Treatment of Domestic Waste Water by Rapid Sand Filter for Reuse in Irrigation Purpose

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Abstract— Domestic Waste water is an immense resource that could find significant applications in regions of water scarcity. The reuse of grey water in certain countries will solve many problems related to water scarcity, and will lead to the saving of financial resources which in turn helps to support the economy so new treatment & technology are needed to be discovered for the treatment of domestic waste water. In this research paper we design a model of rapid sand filter for the treatment of waste water using a low cost adsorbent such as neem leaf powder. the various parameters of grey water will be evaluated as well as the water coming out of the rapid sand filter model will also be analyzed so that comparative study can be done. The working of the model (rapid sand filter) will also be observed by varying the packing of the filter media. Different filter media such as coarse gravel having size 20mm &16.5mm and core segregate having size 6.3mm , fine sand having size 4mm and neem leaf powder & fine sand having size 1mm etc. will be used. Laboratory tests were conducted on these samples (grey water) and they revealed the presence of BOD, TDS, pH hardness, EC etc. whose value varies when compared with that of the parameter for standard irrigation water. We observed that the model of rapid sand filter is, significantly assist in the removal of BOD, COD, TSS, TDS, DO, hardness, EC and will improve the pH quality of the effluent. The purpose of this research paper is to propose some efficient, less expensive and eco friendly filtration technique for grey water treatment for household. Several studies have recommended to reuse the treated grey water which are beneficial to domestics purpose i.e. irrigation, toilet flushing, car washing, constructed wetland etc.

Key words: Grey Water, Rapid Sand Filter, Adsorbent (Neem Leaf Powder)

I. INTRODUCTION

Grey water can be defined as any domestic waste water produced, excluding sewage. In other word we can say that residential grey water is a mixture of all water discharges from the household including bathroom sinks, bathtubs, kitchen sinks, and laundry wash-water sources. Kitchen waste water can contain food particles, grease, oils and fats and its use is not recommended (particularly without treatment). The main differences between grey water and sewage (or black water) is the organic loading, sewage has a much large organic loading compared to grey water.

The rapid sand filter or rapid gravity filter is a type of filter used in water purification and is commonly used in municipal drinking water facilities as part of a multiple-stage treatment system. The first modern rapid sand filtration plant was designed and built by George W. Fuller in Little Falls, New Jersey. Fuller's filtration plant went into operation in 1920 and its success was responsible for the change to this technology in the U.S. Rapid sand filters were widely used in large municipal water systems by the 1920s, because they required smaller land areas compared to slow sand filter. Filtration plays a very important role in water treatment. In the filtering process, water flows onto the top of the filter media and is driven through it by gravity. In passing through the small spaces between the filter's grains, impurities are removed. The water continues its way through the support gravel, enters the under-drainage system, and then flows to the reservoir. It is the filter media, composed of sand or anthracite, which actually removes the particles from the water. The filter media is routinely cleaned by means of a backwashing process.

II. OBJECTIVE OF STUDY

The objective of the present study is

1) To find the economical way to treat grey water and to solve the problem of water in water scarce area.
2) Recycle and reuse of grey water for economic profit.
3) The main objective of the dissertation is to determine the characteristics of the grey water and to design a Model of rapid sand filter for grey water to meet up to the standard of the characteristics of irrigation water and to perform physical and chemical analysis on the sample and estimate contaminant loading before and after filtration.

III. METHODOLOGY

The analysis of physic-chemical parameters started with sample collection. Before a sampling program is undertaken, a detailed sampling protocol must be developed and as a minimum the following item must be specified.

1) Sampling plan
2) Sample labeling
3) Sample storage
4) Sample testing

The Sample were collected from residence in the closed lid plastic bottle at three different time in weekly and store in Environmental Engineering lab refrigerator . the water sample were subjected to analysis within 24hr of collection for the physical-chemical parameter like color, odor, pH, BOD, COD, DO, TDS, TSS, chloride, electrical conductivity, hardness, acidity, alkalinity, fluoride etc.

A. Flow Chart of Methodology

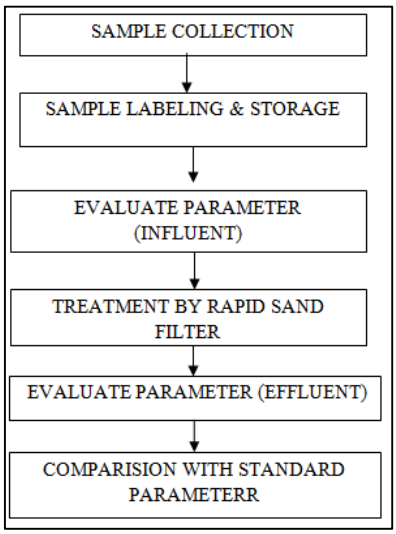

Fig. 1:

B. Construction of Filter

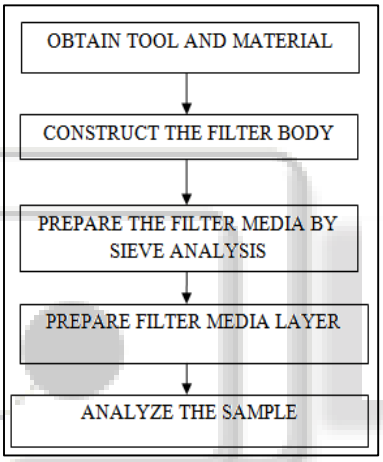

Fig. 2:

IV. Model of Rapid Sand Filter

A. Experimental Setup

The model was fabricated with plastic sheet whose thickness is 0.4mm. The model of rapid sand filter is a circular plastic container, whose capacity is 50 liter, and the depth of the container is 1.20 m and the diameter is 1 ft. the filter media was made of five layers which are fine sand, core segregate and coarse gravel having size.20mm, 16.5mm, 6.3mm, 4mm and 1mm. neem leaf powder used as a adsorbent. Material was filling the entire 90cm.of the depth of the filter as specified for rapid sand filter. The inlet and outlet arrangement were provided at appropriate location. A circular hole was constructed at the base to which 2cm and it can be fitted into tap or plastic pipe for outlet of water. The treated grey water will be collected in another container and finally be removed through the outlet.

s.no	LAYER	DEPTH	SIZE
1	1st	20cm	20mm
2	2nd	20cm	16.5mm
3	3rd	20cm	6.3mm
4	4th	20cm	4mm
5	5th	10cm	1mm

Table 1: Filter medium consist of five layers

Fig. 3: Model of Rapid Sand Filter

Fig. 4: Coarse Gravel 20mm size

Fig. 5: Gravel 16.5 mm size

Fig. 6: Coarse Segregate 6.3mm size

Fig. 7: Fine Sand 4mm size

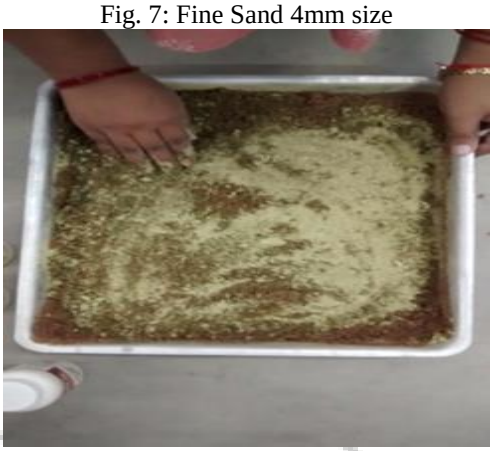

Fig. 8: Neem Leaf Powder & Fine Sand 1mm

Fig. 9: Model of Rapid Sand Filter Filled With Material

B. Working of Model

1) A bucket of grey water is poured into the top of the filter as necessary.
2) The water simply flows through the sand media i.e. fine sand, coarse segregate, coarse gravel. It normally takes a few minute for filtration.
3) When the water is flowing through the filter; oxygen is supplied to the biologic layer at the top of the sand by the dissolved oxygen in the water. If a water depth is greater, result in lower oxygen diffusion and consequently a thinner biological zone.
4) A high water level can be caused by a blocked outlet spout or by an insufficient amount of sand media. As the water depth increase the oxidation and metabolism of the micro- organisms within the biological zone decreases. Eventually the layer dies off and the filter becomes ineffective.
5) The water passes through the sand from top to bottom. Any larger suspended particles are left behind in the top layers of sand.
6) Smaller particles of organic sediment left in the sand filter are eaten by microscopic organisms including bacteria and protozoa's which stick in the layers of slime that form around the sand particles and the clean water which passes through the filter is safe to use for irrigation purpose.
7) After the filtration process the appearance of the water was changed.

The various characteristics of grey water will be evaluated as well as water coming out of the model of rapid sand filter. These parameter include turbidity, pH, BOD_5, COD, TSS, TDS, hardness , DO, total residual chlorine, acidity, alkalinity, electrical conductivity, chloride, fluoride, and color & odor removal for treated grey water.

V. RESULT & DISCUSSION

S.no	Parameters	Units	Before Filtration	After Filtration
1	pH	---------	8.4	7.4
2	Color	Hazen	light grey	light yellow
3	Odor	----------	non offensive	non offensive
4	BOD	mg/l	86	31
5	COD	mg/l	336	96
6	DO	mg/l	3.6	2.8
7	Hardness	mg/l	264	108.3
8	Acidity	Ppm	318	46.6
9	TS	mg/l	1806	977.6
10	Turbidity	NTU	366.6	13.3
11	TDS	mg/l	1216.6	698.3
12	TSS	mg/l	590	280
13	Total residual chlorine	mg/l	4	1.3
14	Fluoride	mg/l	6.03	4.73
15	Alkalinity	mg/l	513.3	96.3
16	EC	ms/cm	704.3	428
17	Chloride	me/l	42	18.1

