Coir Geotextile Baffle as Biofilm Attachment Media for Greywater Treatment

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Abstract: ***The aim of this work was to investigate the feasibility of using coir geotextile as biofilm attachment media in the treatment of greywater for the removal of various pollutants. The main objectives of the study was to determine the performance of coir geotextile in grey water treatment using various types of coir geotextile materials and optimize the material type in which geotextile can perform well. And also test results were comparing with sequencing batch reactor treatment process. The removal of Chemical Oxygen Demand (COD) Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and Turbidity were monitored for different experimental conditions. Results obtained from the experiments indicated that GBCS is an effective tool for the removal of COD, BOD, TSS, Turbidity and TDS from greywater.***

Keywords: Coir geotextile, biofilter, grey water, Removal efficiency, SBR

1. Introduction

Water is one of the basic requirements for existence and survival in biosphere and also it is used for economic developments. Nowadays consumption of water is increased and also availability of natural water resources is reduced. Hence we should find a remedy for the fresh water crises. Use any process that improves the quality of water to make it more acceptable for a specific end use. The end use may be drinking, industrial, water supply, irrigation, river flow, maintenance, water recreation or many other uses. Including being safely returned to the environment.

Grey water is all waste water that is discharged from a house, excluding black water (toilet water). This includes water from showers, bathtubs, sinks, kitchen dishwashers, laundry tubs, and washing machine. It commonly contains soap, shampoo, and tooth paste food scraps, cocking oils, detergents and hair. Typically 50-80% of the household's waste water is grey water.

In this project the grey water can be recycled or treated successfully using simple methodologies. Coir woven geotextile materials are used for the grey water treatment. Geotextile used in the form of baffle and then it fitted in a rectangular tank. This geotextile baffle used as a biofilm attachment media for grey water treatment. Coir geotextile is given in coconut fiber extracted from the husk of the coconut fruit. This project introduces how to use coir geotextile in the environmental field especially in the waste water treatment technologies.

2. Objectives

1. Assessing performance of coir geotextile in grey water treatment using various type of geotextile material and optimize the material type in which geotextile can perform well.
2. Assess the system performance according to change in baffle spacing.
3. Assess the system performance according to change in layers of geotextile in baffle.
4. Evaluate system performance without aeration.
5. Comparison with sequencing batch reactor.

3. Methodology

3.1 Sample collection

Grey water used for the treatment process was collected from M-DIT College Ulliyeri.This include, waste water from college canteen, sink, floor cleaning water and wash base water etc. The samples are collected on morning section of the day. It collected in colour less plastic bucket of 20 liters capacity for Physico-chemical analysis.

3.2 Characteristics of grey water

The characteristics of grey water such as pH, Temperature, Turbidity, Total Suspended Solids, Total Dissolved Solids, Biochemical Oxygen Demand, Chemical Oxygen Demand and Dissolved Oxygen were analyzed using standard methods.

3.3 Material collection

For this experimental study three types of coir geotextile were used. H2M4, H2M5, H2M6

Table 1: Types of Coir Geotextile

Designation	Mass/unit area (g/m2)	Aperture size (mm)
H_2M_4	1400	10×2
H_2M_5	740	11.7×13.2
H_2M_6	400	25×25

3.4 Experimental setup

Experimental setup consists of a rectangular reactor of 60 cm length, 30cm width, and 30cm height. It is a rectangular glass tank and then the tank was fitted with square shaped wooden frames, in order to achieve efficient fitting of the baffles. Baffle is made by using coir geotextile having thickness 0.5 mm. Also in each experiment frame was completely filled with coir geotextile material. In this experiment change the spacing of each baffle and change the thickness of coir geotextile filled in the frames. The width of frame is 2 cm.

Woven type geotextile are used for this experiment. Coir geotextile are available in large mats. They were cut in to rectangles of dimension 30×29 cm so as to form baffles.

The bioreactor was aerated with a fish tank aerator of capacity 2.5 l/min. Provide six air bushes were used in order to supply sufficient air in the baffle pockets.

