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Study on Gray Water Treatment and Reuse for Secondary Purpose

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Abstract: Freshwater scarcity is a serious issue that affects at least one-fifth of the world's population and more will be affected due to population growth, mismanagement, increased urbanization and climate change. Innovative concepts and technologies are straight away needed to close the loop for water. Gray water reuse is one of the main alternatives for reducing potable water consumption in households, industries and commercial buildings. This article aims to review some of the principle gray water treatment technologies and their applications. A water recycling system that can be used for reclaiming and recycling water, waste water, or grey water, for providing landscape irrigation, or for recycling uses such as for sanitary facilities, as well as for pre-heating clean water to save energy. A water recycling system may include a sealable tank, an influx pipe, a self-clearing filter disposed within the tank, a pump, and an effluent pipe.

In our project, we have carried out experimental work for reuse of gray water. Hence we have design Biofilter and studied influent and effluent parameters and treated gray water was used for irrigation in Barbodhan village.

Keyword: Gray water, treatment, recycling water.

I. INTRODUCTION

Gray water is all waste water generated in households or office buildings from streams without fecal contamination. Grey water also known as sullage, is non-industrial waste water generated from domestic processes such as washing dishes, laundry and bathing. Grey water comprises 50-80% of residential waste water. Grey water is different than black water in the amount and composition of its chemical and biological contaminants. Grey water gets its name is come from its cloudy appearance and from its status as being neither fresh nor heavily polluted. Essentially, any water, other than toilet wastes, draining from a household is grey water. This used water may contain grease, food particles, hair and any number of other impurities; it may still be suitable for reuse. Reusing grey water serves two purposes: it reduces the amount of fresh water needed to supply a household, and reduces the amount of waste water entering sewer or septic systems. Grey water is domestic waste water that is collected from dwelling units, commercial building and institutions of the community. It may include process waste water of industry (food, laundries etc.) as well as ground infiltration and miscellaneous waste liquids. It is primarily spent water from building water supply to which has been added to the waste effluent of bathrooms, kitchens and laundry. Domestic waste water is the spent water from the kitchen, bathrooms and laundry. Some of the minerals and organic matter in the water serve as food for saprophytic micro-organism and hence the waste water is unstable bio degradable reduction of relative dependence on potable water usage is becoming a necessary facet of good water management.

II. LITERATURE REVIEW

A. Amr M. Abdel-Kader (2012) [1], reported that the treatment efficiency of the RBC system based on BOD removal was ranged between about 93.0% and 96.0%, and based on TSS removal was ranged between about 84.0% and 95.0% for all concentrations of influent grey water.
B. Bhausaheb L. Pangarkar, et.al . (2010) [2], investigated the economical performance of the plant for treatment of bathrooms, basins and laundries grey water showed in terms of deduction competency of water pollutants such as COD (83%), TDS (70%), TSS *83%), total hardness (50%), oil and grease (97%), anions (46%) and captions (49%).The authors suggested that this technology could be a good alternative to treat grey water in residential rural area.
C. Dr. Mark Pidou et.al. (2007) [3], reported a review of existing technologies and application collating a disparate information bas and comparing strength and weaknesses of different approaches. The best overall performance is observed within the scheme combining different type of treatment to ensure effective treatment of all the fractions.
D. S. Lambe et.al. (2013)[4], reported that with increased population growth and development, there is a need to critically look at alternative approaches to ensure water availability. These alternative resources include rain water and bulk of a water used in

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household will emerge as grey water and contain some minerals, organic waste materials dissolved and suspended in it. The authors suggested to intercept this grey water at the household level, treat it so that it can be recycled for garden washing and flushing purposes.

E. National Environmental Engineering Research Institute (NEERI) and UNICEF (2007) [7], National Environmental Engineering Research Institute (NEERI) Nagpur and UNICEF Bhopal, Madhya Pradesh have developed, implemented and evaluated grey water reuse systems for small buildings (schools) in rural areas. NEERI has developed grey water treatment system as primary treatment (screening and equalization tank) followed by secondary treatment-I (gravel filter and sand filter) and secondary treatment-II(broken brick, charcoal, chlorination)for treatment of grey water at a tune of 1000-2000 l/day from hostels, schools and residential complexes . The drive for this technology was undertaken due to decreasing availability of water, lowering of groundwater table and increase in fluoride concentration in groundwater.

