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Purification of Grey water using the natural method

Snehal Joshi, Priti Palande, Dr. Suneeti Gore, Ms. Anuja Oke, Mrs. Gopika Manjunath, Dr. Chitra Naidu, Dr. Meenal Joshi*

*Scientist Bhide Foundation, S.P. College, Pune 411030, India

Email id: dr.meenal.joshi@gmail.com

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Abstract— *The Water crisis is a major problem now a day. To solve this problem, there are various methods of water conservation such as rainwater harvesting or water reuse. Grey water treatment is also an option for water conservation. Grey water is the untreated household wastewater that has not come into contact with sewage (WHO -ROEM2006). In this study we have used various flocculating agents like alum, PAC, lime, chitosan, alum+ lime, fuller earth, ferric chloride, ferrous sulfate, PAM, Micro+, soya bean, alum+ soya bean etc. and the one thatgave the most significant results were used for further study. Among the flocculating agents used, alum + soybean powder gave promising results. So this flocculating agent and coagulating aid were used for further experiment. We prepared biochar using groundnut husks which is a waste material and activated it using zinc chloride. We prepared a unit which consisted of a column packed with sand, gravel, activated biochar and vetiver roots. We passed the supernatant obtained after flocculation through this unit at flow rate 5L/hr. The effluent water was disinfected using Medichlor. Using this unit the turbidity was decreased to 0.08 NTU, pH was 6.3, TSS was nil, and TDS reduced upto 75%. The microbial load (bacteria, fungi, coliforms, Thermotolerents), MPN test was also found to be negative. The unit which we have prepared was ecofriendly and economically affordable. This treatment system can be used in the new constructions, bungalows, societies etc. The treated water can be used for various purposes such as gardening, car washing, toilet flushing, road construction, irrigation etc.*

Keywords— ***Gray water, flocculation, activated biochar, treatment unit.***

HIGHLIGHTS

- Grey water is the untreated household wastewater that has not come into contact with sewage.
- Microbial contamination of gray water comprises potential risk to health. Grey water also contains some chemical substances which may pollute the natural resources, So grey water needs to be treated.
- During this study, alum + Soybean powder showed best results as coagulation or flocculating agent and coagulation aid.
- Biochar was made using biological or organic material and was activated using $ZnCl_2$
- Water passed through our natural treatment unit followed USFDA norms.
- The treatment unit was made of natural material, hence the unit was ecofriendly and economically affordable.

I. INTRODUCTION

Grey water is spelt and defined differently in different parts of the world. It is the household wastewater that has not come into contact with sewage (WHO ROAM 2006). With an anticipated increase in world population by 2-3 billion people over the next decades (WHO 2010), the water demand is increasing two-fold (64 billion cubic metersper year). Urbanization is growing by 1.5% per year

globally (WHO 2010), and is estimated that by 2050 the percentage of the total population that will live in urban centers is going to increase further. Familiar sources of household gray water include water from showers, baths, sink, water generated from cloth washing, utensil washing, floor washing, hand washing, kitchen washing etc. Wastewater from kitchen sinks and automatic dishwasher have a high concentration of organic matter that encourages the growth of bacteria.This water is sometimes referred to as dark grey water. Grey water can be reclaimed by three main mechanisms; physical treatment, chemical process and biological treatment. Physical treatment is effective in improving the aesthetic quality of the effluent but can be fouled by pollutants and is energy demanding. The organic treatments reduce to some extent all affective components of the gray water but they are costly (Jefferson et al. 2000) variety of gray water treatment units remove microbial load, salts, pollutants etc. but the degree of treatment varies widely.