Table 2: Comparisons of different exiting parameter of grey water before filtration and after filtration

s.no	Parameter	unit	G.W. out	Who/Fao Guidelines	Remark
1	DO	mg/l	2.4mg/l	>2	Acceptable
2	pH	-------	7.4	6.5-8.4[b]	Acceptable
3	BOD_5	mg/l	31mg/l	20c	Not Acceptable
4	COD	mg/l	96mg/l	----------	---------
5	Fluoride	ppm	4.73	----------	---------
6	Total residual chlorine	mg/l	1.3	----------	---------
7	TSS	mg/l	280	20[c]	Not Acceptable
8	EC	ms/cm or ds/m	428ms/cm	0.7-3.0(ds/m)[b]	Acceptable
9	TDS	mg/l	698.3	450-2000[b]	Acceptable

10	Total coli form	cfu/100 ml	----------	1000[c]	----------

Table 3: Comparisons of different exiting parameter of grey water after treatment with WHO/FAO guideline

a------ WHO 1989 guidelines for public park and crops likely to be eaten uncooked.

b------ FAO guidelines for water quality for irrigation.

c------ WHO/AFESD consultation, limit for vegetable likely to be eaten uncooked.

s.no	parameters	units	Result	irrigation water standards (IS: 11624-1986(permissible limit)	Remark
1	pH	--------	7.4	5.5-9.0	Acceptable
2	Color	hazen	Grey	--------	----------
3	Odor	----------	non offensive	--------	----------
4	BOD	mg/l	31	< 5	Not Acceptable
5	COD	mg/l	96	--------	----------
6	DO	mg/l	2.4	---------	----------
7	Hardness	mg/l	108.3	--------	----------
8	Acidity	Ppm	46.6	--------	----------
9	Alkalinity	mgcaco3/l	96.3	--------	----------
10	Turbidity	NTU	13.3	< 2	Not Acceptable
11	TDS	mg/l	698.3	525-1400	Acceptable
12	TSS	mg/l	280		
13	Total residual chlorine	mg/l	1.3	---------	----------
14	Electrical conductivity	ds/m or ms/cm	428ms/cm	0-3	Acceptable
15	Chloride	me/l	18.1	0-30	Acceptable
16	Fluoride	mg/l	4.73	--------	----------
17	Total solid	mg/l	977.6	----------	----------

Table 4: Comparisons of different exiting parameter of grey water after filtration with irrigation water standard

A. Biochemical Oxygen Demand

The BOD of grey water before treatment is 78,85, 95mg/l and the average value is 86 mg/l. the BOD of grey water after treatment is 25,32,35 mg/l and the average value is 31 mg/l. the permissible limit for irrigation water standard is less than 5. According to WHO/FAO the value of BOD should be 20 mg/l.

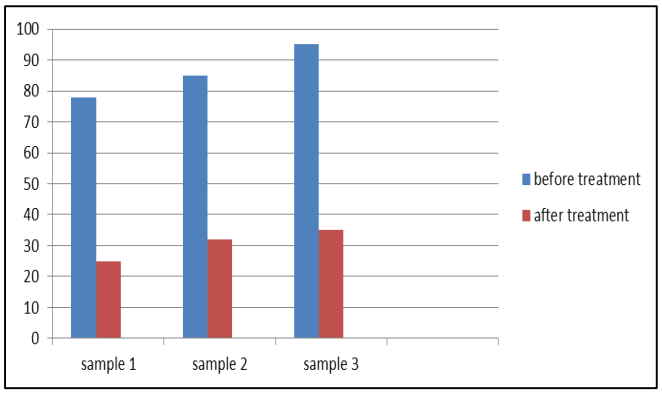

Fig. 9:

B. Chemical Oxygen Demand

The COD of grey water before treatment is 320, 352,336 mg/l and the average value is 336mg/l the COD of grey water after treatment is 96, 80, 112 mg/l and the average value is 96 mg/l. It is suitable for irrigation purpose.

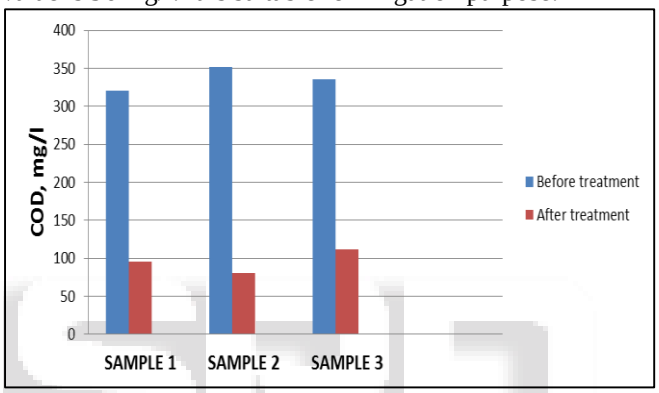

Fig. 10:

C. Dissolved Oxygen

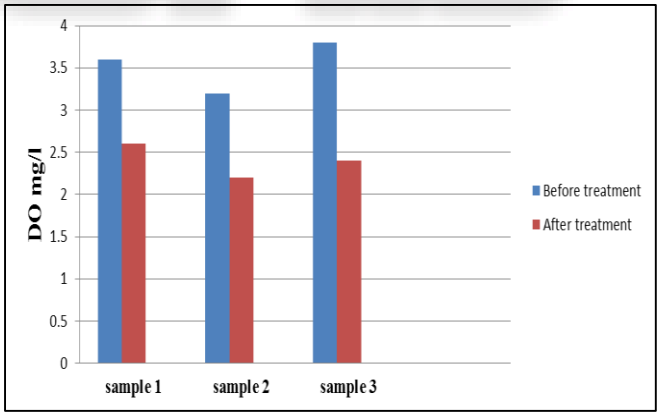

Fig. 11:

The DO of grey water before treatment is 3.6,3.2,3.8 mg/l and the average value is 3.6mg/l. the DO of grey water after treatment is 2.6,2.2,2.4 mg/l and the average value is 2.4 mg/l.

D. Hardness

The hardness of grey water before treatment is 256,264,272 mg/l and the average value is 264 mg/l. the hardness of grey water after treatment is 95,120, 110 mg/l and the average value is 108.3 mg/l.

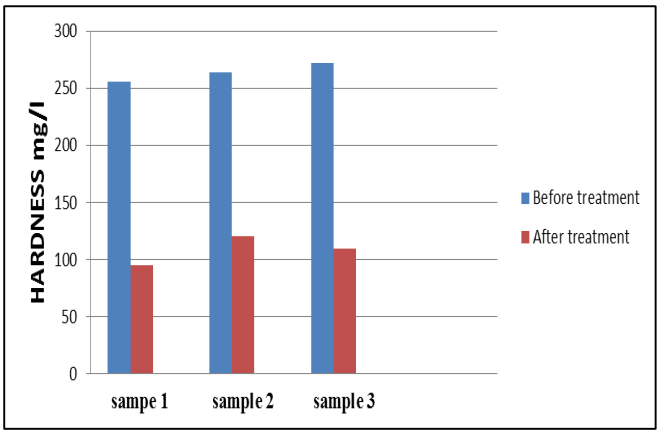

Fig. 12:

E. Turbidity

The turbidity of grey water before treatment is 450, 370, 280 NTU and the average value is 366.6 mg/l. the turbidity of grey water after treatment is 15, 12, 13 NTU and the average value is 13.3 mg/l.

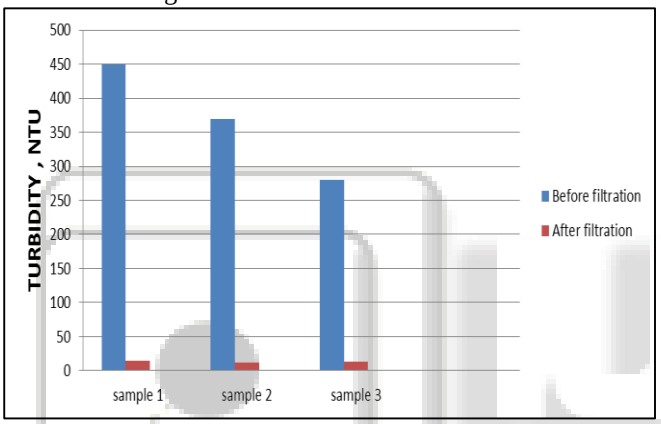

Fig. 13:

F. Acidity

The acidity of grey water before treatment is 315ppm, 318ppm, 322ppm and the average value is 318ppm. The acidity of grey water after treatment is 65ppm, 45ppm, 30ppm. The average value is 46.6 mg/l.

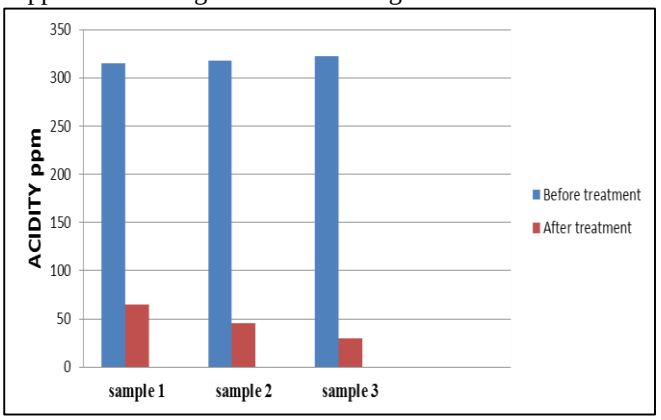

Fig. 14:

G. PH

The pH of grey water before treatment is 8.6, 8.2, 8.4and the average value is 8.4. The pH of grey water after treatment is 7.6, 7.4, 7.2 and the average value is 7.4. According to FAO guideline for water quality for irrigation pH value lie between 6.5 to 8.4 so it is suitable for irrigation purpose.