F. Saroj B. Parjane et.al (2011)[6], presented the finest design of laboratory scale grey water treatment plant, which is a combination of natural and physical operation such as primary settling with cascaded water flow, aeration, agitation and filtration, hence called as hybrid treatment process. The economical performances of the plant were investigated for treatment of bathroom, basins and laundry grey water. The author worked out cost benefit analysis of the system on the large scale and found more effective process in the rural region.

G. Sam Godfrey, et.al.(2009) [8], presented grey water treatment and reuse system in residential schools in Madhya Pradesh, India and treated grey water used for toilet flushing and irrigating the food crops. In this study the cost-benefit analysis was undertaken for grey water reuse by considering internal and external costs and benefits. The analysis carried out indicates that the benefit exceeds the cost of the system.

H. Kamal Rana et. al. (2014)[10], presented some efficient, cheap and sustainable grey water treatment system for households the authors reviewed the processes to identify the best suited processes at household and community level. Septic tank, constructed wetlands and intermittent sand filter are identified as the most suitable processes for decentralized treatment due to the simple operation and maintenance facilities as well as cost effectiveness of the systems.

III. OBJECTIVES

This project research is carried out to serve the following objectives:

A. Collection of domestic gray water.
B. Study of characteristics of Gray water.
C. Experimental study for treatment of gray water and check its feasibility for reuse.
D. Design of irrigation system for reuse.

IV. MATERIALS AND TOOLS

We have designed Biofilter to carry out experimental work.
For design of treatment unit we required following materials:

A. Coarse Aggregate or mixed well stone
B. Crushed Aggregate
C. Fine sand

Coarse aggregate of size 20-60mm size, Crushed aggregate of 2-5 mm size & fine sand having0.075 to4.75 mm. These size of materials are required to trap the different size of impurities or total suspended solids. Grasses like cattails are also useful to for microbiological activities.

Coarse Aggregates Crushed Aggregates Fine sand
FIG: 1 Material used

V. PROTOTYPE OF BIOFILTERATION UNIT

For checking the characteristics of gray water we have taken 60 liter container, and make filtration unit having base of mixed stone aggregate (20-60mm) of thickness 100mm, Crushed Aggregate (2-5 mm) of thickness 120 mm and fine sand (0.075-4.75 mm) of thickness 150 mm as shown in figure. Thickness of the top layer is more as compared to other layers as to trap mostly all impurities or suspended solids & in base layer void ratio is higher so water can stored in that layer. As it is bio filter a layer of grass is provided for microbial activities and for aeration. All material used are washed &dried properly before placing. The prototype was kept outdoors in order to imitate the effects of the local arid weather conditions. The prototype was fitted with an outlet faucet at the bottom. Back wash had to be done to remove any contaminant left over from the grey water and to rewash the biggest layer in the unit, which is the sand layer that have decomposed organic materials and other contaminants. **Bathroom grey water** (bath, basin and shower) contributes approximately 50% of the total grey water volume. **Laundry grey water** contributes approximately 30% of total grey water volume. **Kitchen wastewater** contributes 20% of total gray water volume. Water collected from all the sources are mixed thoroughly and allow to passing through the bio filter, after 24 hours water is collected from bottom of the container and sample were tested by laboratory experiments.

