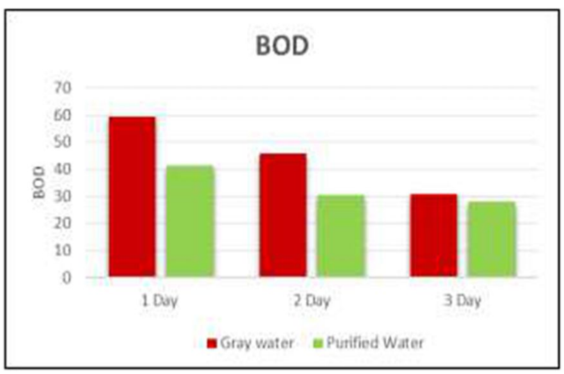


Graph 9: pH Determination

Sr.No.	sample of grey water	pH	
		Gray water	Purified Water
1	1 Day	8.7	8.5
2	2 Day	8.1	7.7
3	3 Day	7.8	7.2

Table 6: pH Determination

4) Biological Oxygen Demand

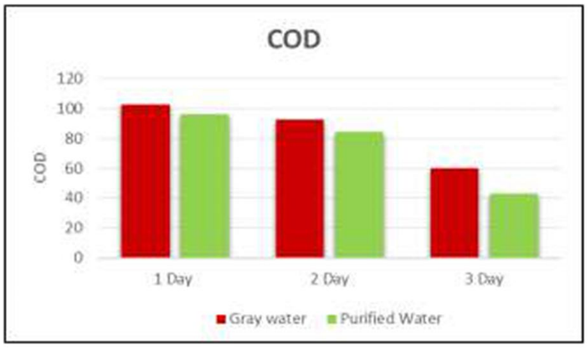


Graph 10: Biological Oxygen Demand

Sr.No.	sample of grey water	BOD	
		Gray water	Purified Water
1	1 Day	59.4	41.2
2	2 Day	45.7	30.5
3	3 Day	30.6	27.9

Table 7: Biological Oxygen Demand

5) *Chemical Oxygen Demand*



Graph 11: Chemical Oxygen Demand

Sr.No.	sample of grey water	COD	
		Gray water	Purified Water
1	1 Day	102.9	96.4
2	2 Day	92.3	84.2
3	3 Day	60.23	42.8

Table 8: Chemical Oxygen Demand

XI. CONCLUSION

The benefits of Grey Water recycling are to reduce the use of freshwater, lessen the strain on septic tanks or treatment plants, more effective purification, reduction in use of energy and chemicals, groundwater recharge, plant growth, reclamation of nutrients, increased awareness of, and sensitivity to natural cycles. The recycled grey water can be reused for toilet flushing and gardening. Grey water is typically alkaline due to soaps & detergents but after treatment pH of grey water is decreases up to 7.5. It removes turbidity with efficiency up to 92%. It removes BOD load with efficiency of 95%. The Adaptations and Optimizations of Greywater Treatment Design proved to be economical.

XII. FUTURE SCOPE

In the above design for “Grey Water Treatment Systems”, having deeply recognized the need for more advancements in this treatment, I hope to design & implement the newest technologies like the **pH Tank** in this system for reusing grey water for drinking purposes, which helps us to boon the stronger social commitment towards welfare & development for the society. Moreover, I hope to advance towards the developments and adjustments for more efficient management for Greywater Treatment Systems in Future.

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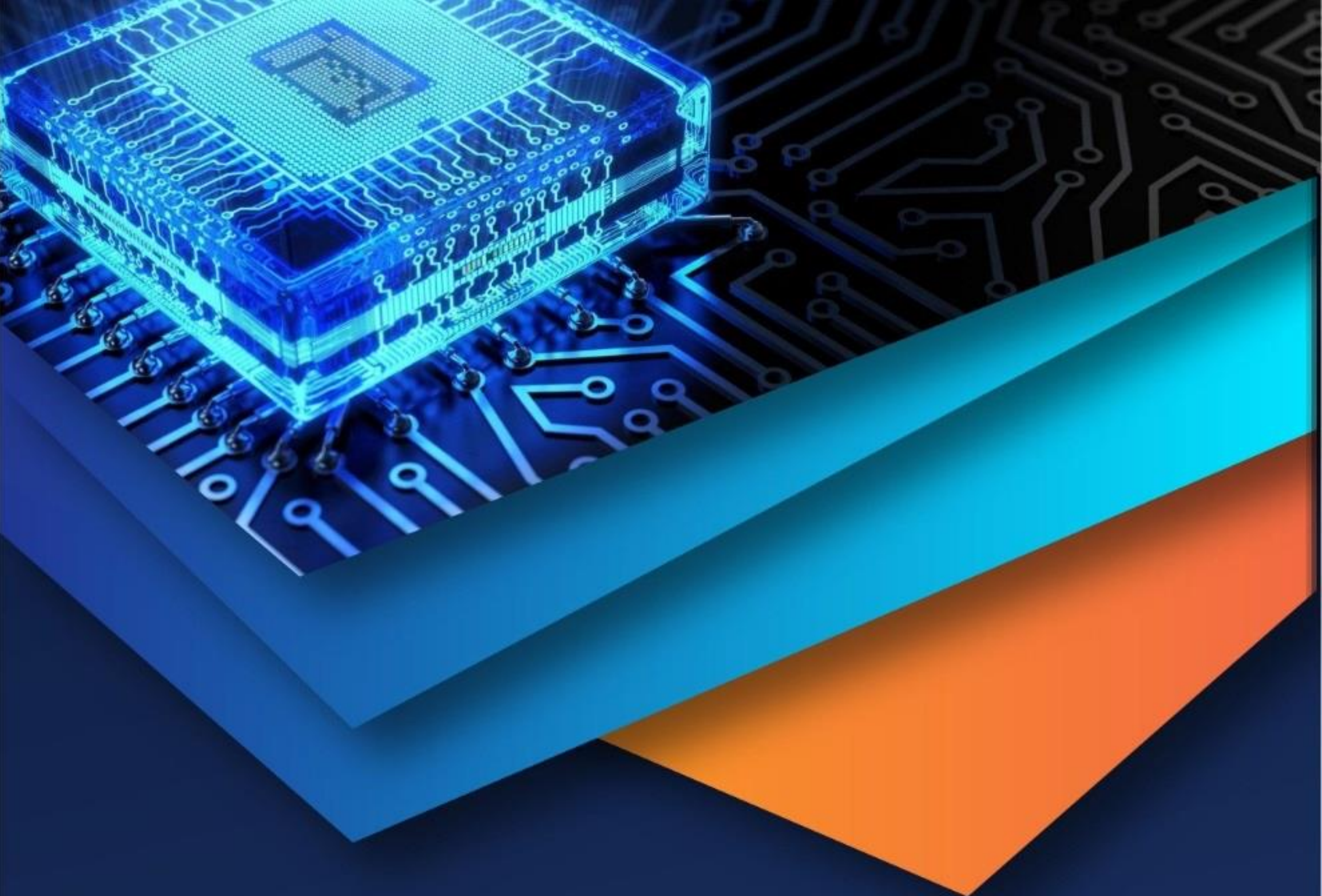

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