Figure 1: Final View of Experimental Setup

3.5 Startup of the reactor

The aerobic sludge collected from diary waste treatment plant and this aerobic sludge seeded in to the biofilter media along with greywater. The geotextile material in the biofilter allowed undergoing acclimatization with bacteria for a period of 5 days.

3.6 Procedure

After the period of acclimatization, collect 20 liters of grey water and fed in to the bioreactor media by means of gravity. The grey water admitted to the bioreactor at a constant rate of 4.5 l/min. then aeration was provided to each compartment by using fish tank aerator. Fish tank aerator supplying 2.5 l/min air in to the reactor. The HRT of the experimental setup is 24 hrs and the effluent is collected from the last compartment and tested the various parameters such as pH, Temperature, Turbidity, Total Dissolved Solids, Total Suspended Solids, Biological oxygen demand, Chemical Oxygen Demand, and Dissolved Oxygen. Then the main objectives of the study are 1. Comparison of different type geotextile material, 2. Assess the system performance according to change in baffle spacing, 3. Assess the system performance according to change in layers of geotextile in baffle, 4. Evaluate system performance without aeration, and 5. Comparison with sequencing batch reactor

3.6.1 Comparison of different type geotextile material

Different types of coir geotextile are fitted on the bioreactor at constant experimental condition and coir geotextile are H_2M_4, H_2M_5, and H_2M_6. Then compares the performance of the bioreactor. After the treatment process effluent collected and test the various parameters such as pH, Temperature, Turbidity, Total Suspended Solids, Total Dissolved Solids, Biological Oxygen Demand, Chemical Oxygen Demand and Dissolved Oxygen.

3.6.2 Assess the system performance according to change in baffle spacing

Assess the system performance according to change in baffle spacing. First set the baffle spacing at 8.3 cm. five numbers of baffles are provided. And check the treatment efficiency. Then change the baffle spacing to 10.4 cm. Four numbers of baffles is provided. Same as, check the treatment efficiency. Effluent collected at a constant interval of 24 hrs

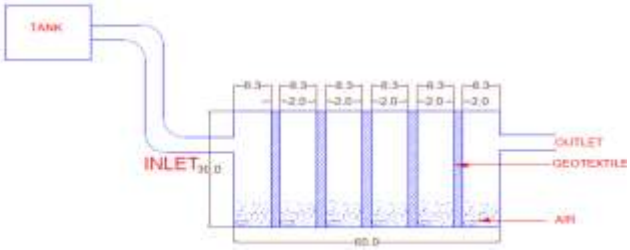

Figure 2: Cross Section of GBCS (Spacing 8.3 cm)

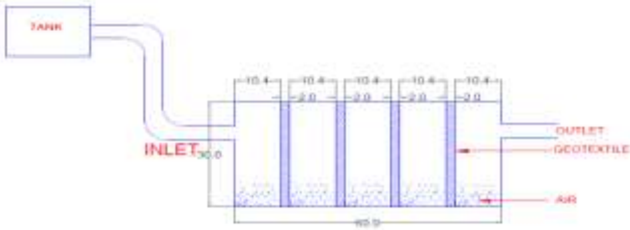

Figure 3: Cross Section of GBCS (Spacing 10.4 cm)

3.6.2 Assess the system performance according to change in layers of geotextile in baffle

System performance was monitored for change in layers of geotextile in baffle. Mainly single and double layer of geotextile are set in the baffle and check the treatment efficiency. Effluent from the reactor was collected at a constant interval of 24 hrs. And test the parameters.

3.6.3 Evaluate system performance without aeration.

The geotextile biofilter media was performing without aeration. Fish tank aerator is not included in the experimental setup. The grey water treated only using coir geotextile material. It not depends on the aeration. Then effluent collects after 24 hrs and tests the parameters.