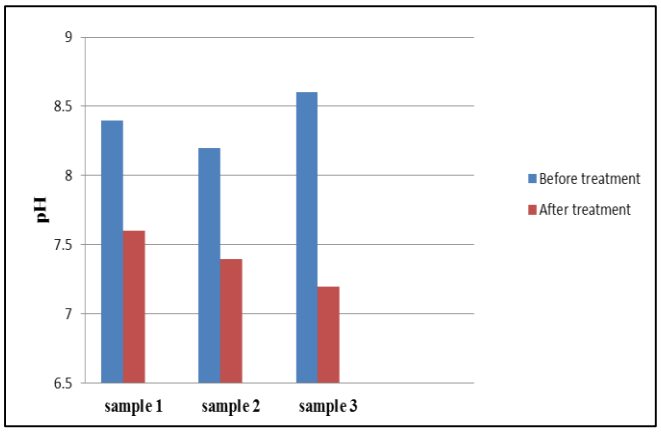

Fig. 15:

H. Electrical Conductivity

The Electrical conductivity of grey water before treatment is 754ms/cm, 735ms/cm, 624ms/cm and the average value is 704.3 ms/cm. The electrical conductivity of grey water after treatment is 464ms/cm, 425ms/cm, 395ms/cm and the average value is 428 ms/cm. According to FAO the permissible limit for irrigation purpose is 315 – 1124 ms/cm or (0-3ds/m) so it is suitable for irrigation purpose.

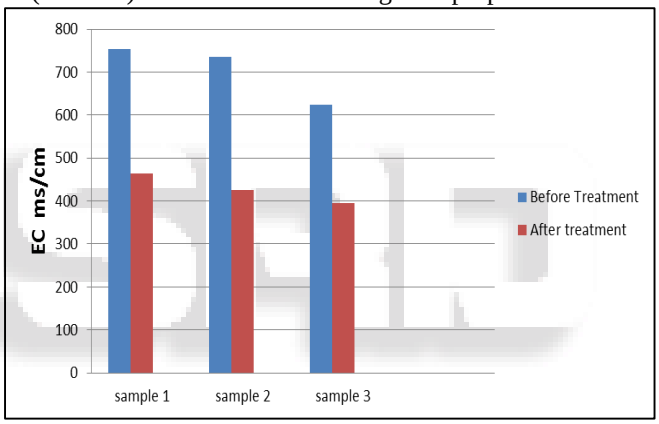

Fig. 16:

I. Total Residual Chlorine

The total residual chlorine of grey water before treatment is 4.5, 4.0, 3.5 mg/l and the average value is 4mg/l. The total residual chlorine of grey water after treatment is 1.5, 1.3, 1.1mg/l and the average value is 1.3mg/l. The permissible limit for irrigation purpose is 0.5mg/l to 2mg/l.

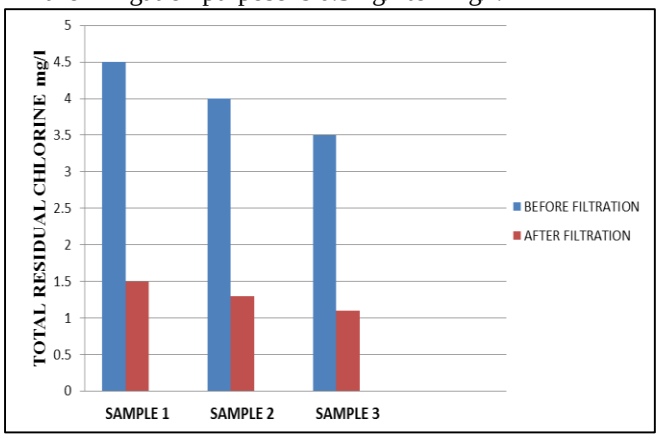

Fig. 17:

J. Alkalinity

The alkalinity of grey water before treatment is 450, 520,570 mg/l and the average value is 513.3 mg/l. The alkalinity of grey water after treatment is110, 84,95mg/l and the average value is 96.3mg/l. it is suitable for irrigation purpose.

