International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 10 | Oct 2018 www.irjet.net p-ISSN: 2395-0072

WATER FILTER USING NATURAL MATERIALS

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Abstract - *The scarcity of clean and safe drinking water is one of the major problems faced by human nowadays. The study is focused on the filtration of grey water. This filtration is done by preparing a filter made of powdered cactus, pine bark, sand and coarse aggregate. The use of pine bark enhances the purification by preventing microbial action and reduces turbidity. But the application of the pine bark increases the concentration of acidity. In order to reduce the acidity, coarse aggregate is used as another layer. Cactus is used for reducing the chemical oxygen demand of the grey water. Finally, a sandy layer is provided as a supporting layer for powdered cactus. Thickness and flow rate of each layer was fixed by column study method. As per the column study, we fixed a 3cm layer thickness and a 10cm layer thickness for cactus and pine bark respectively. The percentage reduction for turbidity and chemical oxygen demand for combined filter were obtained as 72% and 30% respectively. Thus, the filter was constructed by considering the experimental results.*

Key Words: **Cactus, E Coli, Flow Rate, Pine Bark, Turbidity**

1. INTRODUCTION

The growth of the global population, the increasing need of water for agriculture and the increasing urbanization put great pressure on the existing resources of freshwater and the finding of news sources of freshwater become necessary. An alternative source of water can be to reuse wastewater. Grey water is all wastewater from a household, with the exception of toilet water, which is called black water. Water from dishwashing, from kitchen sinks and from laundry machines constitute grey water and it account for 80% of the household wastewater.

Grey water can be reused in areas that do not require portable water such as irrigation and toilet flushing. The reuse of grey water reduces the pressure on freshwater resources and thereby preserves the environment and decrease the cost of water. Grey water in this scenario is a resource of water rather than wastewater. Unfortunately, grey water by its origins contains chemicals, bacteria and viruses. The reuse of raw grey water without a pre-treatment can have negative impacts on the soil, can pollute the groundwater, the surface water or/and contribute to the transmission of diseases.

The high cost and the insufficiency of centralized wastewater treatment plants mainly in low income countries justify the choice of the onsite filtration system with local and inexpensive filter materials. In this study, pine bark, powdered cactus, coarse aggregate and sand were used as filter media in column filters. Some physical and chemical parameters of grey water that can have a negative environment impact were measured before and after filtration with different materials and with different layer thickness.

The filtration efficiency depends on both the flow rate of different filter material. Pine bark, cactus, coarse aggregate and sand were found to be better in reducing some of the chemical and biological parameters. The bark filters have an acidifying effect on the filtrated grey water.

This study has contributed to the finding of methods to improve the quality of grey water for reuse. The study confirmed the possibility to improve the quality of grey water by filtration and showed that degree of the reduction depends on the filter material used and the characteristics of the microorganisms.

Water purification using natural materials such as pine bark, cactus, sand and coarse aggregate can be affordable for all class people and it have some advantages over the most preferable water purifiers.

2. EXPERIMENTAL PROCEDURE

The water samples were collected from sewage treatment plant. The collected water had foul smell and appeared greyish.

2.1 Preliminary test on waste water:

The water was found to be unfit for any purpose. The samples of the same water were collected for conducting purification processes. Physical, chemical and biological tests were conducted on the collected samples. The tests that were conducted were pH, Chloride, Hardness, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Acidity, Alkalinity, Turbidity and E coli. The water quality analysis were done as per the IS specifications. As per the

obtained results, we have decided to make a 4-layered filter with a diameter of 1.5 inches.

2.2 Preparation of filter apparatus:

The pipe is separated as 4 layers and is filled with coarse aggregate, pine bark, cactus and sand respectively from top to bottom.

2.3 Filter materials

i, Pine Bark
ii, Cactus
iii, Sand
iv, Coarse Aggregate

The bark originated from undefined mixture of pine bark was air dried and was sieved through 4.75, 2.36 and 1mm screens. The bark retained on 2.36 and 1 mm screens was mixed in 3:2 ratio by weight. As the first layer from top, the pine bark was filled in the filter pipe at a thickness of 5cm. Powdered cactus were used as the second layer. Cactus were sliced, dried and grinded into a fine powder and sieved to a size of 600µm. It was filled in the filter pipe at a thickness of 3cm. Fine sand is used as the third layer. Sand which is passing through 4.75mm IS sieve, 2.36mm IS sieve and which retains on 1mm IS sieve is taken.