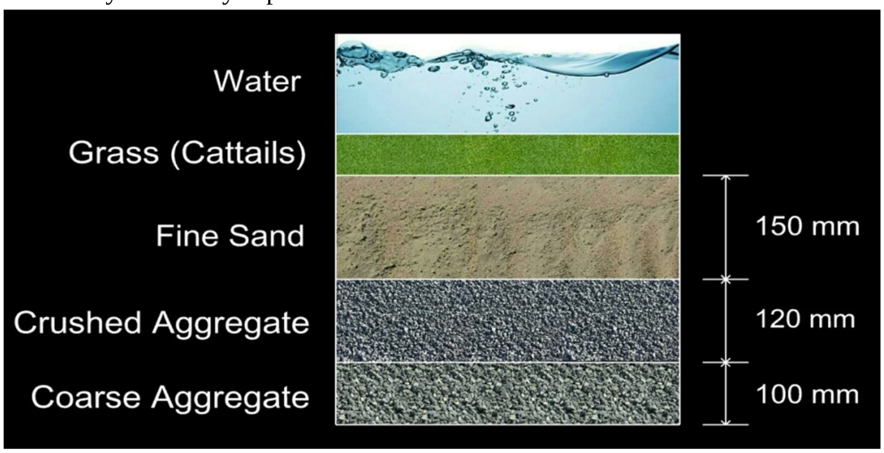

FIG:2 Prototype of Bio filtration

A. Design Of Biofilter

1) Slow sand filter
2) Let half an hour be lost in washing, cleaning and returning to the service after 24 hours.
3) Total time of working will be =24-0.5=23.5 hours
4) 0.6% water is required for washing of the filter every day.
5) Discharge Q=6000 Liter/day (No. of household =6 & 5 person per family)
   Let, no. of filtration unit=1
6) Quantity water to be treated per hour
   $= \frac{6000 \times 1.006}{23.5}$
   $= 256.85 \, liters / hour$
7) Assume Rate of filtration= $100 \, liter / m^2 / hour$
8) Filter area required $= \frac{256.85}{100} = 2.56 \, m^2 \approx 3 \, m^2$
   Let, H =1.5m
   L=1.5B
   1.5B×B=3
   B= 1.22 m ≅ 1.5 m
   L=2.25 m ≅ 2.30m
   Take, H=1.5m, L=2.30m, B=1.5m

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VI. OBSERVATION MATRIX

The data of two household having 5 persons per house and average value of water consumption for any purpose is taken in consideration.

TABLE I
Data Collection

Personal water uses	Average time required (min)	Flow rate (L/min)	Amount of water per end use, Q (Liter)	Frequency of use, F (per person per day)	Average water consumption (Lpcd)
Bath	12	5	60	1.4	84
Tooth Brush	2.6	1.9	5	1.2	6
Hand wash	1	3	3	4.9	15
Face wash	0.6	8	5	2.8	14
Family water use					
Dish wash	-	-	33	4.5	15
Laundry	-	-	100	1(7 per week)	10
Total					144

As per IS: 1172-1993, the minimum domestic consumption for a town or city with full flushing system should be taken as 200 l/h/d.

VII. EXPERIMENTAL WORK

A. Following test are performed in laboratory to check the gray water parameters before and after the treatment.

1) pH
2) Turbidity
3) Biological oxygen demand (BOD)
4) Chemical Oxygen demand (COD)
5) Total Suspended solids (TSS)

B. Results of experimental work

TABLE II
RESUTLS

Sr No.	Parameters	Sample-1		Sample-2		Sample-3		Sample-4		Sample-5	
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1.	pH	5.1	7.1	5.0	6.9	5.5	7.5	5.0	7.1	5.3	7.4
2.	Turbidity(NTU)	4.0	2.0	3.88	1.6	3.0	1.2	3.5	1.4	3.64	1.45
3.	BOD (mg/l)	35	8.0	42	14.5	43	16	40	12	38	10
4.	COD (mg/l)	405	110	394.2	108	420	125	390	100	410	112
5.	TSS (mg/l)	200	78	195	75.8	180	70	204	79	186	72.4

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VIII. DESIGN OF IRRIGATION SYSTEM

The Study is carried out in the Barbodhan village for work. Barbodhan village is located in Olpad Tehsil of Surat district in Gujarat, India. The total geographical area of village is 1421.6 hectares. There are 785 households. Barbodhan has a total population of 3,358 peoples.