Grey water can be used for various purposes that don't require potable water such as landscaping, agricultural use, gardening, car washing, toilet flushing, road construction etc. It will reduce the demand of fresh water.(A.Gross. et al. 2007) Grey water may contain contaminants that are present in raw sewage or wastewater but in very low concentration. It contains coliforms, fungus, nutrients like nitrogen and phosphorus, detergents, surfactants and some amounts of oil or grease. Microbial contamination of grey water comprises potential risk to health. Grey water also contains detergents or surfactants, which will affect soil quality. So there is a need to treat the grey water and reuse it for various purposes in the regions where the population is high and scarcity of water. (Eriksson et Al. 2016)

Gray water treatment using natural treatment methods have not been fully explored . Hence we decided to identify natural ways that may be used to treat gray water. our present study aimed to reduce the pollutants by natural treatment system on a laboratory scale. This treatment system will be eco-friendly and economically affordable.

II. MATERIALS AND METHODS

Survey - we carried surveyed to get information regarding water usage, the quantity of wastewater or gray water generated, sources etc. For this purpose, we selected five homes. We prepared a questionnaire and gave it to the owners of the selected houses. Based on the information collected, we procured the gray water. (Pangarkar*etal*. 2010)

Collection - we received the gray water sample from houses. The sources of gray water were wastewater from cloth washing, utensil washing, floor washing, kitchen washing, bathing kitchen sink, hand washing etc. Approximately 5 L Of gray water used for the experiment. (Pangarkar*et al*. 2010)

Characterization of gray water – First, we collected the gray water and characterized it using following physicochemical and biological parameters. (Joonkyu Kim *et al.* 2009)

pH, Turbidity, Total suspended solids, Total dissolved solids, Total solids, Chemical oxygen demand (COD), Biological Oxygen Demand (BOD), Surfactants, oil and grease, Nitrates, Sulphates, Total Viable Count, Most Probable Number (MPN), Coliform count, Thermotolerant organisms.

Coagulation and flocculation - To reduce the load on the treatment system, the preliminary study on the gray water was coagulation and flocculation. For this purpose, we have used various coagulation agents and one amongst them which gave the best result was used for further experiment.

Jar test method - we used the jar test method for the process of coagulation and flocculation. The process was as follows,take 1000 ml of gray water in a jar. Add flocculating agent in the gray water. 3 minutes slow stirring and 9 minutes fast stirring. Allow to settle down the floccs for 30 minutes. Take the supernatant for further experiment.

Characterization of Supernatant - The supernatant collected was analyzed for the physico-chemical biological parameters using following testspH, Turbidity, TDS, TSS, Total viable count, MPN.

Preparation of Biochar

Biochar - charcoal prepared from biological waste materials.

To prepare the biochar we used organic or biological material. We collected groundnut shells. Washed them with water, and then dried them in the sunlight. Then again kept washed anddried shells in the hot air oven to remove moisture if any. The fully dried shells were ground using mortar and pestle. The powder was then placed in Muffle furnace for the charcoal preparation. (M.F.Olmenarejo*et. al*. 2006)

Activation of biochar

The prepared biochar was activated using zinc chloride ($ZnCl_2$) . Following procedure was followed for activation ofbiochar. Wash the prepared biochar with distilled water. Dry it in the hot air oven Prepare a solution of 33 ml distilled water and 2.1 gm of $ZnCl_2$. Take 30 gmofbiochar, add the prepared $ZnCl_2$ solution to it. Boil this mixture on water bath at100°C. Keep it in hot air oven for 20-24

hours. Wash the activated biochar with distilled water, again dry it in the hot air oven to remove moisture. The activated biochar was ready for the use.

Unit preparation

We prepared an unit of 45 cm. It considered of sand layer of 7.5 cm which was present at the bottom, next to it gravels layer of 5cm was present, on the gravels charcoal + activated biochar layer of 5cmwas present, next to it sand + coal layer of 7.5 6cm was present and the upper layer was of vetiver and is about 5 - 10 cm in length. The supernatant collected from flocculation treatment was passed through this improved unit. The effluent from this improved unit subjected to the physico-chemical and biological analysis. (Parjane Saroj and *et. al*. 2011 ;Tan I. A. W. And*et al*.2008).