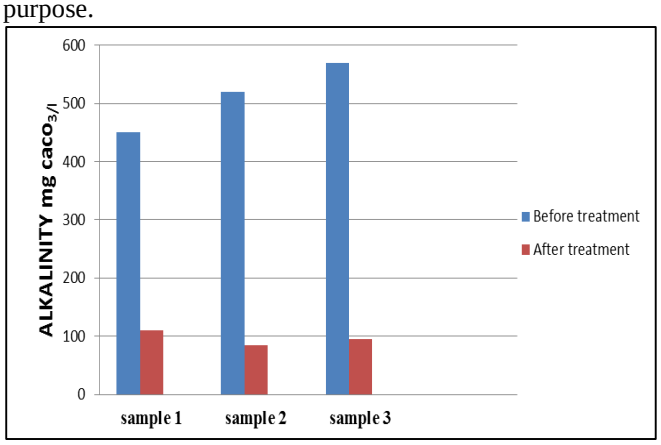

Fig. 18:

K. Total Dissolve Solid

Total dissolve solid in grey water before treatment is 1190mg/l, 1210mg/l, 1250mg/l and the average value is 1216.6mg/l. total dissolve solid in grey water after treatment is 765mg/l, 650mg/l, 680mg/l. the average value is 698.3 mg/l. The permissible limit for irrigation purpose, according to Indian standards is 525-1400mg/l.

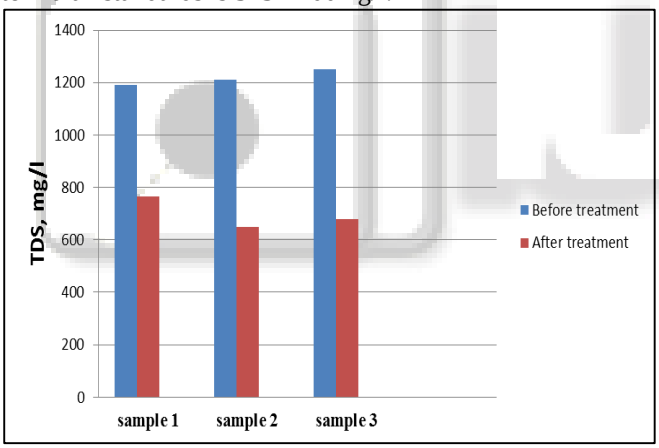

Fig. 19:

L. Total Suspended Solid

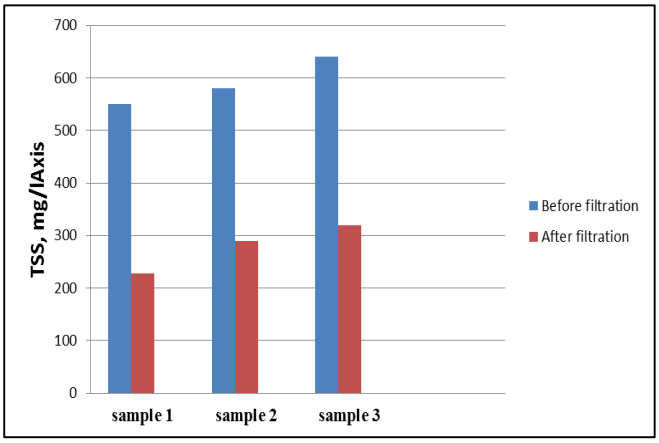

Fig. 20:

Total suspended solid in grey water before treatment is 550mg/l, 580mg/l, 640mg/l and the average value is 590mg/l. total suspended solid in grey water after treatment is 228mg/l, 290mg/l, 320mg/l. the average value is 280 mg/l.

M. Total Solid

Total solid in grey water before treatment is 1740mg/l, 1790mg/l, 1890mg/l and the average value is 1806 mg/l. total solid in grey water after treatment is 993 mg/l, 940mg/l, 1000mg/l. the average value is 977.6 mg/l.

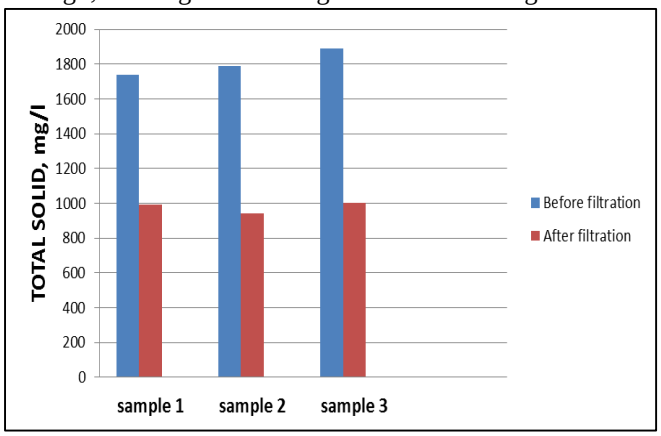

Fig. 21:

N. Chloride

The value of chloride of grey water before treatment is 55, 40.5,45.5 me/l and the average value is 42me/l.the value of chloride grey water after treatment is 20.5, 15.5 , 18.3 me/l. the average value of grey water after treatment is18.1 me/l. The permissible limit for irrigation purpose lie between 0-30me/l. it is suitable for irrigation purposes.