FIG: 3 Barbodhan village

Design for residence near by Barbodhan village
The total discharge of gray water from 6 residence=6000liter/day.
Two pipe line system of plumbing is provided in every residence

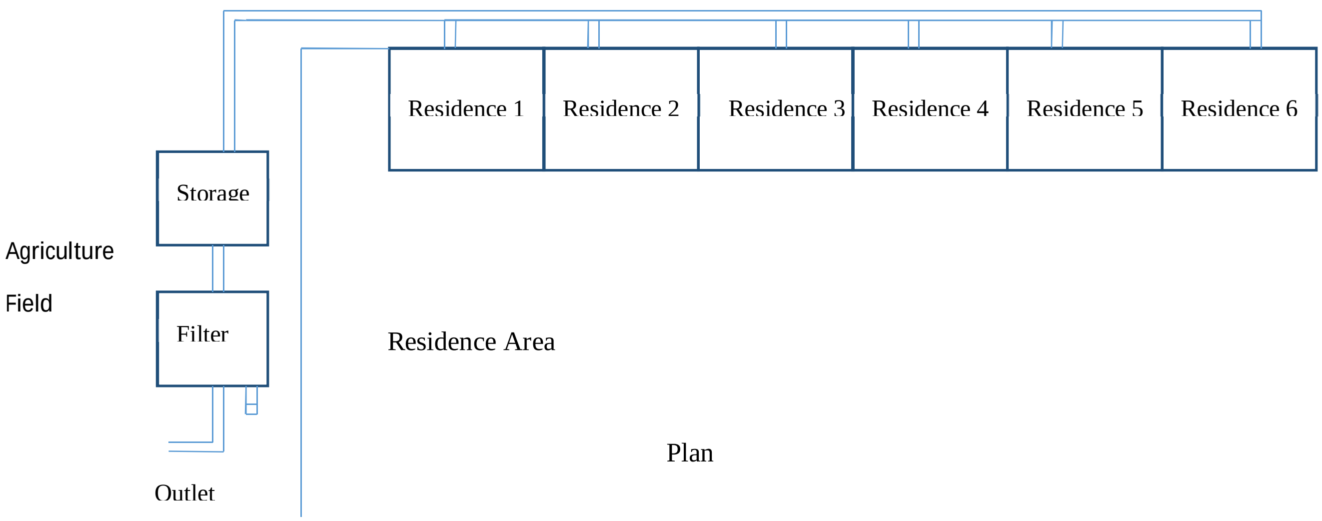

FIG: 4 Arrangement of collection, storage, filter and supply unit

Weekly irrigation (gal/wk) = A (sqft) × Etlawn(in.)×ks × 0.62 [11]
Where,
A is the area needing irrigation
ETlawn is the weekly evapotranspiration rate
Ks is the species factor (ex: percentage of the ETlawn) and
0.62 is the conversion from inches of water to gallons.
From 6 Residence total Gary water generation =6000liter/day
Area of irrigation: 20,000 sq feet
Vegetation: Vegetables
Weekly irrigation = 20000×1 inch×0.75×0.62
=9300×0.541 liter/day
Daily irrigation = 5031.3 liter/day≈5100 liter/day

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Area to be irrigated=37.2m×50 m
Discharge require for irrigation=5500liter/day
Let assume that water is to be supply for 3 hours
Economic Diameter of main pipe:

$$Q = \frac{5500 \times 10^{-3}}{3 \times 60 \times 60} = 5.09 \times 10^{-4} m^3 / s$$

$$D = 1.22\sqrt{Q} = 1.22\sqrt{(5.09 \times 10^{-4})} = 30mm$$

$$\therefore Q = A \times v$$

$$\therefore 5.09 \times 10^{-4} = \frac{\pi}{4} \times (0.03)^2 \times v$$

$$\therefore v = 0.7m / s$$

Let, Discharge is constant at every junction
Diameter of lateral pipe =Half of Diameter of main pipe = 15mm

$$\therefore Q = A_1 v_1 = A_2 v_2$$

$$\therefore \frac{\pi}{4} \times (0.03)^2 = \frac{\pi}{4} \times (0.015)^2 \times v_2$$