3.6.4 Comparison with sequencing batch reactor

Sequencing batch reactor utilizes fill and draw with complete mixing during batch reaction step. Where subsequent step of aeration and clarification are occur in the same tank. All SBR process five step occur

(a) Fill

During fill operation, volume and substrate (raw waste water) are added to the reactor. The fill process typically allows the liquid level in the reactor to rise from 75% of capacity to 100%.during fill; the reactor may be mixed only or mixed and aerated to promote biological reaction with the influent waste water.

(b) React

During the react period, the biomass consumes the substrate under controlled environmental conditions.

(c) Settle

Solids are allowed to separate from the liquid under quiescent conditions, resulting in a clarified supernatant that can be discharged as effluent.

(d) Draw

Clarified effluent is removed during the decant period. Many types of decanting mechanisms can be used, with the most popular being floating or adjustable weirs.

(e) Idle

An idle period is used in a multitank system to provide time for one reactor to complete its fill phase before switching to another unit. Because idle is not a necessary phase, it is sometimes omitted.

The treatment efficiency of sequencing batch reactor is compare with treatment efficiency of geotextile used bioreactor.

4. Result and Discussion

4.1 System performance under different coir geotextile material

Table 2: System Performance under H_2M_4 Type Coir Geotextile Material (8.3 cm Spacing)

Parameters	H_2M_4-8.3 cm spacing		Removal efficiency (%)
	Effluent	Influent	
pH	8.5	7.52	
Turbidity (NTU)	381	15	96.06
Temperature (ºC)	30.1	30.1	
Total dissolved solids (ms/ppt)	590.1	1.03	99.82
Total suspended solids (mg/l)	127.8	56.15	99.72
BOD (mg/l)	148	39.6	73.24
COD (mg/l)	421.6	80.56	80.89

Table 3: System Performance under H_2M_5 Type Coir Geotextile Material (8.3 cm Spacing)

Parameters	H_2M_5-8.3 cm spacing		Removal efficiency (%)
	Effluent	Influent	
pH	9.7	7.3	
Turbidity (NTU)	385	28	92.72
Temperature (ºC)	30.1	29.4	
Total dissolved solids (ms/ppt)	534.52	2.7	99.49
Total suspended solids (mg/l)	145.5	60.8	58.21
BOD (mg/l)	186.5	59.4	68.15
COD (mg/l)	340	86	74.47

Table 4: System Performance under H_2M_6 Type Coir Geotextile Material (8.3 cm Spacing)

Parameters	H_2M_6-8.3 cm spacing		Removal efficiency (%)
	Effluent	Influent	
pH	5.12	7.27	
Turbidity (NTU)	492	198	59.75
Temperature (ºC)	31.7	32.8	
Total dissolved solids (ms/ppt)	563.33	80.95	78.55
Total suspended solids (mg/l)	210.32	98.5	53.16
BOD (mg/l)	210	120.6	42.57
COD (mg/l)	340	98	71.17

Table 5: System Performance under H_2M_4 Type Coir Geotextile Material (10.4 cm Spacing)

Parameters	H_2M_4-10.4 cm spacing		Removal efficiency (%)
	Effluent	Influent	
pH	8.7	7.7	
Turbidity (NTU)	285	28	90.17
Temperature (ºC)	31.1	30.7	
Total dissolved solids (ms/ppt)	478.78	5.14	98.92
Total suspended solids (mg/l)	205.6	75.51	63.27
BOD (mg/l)	128.4	65.8	48.75
COD (mg/l)	413.5	102	75.33

Table 6: System Performance under H_2M_5 Type Coir Geotextile Material (10.4 cm Spacing)

Parameters	H_2M_5-10.4 cm spacing		Removal efficiency (%)
	Effluent	Influent	
pH	5.73	7.48	
Turbidity (NTU)	166	58	65.06
Temperature (ºC)	29.1	28.5	
Total dissolved solids (ms/ppt)	225.38	6.92	96.92
Total suspended solids (mg/l)	56.5	28.3	49.91
BOD (mg/l)	101.6	56.5	44.38
COD (mg/l)	402.3	124	69.19