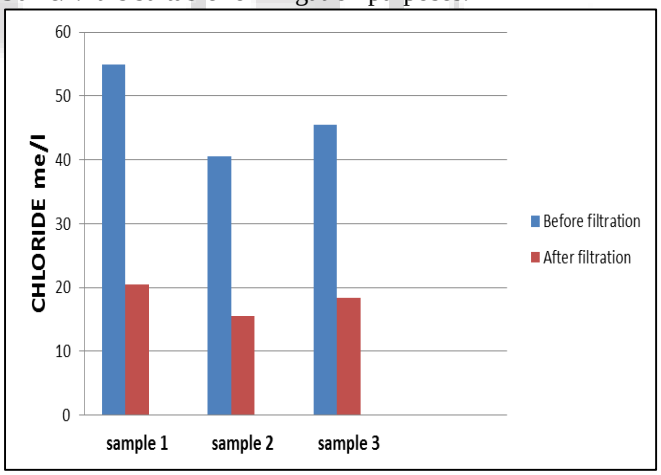

Fig. 22:

O. Fluoride

The fluoride of grey water before treatment is 5.5, 6.2, .6.4ppm and the average value is 6.03ppm. The fluoride of grey water after treatment is 4.5, 5.1, 4.6ppm and the average value is 4.73ppm.

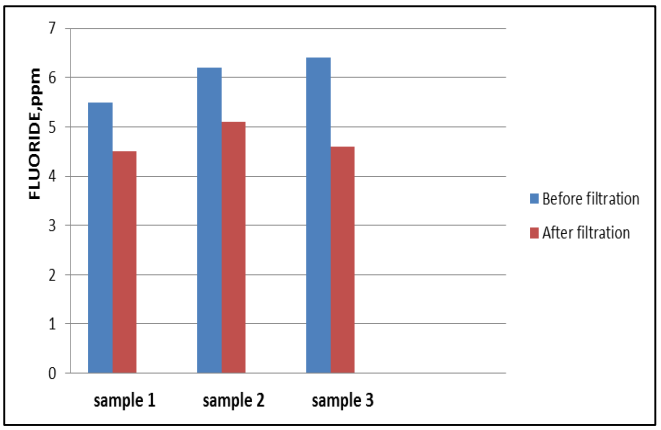

Fig. 23:

VI. DISCUSSION

The purpose of this research paper is to bring new low cost technology and make a model of rapid sand filter using low cost adsorbent (neem leaf powder), which can be used in small scale like house hold and reuse the grey water for domestic purpose for e.g. gardening, irrigation, toilet flushing, car washing etc. The working of the experimental model (rapid sand filter) will also be observed by varying the packing of the filter media. Different filter media such as coarse gravel having size 20mm &16.5mm and core segregate having size 6.3mm , fine sand having size 4mm and neem leaf powder & fine sand having size 1mm etc. will be used. The analysis of the performance shows a gradual decrease in different parameters use for characteristic analysis of grey water. This shows the rapid sand filter using filter media such as coarse gravel, sand and neem leaf powder are a good approach of water treatment. We observed that the model of rapid sand filter is, significantly assist in the removal of BOD, COD, TSS, TDS, DO, hardness, EC and will improve the pH quality of the effluent. This project will help to understand a new approach of an environmental friendly filtration technique.

VII. CONCLUSION

The reuse of grey water in certain countries will solve many problems related to water scarcity, and will lead to the saving of financial resources which in turn helps to support the economy. The grey water treatment work has started with sample collection from residence closed lid bottle at three different times and went for the physical-chemical analysis of the samples. In this project the various characteristics of grey water will be evaluated as well as the water coming out of the rapid sand filter will also be analyzed so that a comparative study can be done. The physical chemical analysis of different parameters such as pH was there was average reduction of 12 % which was found in sample 1, 2 and3. Color has help to assess the qualitative characteristic for the general condition of grey water. After the filtration process the appearance of the water (grey water) was slightly changed to light yellow due to neem leaf powder. There was a major variation in turbidity value of water before and after filtration. The value of total solid has significantly changed after filtration the initial value was 1740, 1790, 1890 mg/l and the final value after filtration was 996,940,1000mg/l. The value of total dissolved solid has significantly changed after filtration, the initial value was 1190, 1210, 1250 mg/l and the final value after filtration was 765, 650,680 mg/l. the value of BOD has significantly changed after filtration, the initial value was 78, 85, 95mg/l and the final value after filtration was 25, 32, 35 mg/l. the value of COD has significantly changed after filtration the initial value was 320,352,336 mg/l and the final value was 96, 80, 112 mg/l. the value of Electrical conductivity has significantly changed after filtration, the initial value was 754, 735, 624 ms/cm and the final value after filtration was 464,425,395 mg/l. The analysis of the performance shows a gradual decrease in different parameters use for characteristic analysis of grey water. This shows the rapid sand filter using filter media such as coarse gravel, sand and neem leaf powder are a good approach of water treatment. We observed that the model of rapid sand filter is, significantly assist in the removal of BOD, COD, TSS, TDS, DO, hardness, EC and will improve the pH quality of the effluent. Calculated data of the parameter of the sample reveals that there was a significant decrease in the physical-chemical characteristic of the sample as the parameters such as pH, BOD, COD,, TDS, , TSS, EC, hardness, total residual chlorine etc which shows that treated grey water are suitable for irrigation according to WHO guide line.