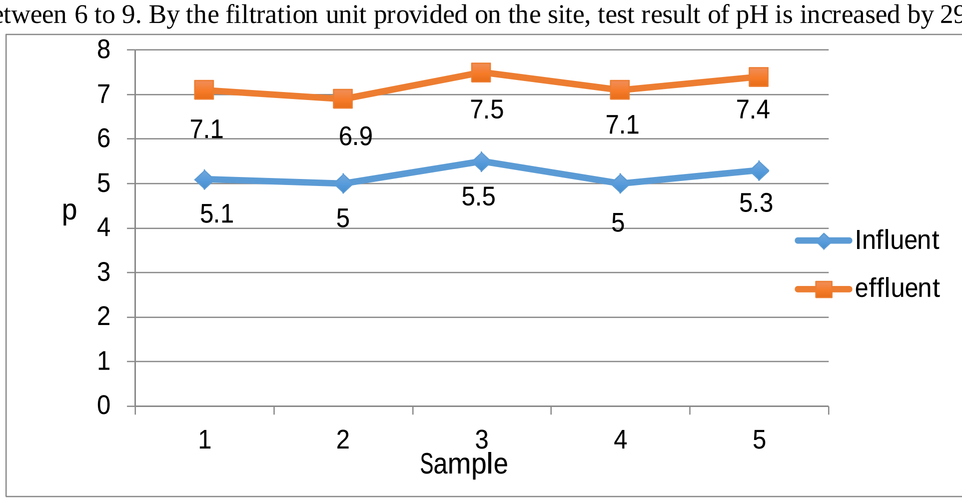
$$\therefore v_2 = 2.6m / s$$

Let spacing of laterals be 2m c/c
No. of lateral required= $\frac{37.2}{2} = 18.6 \approx 19\ nos.$ on each side.
Total no. of laterals required 2×19=38 nos.
Now, length of lateral= $\frac{50}{2} - \frac{0.03}{2} = 24.98m$
Perforation (Emitters) are provided at 1.5m c/c
Diameter of perforation =10 mm
No. of emitters per lateral= $\frac{24.98}{1.5} = 16.66 \approx 17$

IX. RESULT AND CONCLUSION

A. Result of pH

The pH level in the gray water of different samples was found to increase from 5.1 to 7.2, 5 to 6.9, 5.5 to 7.5and 5.3 to 7.4 so the average value of pH is 7.2 after 1 day of retention in the vegetative system. This satisfies the CPCB criteria that the value of pH for effluent should be between 6 to 9. By the filtration unit provided on the site, test result of pH is increased by 29%.



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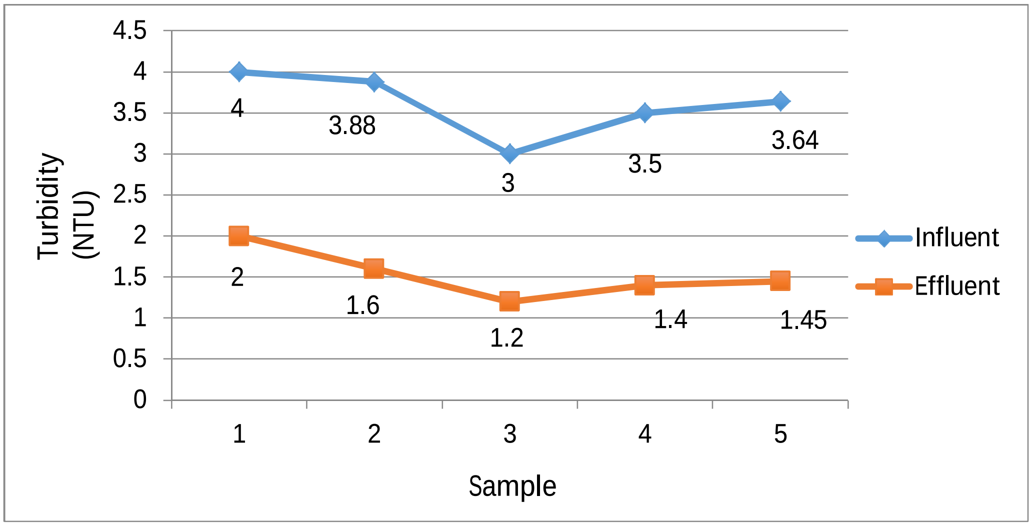
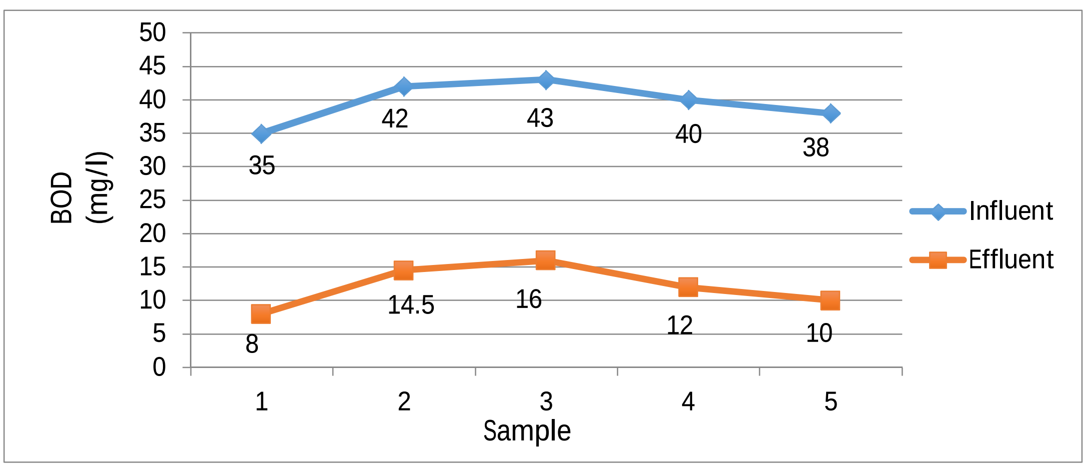
B. Result of Turbidity