Table 7: System Performance under H_2M_6 Type Coir Geotextile Material (10.4 cm Spacing)

Parameters	H_2M_6-10.4 cm spacing		Removal efficiency (%)
	Effluent	Influent	
pH	5.3	7.3	
Turbidity (NTU)	356	156	56.17
Temperature (ºC)	30.1	30	
Total dissolved solids (ms/ppt)	239.8	80.4	66.47
Total suspended solids (mg/l)	186	100.3	46.07
BOD (mg/l)	189	110	41.79
COD (mg/l)	327	115	64.83

Table 8: System Performance under Different Coir Geotextile Material (8.3 cm Spacing)

Parameters	Removal efficiency(%)-8.3 cm spacing		
	H_2M_4	H_2M_5	H_2M_6
Turbidity (NTU)	96.06	92.72	59.75
Total dissolved solids (ms/ppt)	99.82	99.49	78.55
Total suspended solids (mg/l)	83.69	58.21	53.16
BOD (mg/l)	73.24	68.15	42.57
COD (mg/l)	80.86	74.47	71.17

Table 9: System Performance under Different Coir Geotextile Material (10.4 cm Spacing)

Parameters	Removal efficiency(%)-10.4 cm spacing		
	H_2M_4	H_2M_5	H_2M_6
Turbidity (NTU)	90.17	65.06	56.17
Total dissolved solids (ms/ppt)	98.92	96.92	66.47
Total suspended solids (mg/l)	63.27	49.91	46.07
BOD (mg/l)	48.75	44.38	41.79
COD (mg/l)	75.33	69.19	64.83

On the basis of test results the percentage removal for BOD, COD, TDS, TSS, and Turbidity showed maximum removal for the H_2M_4 coir geotextile material. H_2M_4 has small mesh size compared to H_2M_5 and H_2M_6. The mesh size of H_2M_4 is 10×2 mm. The mesh size decreases or pore size decreases then increase the specific area available for attach the biomass in to the material. Then the treatment efficiency increased. The removal efficiency for COD, BOD, TDS, TSS and Turbidity at 8.3 cm spacing and 24hr HRT for the material H_2M_4 was recorded as 80.89%, 73.24%, 99.82%, 99.72%, 96.06%.And also at 10.4 cm spacing the efficiency was recorded as 75.53%, 48.75%, 98.92%, 63.27%, 90.97%

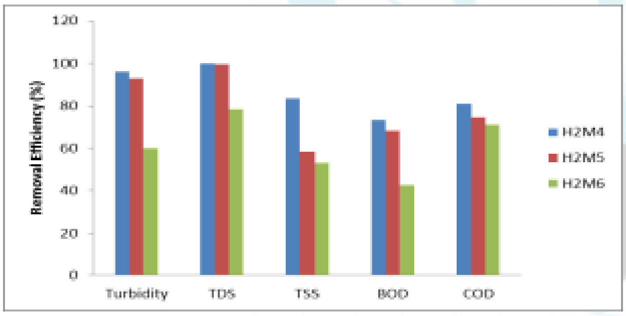

Figure 4: System Performance under Different Geotextile Material (8.3 cm Spacing)

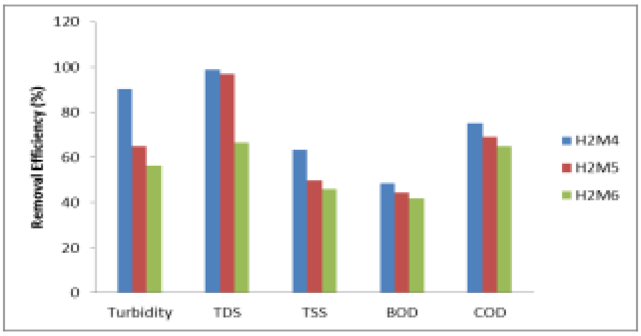

Figure 5: System Performance under Different Geotextile Material (10.4 cm Spacing)