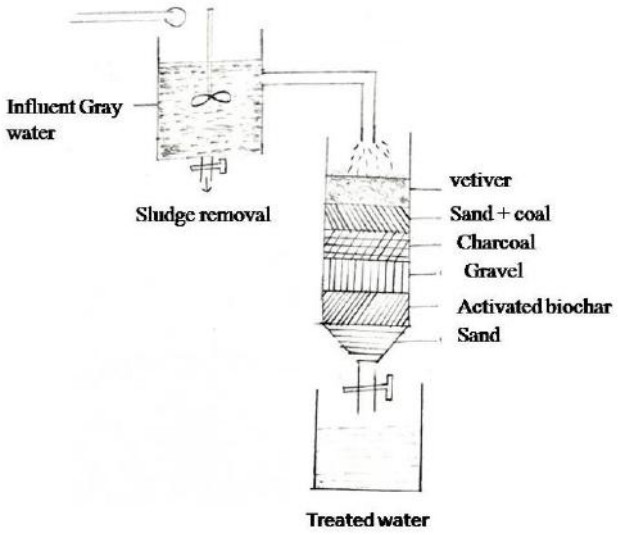

Fig. 1 Schematic representation of Gray water treatment unit

III. RESULTS AND DISCUSSION

To know the water consumption per house per day we did statistical analysis using the data obtained from the questionnaire. We also got the information regarding the use of water per day for various household purposes and generation of waste water. Average 755 L water was used by per family per day.

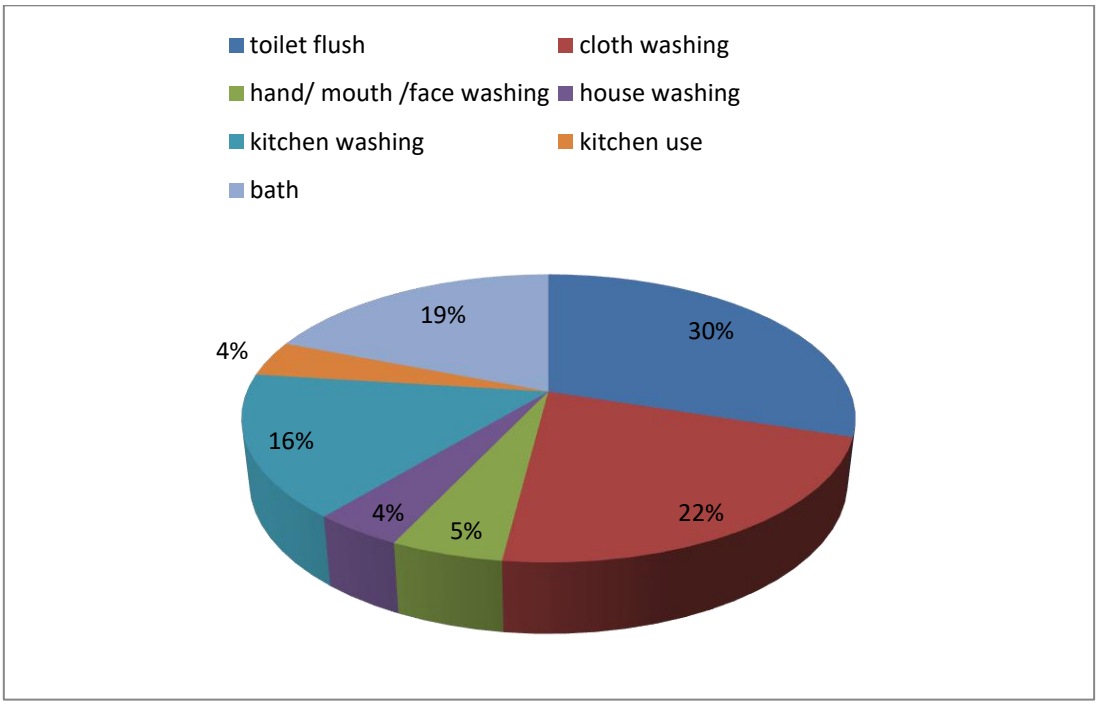

Fig. 2 Percent of water used by per family per day

Color of gray water was grayish black, brown, grayish white. After collection of gray water physico-chemical and biological parameters were analyzed. Physico-chemical and biological characterization of parameters is shown in table.