The turbidity of greywater was observed to fall sharply after 1 day retention by 4 to2, 3.88 to 1.6, 3 to 1.2, 3.5 to 1.4 and 3.64 to 1.45(NTU). The maximum allowable turbidity limit is 2 NTU. It was observed that the removal of turbidity from grey in the bio filtration system does not depend on greywater sources and vegetation features. This is because turbidity results from suspended solids and they adsorbed or settled into the bio filtration filter media (sand). By the filtration unit provided on the site, test result of turbidity is reduced by 60%.



C. Result of BOD

The efficiency of vegetative systems was found excellent in removing the BOD from the greywater. After one day of retention, the vegetative system removed the BOD from 35 to 10, 42 to 14.5,43 to16, 40 to12 and 38 to10 (mg/l).The maximum allowable limit for BOD is 30 mg/l according to CPCB. This indicates that system is very efficient in lowering the greywater BOD level after 24 hours of retention period. By the filtration unit provided on the site, test result of BOD is reduced by 70%.



D. Result of COD

The efficiency of vegetative systems was found excellent in removing the COD from the greywater. After one day of retention, the vegetative system removed the COD from 405 to 110, 394.2 to 108,420 to 125,390 to 100 and 112 (mg/l). The maximum allowable limit for COD is 250 mg/l according to CPCB. This indicates that system is very efficient in lowering the greywater COD level after 24 hours of retention period. By the filtration unit provided on the site, test result of COD is reduced by 73%.