4.2 System performance under different baffle spacing

Table 10: System Performance under Different Baffle Spacing

Parameters	Removal efficiency(%)-10.4 cm spacing					
	8.3 cm spacing			10.4 cm spacing		
	H_2M_4	H_2M_5	H_2M_6	H_2M_4	H_2M_5	H_2M_6
Turbidity (NTU)	96.06	92.72	59.75	90.17	65.06	56.17
Total dissolved solids (ms/ppt)	99.82	99.49	78.55	98.92	96.92	66.47
Total suspended solids (mg/l)	83.69	58.21	53.16	63.27	49.91	46.23
BOD (mg/l)	73.24	68.15	42.57	48.75	44.38	41.79
COD (mg/l)	80.89	74.47	71.17	75.33	69.19	64.83

It is observed that system performance get decreased as baffle spacing increased. System performance according to change in baffle spacing is shown in above table. As baffle spacing increases specific area of biofilter available for adhering the biomass decreased thus biomass intensity get decreased.

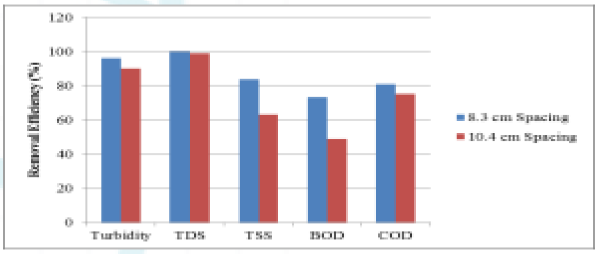

Figure 6: System Performance under Different Baffle Spacing (H_2M_4)

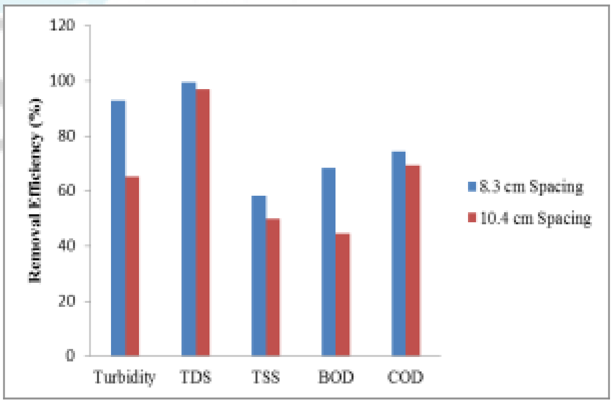

Figure 7: System Performance under Different Baffle Spacing (H_2M_5)

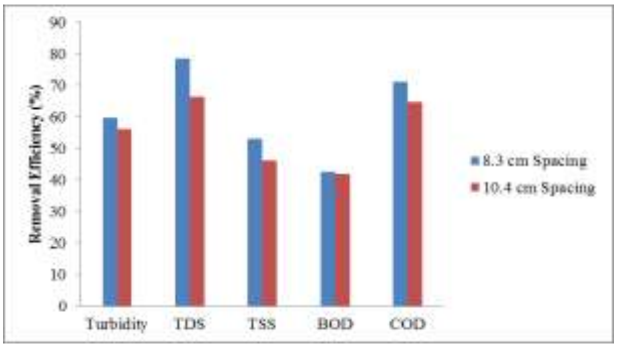

Figure 8: System Performance under Different Baffle Spacing (H_2M_6)

4.3 System performance according to change in layers of geotextile in baffle

Table 11: Double Layers of Geotextile in Baffle

parameters	Double Layers Of Geotextile In Baffle		Removal efficiency (%)
	Effluent	Influent	
pH	8.5	7.5	
Turbidity (NTU)	325	3	99.07
Temperature (ºC)	31	31	
Total dissolved solids (ms/ppt)	590.1	1.03	99.82
Total suspended solids (mg/l)	116.3	15.3	86.84
BOD (mg/l)	165.6	22	86.71
COD (mg/l)	364	45.36	87.75

Table 12: System performance according to change in layers of geotextile in baffle