Fig-1: Powdered Cactus

Fig-2: Powdered pine bark

Fig-3: Pieces of roof tile

Fig-4: Sand

2.4 Reducer with a sieve net

A reducer which is attached with a sieve net is placed at the end of bottom most filter layer in the pipe. The size of the reducer varies from 1.5 inches to 1.25 inches. 1 mm size of sieve net is provided at end of arrangement to retain the sandy layer

Fig-5: Setting of layer thickness

3. WORKING OF THE FILTER

The waste water filter is constructed in 4 layers. These layers are filled with 4 different materials. The materials are coarse aggregate, grinded pine bark, powdered cactus and sand. The materials are added in order to remove various biological, chemical and physical characteristics of water.

The filter is constructed using a 50mm PVC pipe. The top most layer is filled with the coarse aggregate (clay). The application of coarse aggregate is more effective in removing acidity (Tesfaye Betela Bekalo (2017)). Pine bark is used as the second layer. By the addition of pine bark the reduction of E coli and turbidity is done. The third layer is filled with powdered cactus. COD, BOD and turbidity can be reduced by the application of cactus. The bottom most layer is filled with sand, which act as a supporting layer for the top layers.

The bottom most portion of the pipe is attached to a reducer with a sieve net. The flow rate is found out for different thickness of materials. Column study in different cases was found out and the most effective case is used. The material thickness which gives the better flow rate and material properties is taken into consideration.

Fig-6: Finalised filter model

4. PRELIMINARY TESTS RESULT ON RAW WATER

Table-1: Results of tests conducted on raw water

PARAMETER	UNIT	RESULTS	Desirable Limit
pH	-	6.74	6.5-8.5
Turbidity	NTU	80	5
Total Alkalinity	mg/l	180	200
	mg/l	35	200
Chloride	mg/l	75	250
Chemical Oxygen Demand	mg/l	288	250
DO	mg/l	0.6	4
BOD	mg/l	23	1
E coli	MPN/100ML	500	3
Acidity	mg/l	50	50

5. COLUMN STUDY

Column study is done using trial and error method. Various materials are applied at different thickness and in different layers. The following results were obtained:

A. PINE BARK

Table-2: Properties of water on 10cm and 15cm layer thickness

Parameter	Unit	Raw water	Passing through 10cm thickness	Passing through 15cm thickness	Desirable Limit as per Is 10500 :1991
pH	-	6.74	5.97	5.82	6.5-8.5
Turbidity	NTU	80	67	61	5
Total Alkalinity	mg/l	180	155	135	200
Total Hardness	mg/l	35	32.5	30	200
Chloride	mg/l	75	73	73	250
Chemical OxygenDemand	mg/l	288	264	256	250
DO	mg/l	0.6	5.33	6.3	4
BOD	mg/l	23	3.1	3.4	1
E coli	MPN /100 ML	500	90	70	3
Acidity	mg/l	50	80	95	50

FLOW RATE

- Flow rate (10 cm thickness) = inlet volume / time
  = 250/ 58
  = 4.31ml/ sec
- Flow rate (15 cm thickness)
  =250/ 81
  =3.1ml/sec

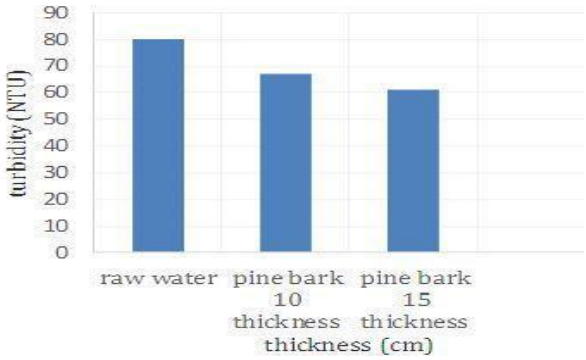

Fig-7: Turbidity v/s thickness graph for pine bark

By trial and error method, acidity is higher and flow rate is lesser for 15 cm thickness layer. 10cm layer is reducing turbidity and E coli without creating a greater difference with 15cm thickness. The efficiency of 10cm layer thickness is calculated as 16% and 15cm layer thickness is calculated as 23%. So 10cm layer is more preferred here. Since the acidity is increasing by the application of pine bark, coarse aggregate is introduced as another filter material (Tesfaye Betela Bekalo (2017)). The increase in acidity is due to the acidic nature of pine bark.