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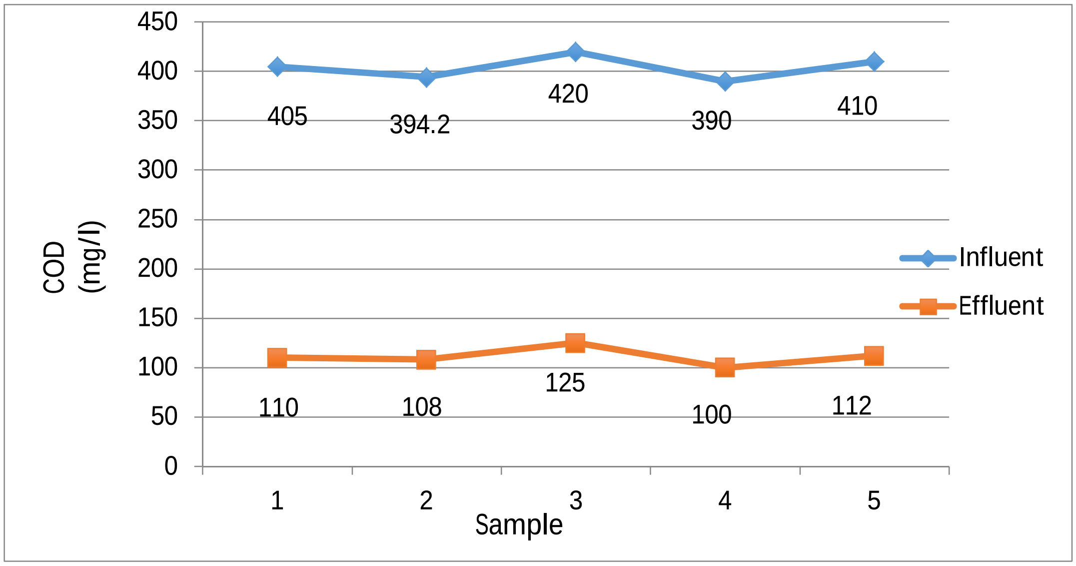
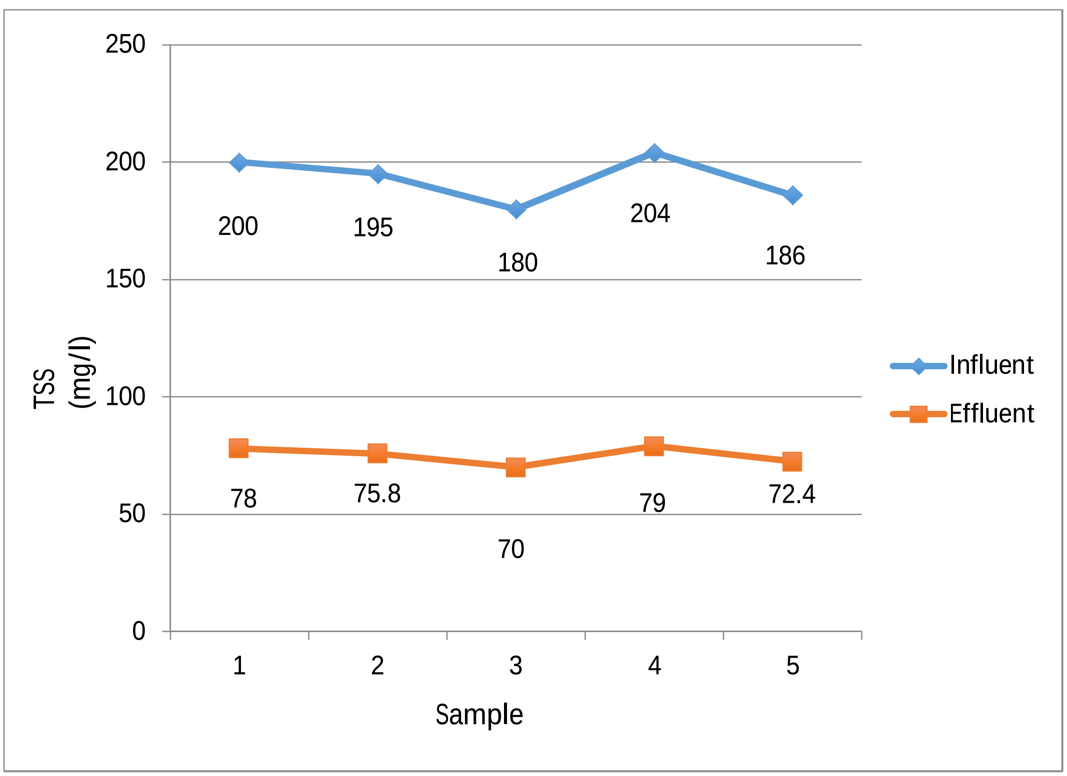


E. Result of TSS

The efficiency of systems was found excellent in removing the Total suspended solid after one day of retention, it reduce from 200 to 78, 195 to 75.8, 180 to 70, 204 to 79 and 186 to 72.4 (mg/l).The maximum allowable limit as per CPCB is 100 mg/l. By the filtration unit provided on the site, test result of TSS is reduced by 61%.