Parameters	Removal efficiency (%)-H2M4	
	Single Layer	Double Layer
Turbidity (NTU)	96.06	99.07
Total dissolved solids (ms/ppt)	99.82	99.82
Total suspended solids (mg/l)	83.69	86.84
BOD (mg/l)	73.24	86.71
COD (mg/l)	80.89	87.75

According to test results geotextile layer in baffle play a great role in the treatment mechanism. The layers of geotextile in baffle increases growth of microorganism increases on the geotextile and then biodegradation of organic matter in the grey water increases. The removal efficiency for turbidity, TDS, TSS, BOD, and COD was recorded as 99.07%, 99.82%, 86.84%, 86.71%, and 87.75% respectively.

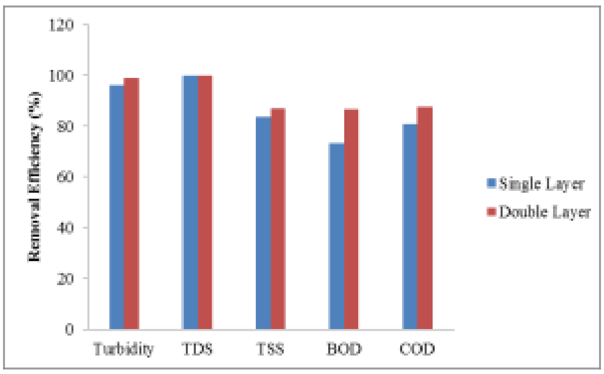

Figure 9: System Performance According to Change in Layers of Geotextile in Baffle

4.4 System performance without aeration

Table 13: System performance without aeration

Parameters	H_2M_4- Without Aeration		Removal efficiency (%)
	Effluent	Influent	
pH	7.6	6.3	
Turbidity (NTU)	356	199.3	44.01
Temperature (ºC)	31.6	30.6	
Total dissolved solids (ms/ppt)	506.52	227.87	55.01
Total suspended solids (mg/l)	125.6	68.3	45.62
BOD (mg/l)	189.2	120.3	36.41
COD (mg/l)	327	202	38.22

Table 14: Removal efficiency with and without aeration

Parameters	Removal efficiency (%)-H2M4	
	With Aeration	Without Aeration
Turbidity (NTU)	96.06	44.01
Total dissolved solids (ms/ppt)	99.82	55.01
Total suspended solids (mg/l)	83.69	45.62
BOD (mg/l)	73.24	36.41
COD (mg/l)	80.89	38.22

The removal efficiency for Turbidity, TDS, TSS, BOD and COD without aeration was recorded as 44.01%, 55.01%, 45.62%, 36.41% and 38.22% respectively. Aeration is an efficient factor for this treatment process. Biofiltration process is usually aerobic, which mean microorganisms require oxygen for their metabolism. Due to the absence of oxygen or air in to the biofilter media the growth of microorganisms does not occur. So aeration has a vital role in the treatment process.

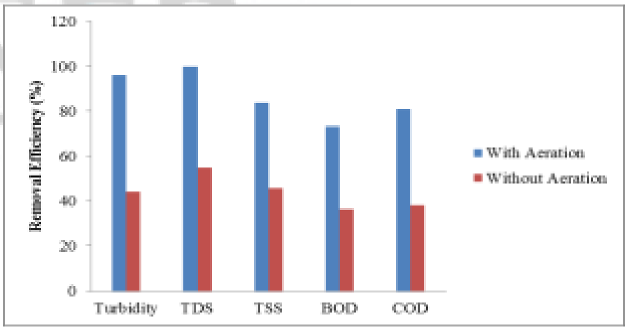

Figure 10: Removal Efficiency With and Without Aeration

4.5 Performance of sequencing batch reactor

Table 15: Performance of sequencing batch reactor

Parameters	SBR		Removal efficiency (%)
	Effluent	Influent	
pH	8.5	7.5	
Turbidity (NTU)	381	63	83.46
Temperature (ºC)	30.1	30.1	
Total dissolved solids (ms/ppt)	590.13	67.7	88.52
Total suspended solids (mg/l)	127.8	36.3	71.59