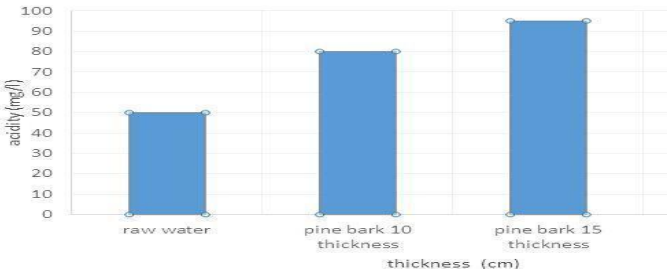

Fig-8: Acidity v/s thickness graph for pine bark

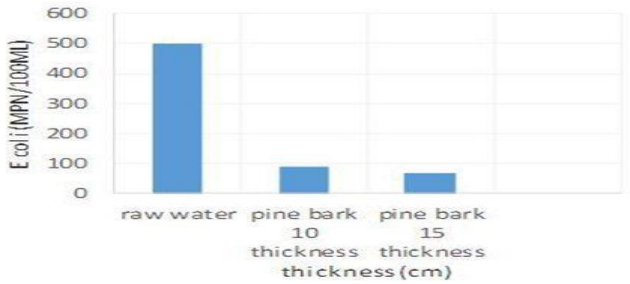

Fig-9: E coli v/s thickness graph for pine bark

The efficiency of E coli for 10cm layer thickness is calculated as 82% and 15cm layer thickness is calculated as 86%. The reduction in E coli is due to the presence of pycnogenol in pine bark.

Presence of ligno cellulose in pine bark harboured essential microorganisms and for the existence of this, the dissolved oxygen is consumed.

B. CACTUS

Table-3: Properties of water on 3cm and 6cm layer thickness

Parameters	Unit	Raw water	Passing through 3cm thickness	Passing through 6cm thikness	Desirable Limit as per Is1050 0 :1991
pH	-	6.74	6.7	6.51	6.5-8.5
Turbidity	NTU	80	34	2 8	5
Total Alkalinity	mg/l	180	170	180	200
Total Hardness	mg/l	35	27.5	20	200
Chloride	mg/l	75	75	75	250
Chemical Oxygen Demand	mg/l	288	232	218	250
DO	mg/l	0.6	0.98	1.18	4
BOD	Mg/l	23	15.1	12.2	1
Acidity	mg/l	50	45	35	50

FLOWRATE

For 3cm thickness = 250/315.6

= 0.8 ml/sec

For 6cm thickness = 250/ 1573.8

= 0.15ml/sec

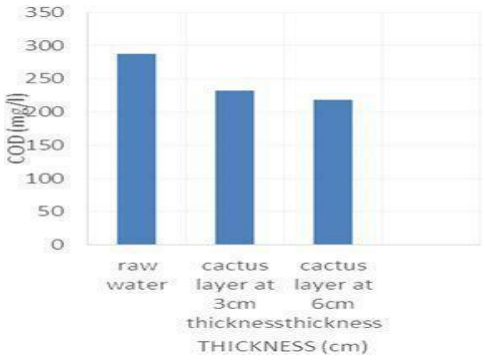

Fig-10: COD v/s thickness graph for cactus

By trial and error method, COD removal of 3cm and 6cm layers shows negligible difference. But 6cm layer has less flow rate and thus we fixed 3cm cactus layer. The efficiency of 3cm layer thickness is calculated as 19% and 6cm layer thickness is calculated as 30%. By the application of cactus, the presence of cladode in it reduces chemical oxygen demand and turbidity