X. CONCLUSION

We concluded that the design treatment unit is highly efficient to control the parameters needed for the reuse for secondary purposes. As it reduced Turbidity by 60%, Biological Oxygen Demand (BOD) is reduced by 70%, Chemical Oxygen Demand (COD) is reduced by 73% and Total Suspended Solids (TSS) reduced by 61% hence all the parameters fulfill the CPCB criteria. So that we can use treated gray water for secondary purposes such as irrigation, landscaping, road washing, etc. We also suggest that residence should have two pipe systems of plumbing for carrying gray water separately.

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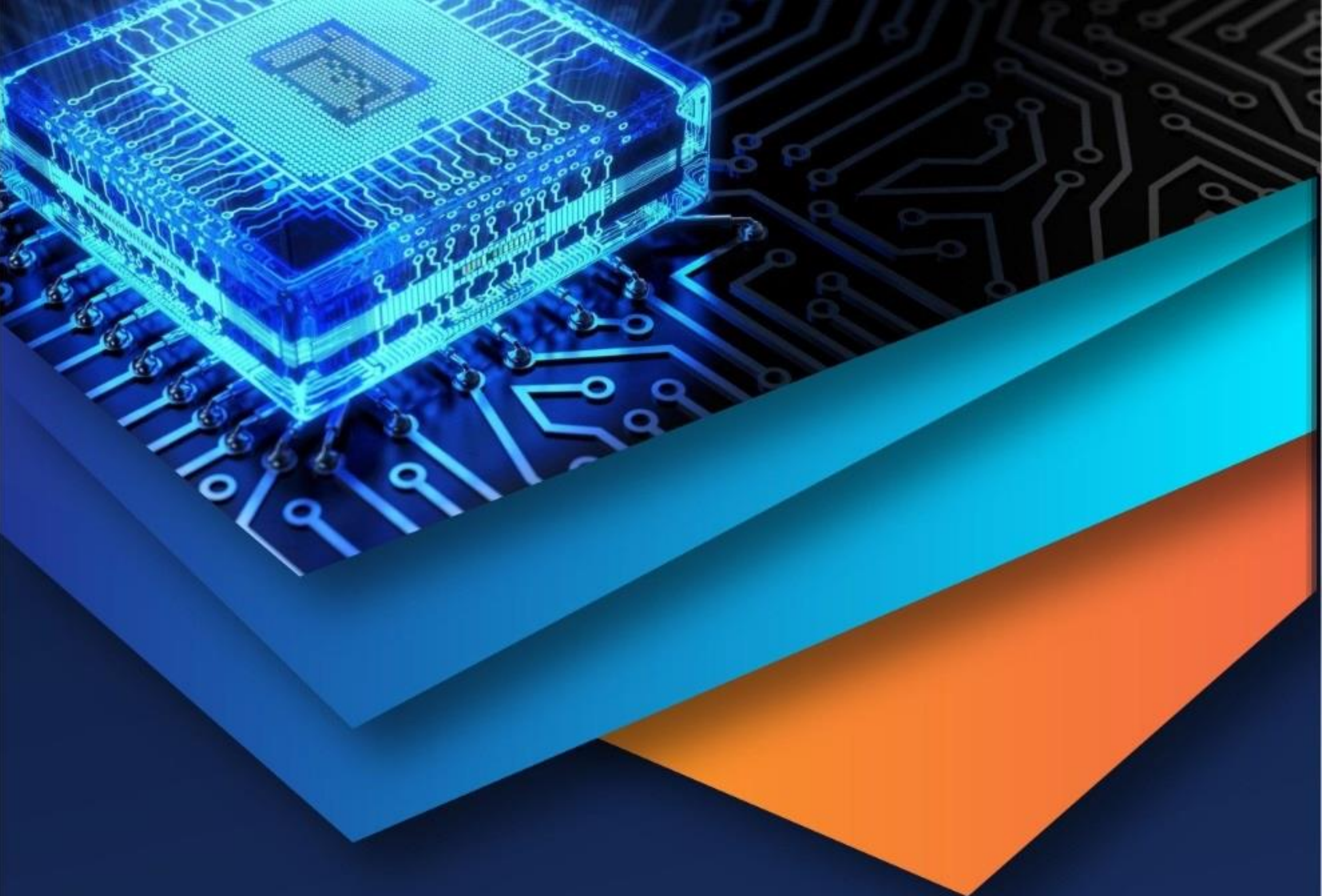

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