This project will help to understand a new approach of an environmental friendly filtration technique which can be used commonly in the household. Overall performance of the filter was satisfactory since the quality of grey water after filtration was improved considerably. This water now can be used such as irrigation, gardening, toilet flushing and car washing etc. I hope, grey water treatment by rapid sand filter using different filter layers are very effectively and efficiently.

REFERENCES

[1] B. Jefferson, A Palmer, P Jeffey, R.Stuetz and S. judd " grey water characterization and its impact '' water science & technology(W.S.T) volume 50
[2] Chidozie C Nnaji1 ,Cordelia N Mama1, Arinze Ekwueme1 and Terlumun, " Feasibility of a Filtration-Adsorption Grey Water Treatment System for Developing Countries '' Nnaji et al., Hydrol Current Res 2013, S1-006
[3] D. Rowe and I Abdel-Magid, hand book of waste water reclamation and reuse, Lewis publishers, New York, 1995.
[4] Dr sunita rattan, 'Experiments in applied chemistry" S.k.kataria & sons publishers, India
[5] Drinking water quality standards of BIS (IS: 10500:1991)
[6] Fangyue Li, Joachim Behrendt, Knut Wichmann and Ralf Otterpohl "Resources and nutrients oriented grey water treatment for non-potable reuses''water science & technology -WST/57.12/2008
[7] Francis W. Kariuki, Kiplagat Kotut and Victor G. Ngángá "The Potential of a Low Cost Technology for The Greywater Treatment'' The Open Environmental Engineering Journal, 2011, 4, 32-39
[8] Irrigation water quality standard and salinity management strategies B-1667,4-03

[9] J.S. Lambe, R.S. Chougule " grey water treatment and reuse" IOSR Journal of mechanical and civil engineering (IOSR-JMCE) ISSN:2278-1684,PP:20-26,
[10] Kamal rana, mitali shah, amita upadhyay " integrated approach towards grey water management " international journal of engineering research & technology (IJERT) ISSN: 2277-9655,
[11] Krishna kumar O, k. Adithya , abhilash R.and Arvind T "house hold grey water treatment—utilization for flushing of toilets" international journal of applied engineering research. ISSN: 0973-562, volume & number 15 (2013) pp. 1801-1808,
[12] Lucia Hernandez leal, Hardy temmink, Grietje Zeeman and Cees.J.N Buisman "comparision of three systems for biological grey water treatment " ISSN 2073-4441,
[13] Mohammed Hasan Al-Mughalles ,Rakmi AbdulRahman,Fatihah Binti Suja Mastura Mahmud And Sharifah Matura Syed Abdullah "grey water treatment using GAC biofilm reactor and sand filter system. Australian journal of basic and applied science 6(3), ISSN 1991-8178
[14] M.s.Islam and S.z.k.m shamsad " Assessment of irrigation water quality of Bogra district in Bangladesh ISSN 0258-7122 Bangladesh , December 2009
[15] National environmental engineering research institute (NEERI), (2007) "grey water reuse in rural schools" wise water management, and guidance manual.
[16] Rajarshi kar , oindrila gupta " grey water treatment and recycling for use in household application " international journal of engineering research & technology (IJERT) ISSN: 2278-0181
[17] R.T.Peche, Dr S.S Jamkar, Dr P.S Sadgir " grey water – A potential source of water for construction" IOSR Journal of mechanical and civil engineering. ISSN: 2278-1684, P-ISSN:2320-334X, PP 12-17,
[18] Sandeep Thakur, M.S. Chauhan ''Grey water recycling'' Journal of Environmental Science and Sustainability (JESS) Vol. 1 (4): 117 – 119, 2013
[19] Santosh kumar garg ''Environmental Engineering Volume-1" Khanna Publisher 1977.
[20] Suman Kanukati1, Bharat Rao, Harish P "Intelligent Grey Water Management System- New approach to use grey water efficiently" international journal of emerging technology and advanced engineering. (ISSN-2250-2459, ISO 900:2008) certified journal.
[21] Pali Sahu, Swapnali Raut and Sagar Mane ''Treatment of grey and small scale industry waste water with the help of vermi-filter.'' Civil Engineering and Urban Planning: An International Journal (CiVEJ) Vol.2,No.1, March 2015
[22] Tiyasha, shaktibala, suraj kr bhagat " phyto-filtration : A new approach of waste water treatment" international journal of engineering and innovative technology(IJEIT),ISSN: 2277-3754 volume 3.
[23] Ukpong, E.C, Agunwamba J.C. "grey water reuse for irrigation ''international journal of applied science and technology. Volume 2.