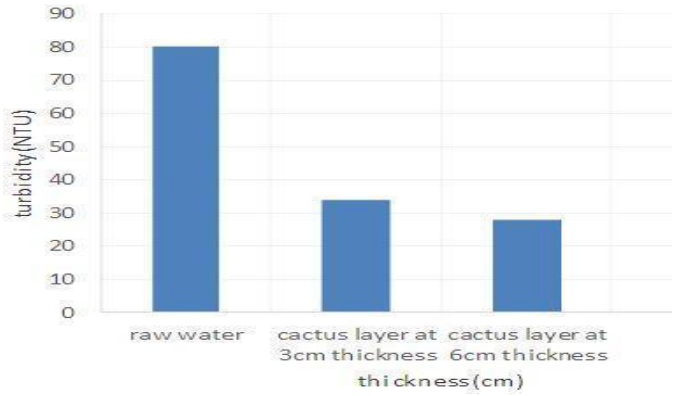

Fig-11: Turbidity v/s thickness graph for cactus

The efficiency of 3cm layer thickness is calculated as 57% and 6cm layer thickness is calculated as 65%. Since 3cm shows 5 times flow rate than 6cm layer thickness it is taken into consideration.

As per the obtained results, we can see a slight reduction in the amount of acidity.

FLOW RATE

For combined filter = inlet volume / time

= 250 / 423.6

= 0.6 ml/sec

EFFICIENCY

For combined filter = 100 (initial E Coli –final E Coli)/ initial E Coli

= 100(500-70)/500

= 86%

C. COMBINED LAYER

Table 6.3: Properties of water on combined layer

Parameter	Unit	Raw water	Combined layer	Test procedure	Desirable Limit as per Is 10500 :1991
pH	-	6.74	6.6	IS : 3025 Part 11-1983 (Reaff: 2002)	6.5-8.5
Turbidity	NTU	80	22	IS : 3025 Part 10-1984 (Reaff: 2002)	5
Total Alkalinity	mg/l	180	165	IS : 3025Part 23-1986(Reaf f:2003)	200
	mg/l	35	25	IS : 3025 Part 21-1983 (Reaff: 1998)	200
Chloride	mg/l	75	75	IS : 3025 Part 32-1988 (Reaff: 2003)	250
Chemical Oxygen Demand	mg/l	288	200	IS:3025:Part-58:2006	250
DO	mg/l	0.6	5.9	IS:3025:Part-38:2006	4
BOD	mg/l	23	2.9	IS:3025:Part-44:2006	1
E coli	MPN /100 ML	500	70	-	3
Acidity	mg/l	50	40	IS: 3025 Part 23-1986(Reaf:2003)	50

6. RESULTS AND DISCUSSIONS

The reduction in pH is due to acidic nature of pine bark.

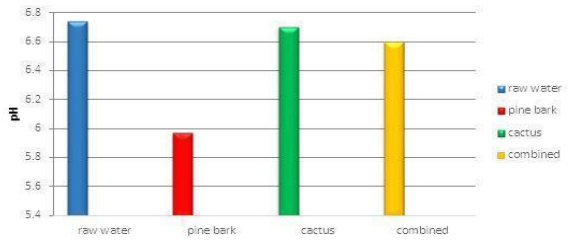

Fig-12: Variation of pH with different layer thickness

Turbidity is the measure of clarity of water. Lesser the value of turbidity more is the clarity of water. The combined efficiency is calculated as 72%. Pine bark and roof tile materials are capable of reducing turbidity.

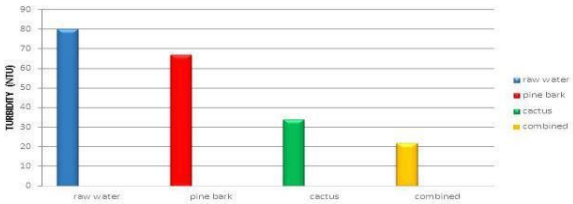

Fig-13: Variation of turbidity with different layer thickness

Alkalinity of water may be defined as its capacity to neutralize acid. Alkali substances in water include hydroxides or bases. They can be detected by their acrid taste.