Table- 1 Physico-chemical and biological characteristics of sampled gray water

Parameters	Observed values
pH	6.9
Turbidity	400-1241 (NTU)
Oil content	370mg/L
Total Dissolved Solids (T.D.S.)	827.5-5700mg/L
Total Suspended Solid (T.S.S.)	282.5-1300mg/L
C.O.D.	2244mg/L
B.O.D.	1100mg/L
Nitrates	3.07mg/L
Sulphates	21.79mg/L
Detergents	8.93mg/L
Most Probable Number(MPN)	16
Thermotolerants	-
E.coli	351×104
Total Viable Count 1)Bacterial 2)Fungal	 96×10^5CFU/mL 32×10^5CFU/mL

- Physico-chemical and biological parameters were very high and pose the pollution threat to the receiving water bodies or natural streams that will receive gray water.
- It indicates that treatment of gray water is essential.

Flocculating agents

Different flocculating agents were used for removal of turbidity. Use of different flocculating agents, their efficiency with respect to turbidity removal, effect on pH, TSS, TDS was analyzed. The flocculating agent which gave promising results was used for further experiment.

During past years research has been carried out natural coagulant for the turbidity removal. To explore the use of soybean powder along with the alum we used different combinations of the two. It is economically affordable and eco-friendly agro-based product used for turbidity removal. It also reduced the amount of alum required.

- 1% alum and 1% soybean powder solution were used.

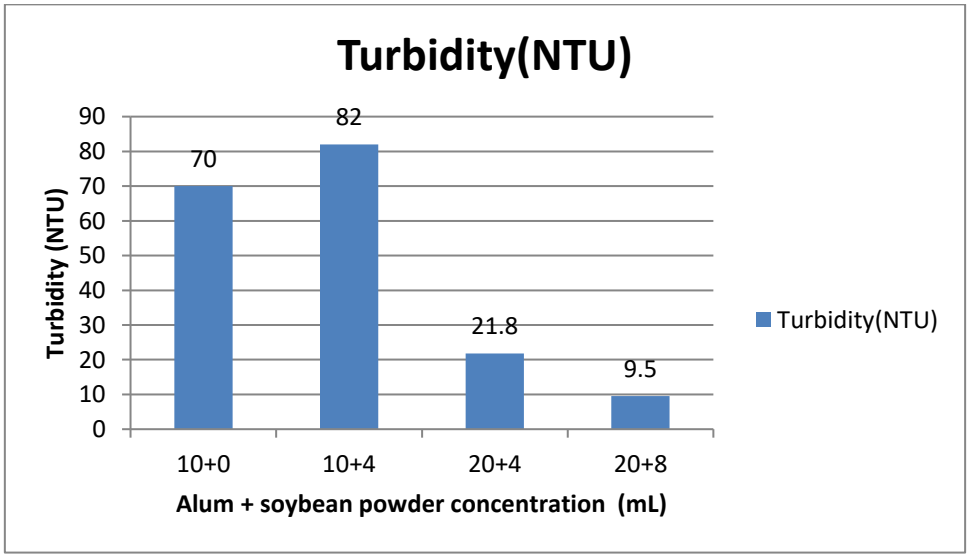

Fig. 3 Turbidity removal by Alum + Soybean powder

Table 2 characterization of gray water after 1st treatment (flocculation and coagulation)