BOD (mg/l)	148	69	53.33
COD (mg/l)	421.6	206	51.13

Table 16: Comparison with sequencing batch reactor

Parameters	Removal efficiency (%)	
	Geotextile (H_2M_4)	SBR
Turbidity (NTU)	96.06	83.46
Total dissolved solids (ms/ppt)	99.82	88.52
Total suspended solids (mg/l)	83.69	71.59
BOD (mg/l)	73.24	53.33
COD (mg/l)	80.89	51.13

The SBR performance was evaluated by effluent characteristics. In the SBR treatment process percentage removal efficiency for Turbidity, TDS, TSS, BOD and COD was recorded as 83.46%, 88.52%, 71.59%, 53.33% and 51.13%. Coir geotextile baffle wall treatment process get good treatment efficiency compare to SBR process. Bio filtration, biodegradation, adsorption mechanism occur in highest level compare to SBR process**.**

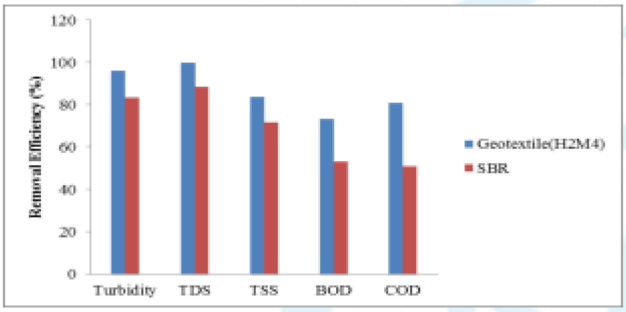

Figure 11: Comparison with sequencing batch reactor

4.6 Comparison with prescribed standards

Table 17: Comparison with prescribed standards

Parameters	Influent	Effluent	Permissible Value
pH	8.5	7.5	5.5-9
Turbidity (NTU)	325	3	5-10
Temperature (ºC)	31	31	-
Total dissolved solids (ms/ppt)	590.1	1.03	2100
Total suspended solids (mg/l)	116.3	15.3	200-for land irrigation 100-inland irrigation
BOD (mg/l)	165.6	22	30-For inland irrigation 100-land irrigation
COD (mg/l)	364	45.36	250-Land Irrigation

According to this BOD, COD, Turbidity, TDS, TSS & pH reaches the required quality for land irrigation. So the treated water by GBCS treatment will be suitable for irrigation and agricultural purposes

5. Conclusion

Water is one of the basic requirements for existence and survival in biosphere and also it is used for economic developments. Nowadays consumption of water is increased and also availability of natural water resources is reduced. Hence we should find a remedy for the fresh water crises. Use of any process that improves the quality of water to make it more acceptable for a specific end use. From the experiment result, it is proved that GBCS is an effective tool for grey water treatment.

- Based on the test result this experimental setup is woven type coir geotextile material treat the grey water successfully.
- Filter media used in GBCS is woven Coir geotextiles which are cheap, easy to available, biodegradable, durable and also have ability to attach and culture biomass. So it can be considered as an effective material to use as bio filter media.
- The main factors affect the performance of the bioreactor is type of the material baffle spacing, layers of geotextile and aeration availability.
- GBCS filtering media is arranged as vertical baffle walls. This arrangement support both suspended and attached growth of microbes.
- The material H2M4 showed maximum removal efficiency compare to other type of material because the material pore size decreased the specific area available for adhering the biomass gets increased. This directly increases the system performance.
- System performance decreases with increase in baffle spacing. As baffle spacing increases system performance suddenly reduced.
- System performance increase with increase in layers of geotextile in baffles. Layers increases specific weight of material increases then system performance gets increased.
- Bioreactor needs good aeration condition for the better performance. This is the only disadvantage to the system because it enhances the cost of setup.
- The geotextile bioreactor have high removal efficiency compare with Sequencing batch reactor

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