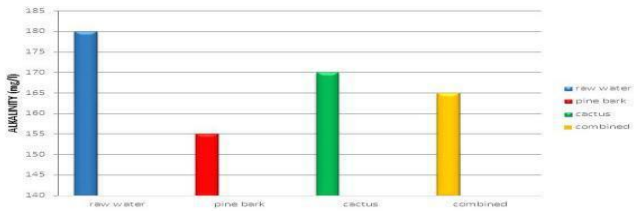

Fig-14: Variation of alkalinity with different layer thickness

Hardness; Calcium and magnesium dissolved in water are the two most common minerals that make water "hard". The hardness was reduced when passed through fine powdered cactus.

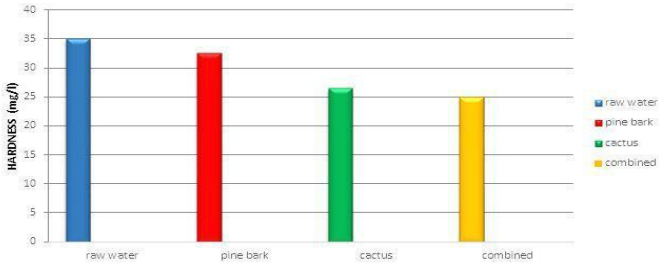

Fig-15: Variation of hardness with different layer thickness

Chloride content is the presence of Cl- ions in water. The chloride content should not exceed 250mg/l as per the IS 10500, 1992 which shows that the water is unfit for drinking purposes.

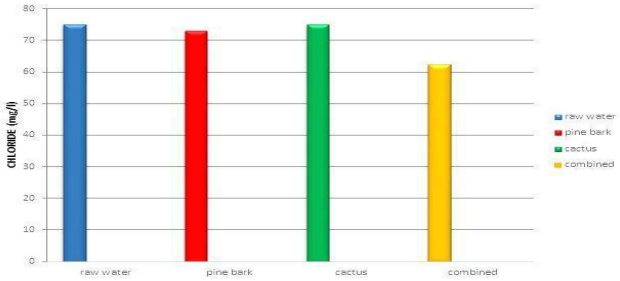

Fig-16: Variation of chloride with different layer thickness

Dissolved oxygen refers to the level of free non-compound oxygen present in water. It's an important parameter in assessing water quality because it influences the living organisms within the water body.

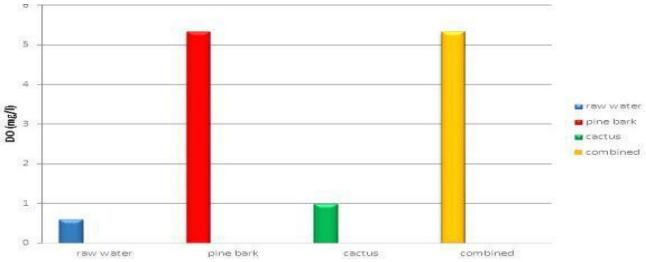

Fig-17: Variation of dissolved oxygen with different layer thickness

Biochemical Oxygen Demand is the amount of dissolved oxygen needed or demanded by aerobic microorganisms to break down organic material present in given water sample at certain temperature over specific time period.The reduction of BOD is due to the lingo cellulose present in pine bark.

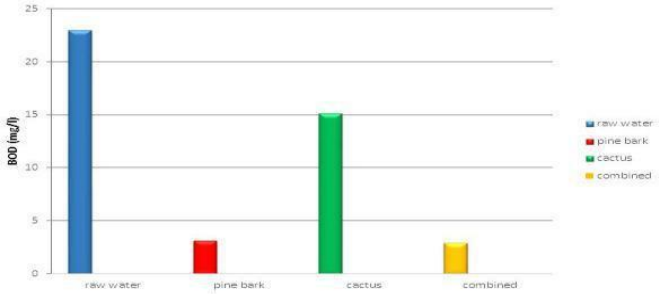

Fig-18: Variation of BOD with different layer thickness

Chemical Oxygen Demand (COD) is the measure of the capacity of water to consume oxygen during the decomposition of organic matter and oxidation of inorganic chemicals such as ammonia and nitrate. The percentage reduction of COD content is calculated as 30%. The presence of cladode in cactus reduce COD content