	Turbidity (NTU) **For 500mL of gray water sample**		**pH** **For 500mL of gray water sample**	
Alum + soybean	Initial	After 1st treatment	Initial	After 1st treatment
10 + 0	435	23.7	8.3	5.4
10 + 2	435	22.5	8.3	6.2
10 + 4	435	17.8	8.3	6.9
	Turbidity (NTU) For 1000mL of gray water sample		pH For 1000mL of gray water sample	
Alum + soybean	Initial	After 1st treatment	Initial	After 1st treatment
10 + 0	550	70	7.5	5.4
10 + 4	550	82	7.5	6.2
10 +4	550	21.8	7.5	6.0
20 + 8	550	9.5	7.5	6.3
	T.S.S. (mg/L) 30 mL sample after 1st treatment is used		T.D.S. (mg/L) 30mL sample after 1st treatment	
Alum + soybean	Initial	After 1st treatment	Initial	After 1st treatment
	366.6	33.33	2733.3	333.3
	MPN		Total viable count	
Alum + soybean			Bacterial	Fungal
	-		25×10^6CFU/mL	-

Table -3 Characterization of effluent from unit prepared

Sample	**pH**	**Turbidity (NTU)**	**T.S.S. (mg/L)**	**T.D.S. (mg/L)**	**MPN**	**E.coli**	**Total viable count**
Initial	8	450	433.3	666.6	16	35×10^4CFU/mL	Bacterial Fungal
After 1st treatment	6.3	9.5	33.33	366.6	-	-	25×10^6 – CFU/mL
unit	6.3	0.082	-	166.6	-	-	- -

Table 4- Performance of gray water treatment unit

Parameters	Initial Greywater	Treated Effluent	% of removal Efficiency	Standard of USFDA
pH	6.9	7.2	-	6.5-8.5
Turbidity(NTU)	400-1241	0.08-2	99.82-99.98	5
Color	Grayish	Colorless	-	Colorless
Odour	Soapy, phenolic	Unobjectionable	-	Unobjectionable
Oil content	370	-	100	0.01
TSS(mg/L)	282.5	-	100	*

TDS(mg/L)	827.5	166	80	500
COD(mg/L)	2244	134	94	*
BOD(mg/L)	1100	38	96	*
Nitrates	3.07	3.01	2	45
Sulphates	21.79	141	-	200
Detergents	8.93	-	100	NIL
MPN	<16	-	100	NIL
E.coli	341×10^4	-	100	NIL
Total Viable Count (CFU/ml)				
i. Bacterial	96×10^5	-	100	NIL
ii. Fungal	32×10^5	-	100	NIL

* In case of drinking water standards USFDA, BIS do not define the limits.

The results presented in this study establish the potential applicability of the development of treatment unit. During this research we found soybean powder which acts as an amazing coagulant aid. Naturally and easily available low cost materials were used like sand and gravel, coal etc. for the treatment processes. The ground nut husks are the biological waste material which was used for activated charcoal preparation. It acts as an adsorbent. Similarly Vetiver roots are also easily available. They can act as an adsorbent and remove heavy metals from gray water. In economy of the unit which is an important part of the operation cost. Only forcoagulation or flocculation process stirring is required which consumes electricity. As per Indian Standards, the treated water can be used for landscaping, gardening, toilet flushing, floor washing, car washing and irrigation.

We compared our treatment unit with previously reported treatment units. Physical treatment unit removed T.S.S. (98%), BOD (100%), C.O.D(81%), Coliform (99%). (Gross *et al.*2007). Biological treatment unit removed C.O.D(89%), T.S.S.(95%) (Gros*et al*. 2007). Physical and chemical unit removed Turbidity (18%), C.O.D (25%) (Gual*et al*.2007). Physical and chemical method removed Turbidity (98%), C.O.D (99%) (Kim *et.al*.2007). And our treatment unit removes Turbidity (99.98-99.99%), C.O.D (64%), BOD (96%), T.D.S (80%).

Various benefits of gray water –

1. Reduced use of fresh water
2. Less strain on septic tanks.
3. More effective purification.
4. Reduced use of energy and chemicals.
5. Ground water recharge.
6. Saving consumption of water per day.
7. Saving of drinking water by reuse of gray water.

IV. CONCLUSION

The present study demonstrate the reuse and treatment of gray water efficiently. Based on the findings of the present study, this unit can be considered as a viable alternative to conventional treatment plants. The unit which we have prepared was eco-friendly and economically affordable.

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