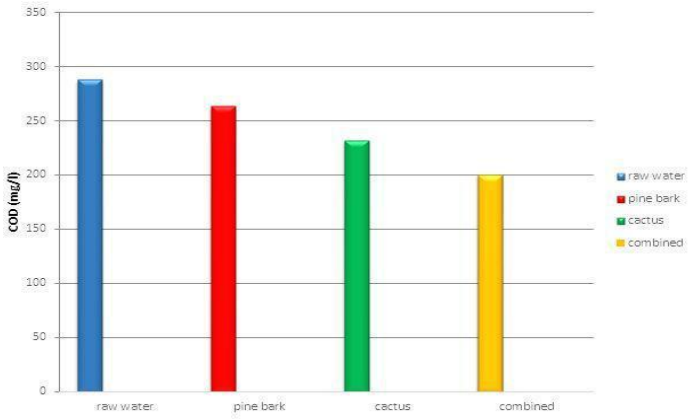

Fig-19: Variation of chemical oxygen demand with different layer thickness

E-coli – A convenient test for quantitative measure of total coliform and E coli bacteria. The reduction of E coli is due to the pycnogenol present in pine bark. Since the cactus has no ability to remove E coli, the test was not conducted.

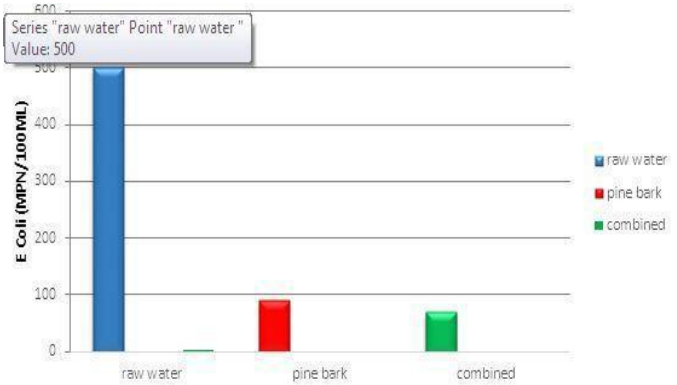

Fig-20: Variation in E coli with different layer thickness

Acidity is defined as a substance which react with base. Hydrogen ions present in sample as a result of dissociation hydrolysis of solutes is neutralized by titration with standard alkali. Thus the acidity depends on end point pH or indicator used. The acidity increased by the addition of pine bark due to its acidic nature

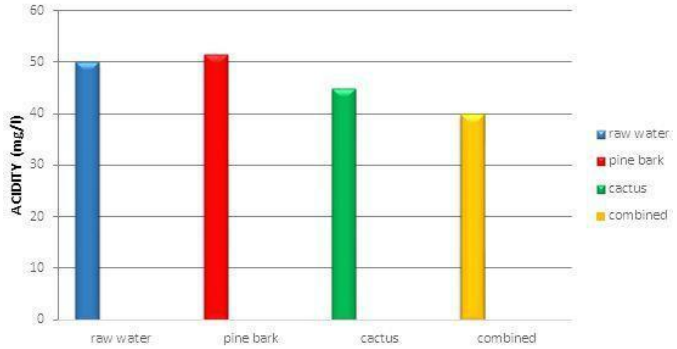

Fig-21: Variation of acidity with different layer thickness

3. CONCLUSION

An experimental study was conducted to analyse the waste water characteristics. The filter was designed by trial and error method. The materials which were used here are pine bark, cactus, pieces of roof tiles as coarse aggregate and sand. The flow rate of different materials was found out at different thickness. The application of pine bark proves the reduction of turbidity, E coli but it leads to increase in acidity. Therefore, a new material i.e. roof tile pieces was introduced for reduction of acidity. The application of cactus helped in the reduction of COD and turbidity. Effective thickness was found out using column study and it was concluded that 10cm thick pine bark layer and 3cm thick cactus layer will give more efficient result at better flow rate. The combined percentage reduction for turbidity, COD, E coli is obtained as 72%, 30%, and 82% respectively. The reduction of COD is due to the addition of cactus and turbidity is reduced due to pine bark and roof tile coarse aggregate. A combined layer filter was constructed which is capable in reduction of COD, turbidity and E coli.

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