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Performance Evaluation of Packed Bed Reactor for the Treatment of Domestic Waste Water

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***Abstract**: The paper presents the importance and the necessity the efficiency of cleaning process of the domestic waste water. Attached biofilm reactors provide the means for implementing energy efficient anaerobic waste water treatment at full scale. Progress has been made in the development for fixed expanded and fluidized bed anaerobic process by addressing fundamental reactor design issues. The performance of aerobic submerged packed bed reactor was studied for the treatment of domestic waste water using different kinds of packing material with specific area. A reactor in which the filled inert packing material for the growth of biomass is kept packed is called as PBR. The flow of wastewater through the reactor may be upward or downward. The packing material commonly used as slag, rock or ceramic. In the present study, the treatment of domestic wastewater by using packed bed reactor with packing material of PVC flexible pipe is analysed.*
***Keywords: Alkalinity, Hardness, BOD, COD, Packed bed reactor, PVC flexible pipes**.*

I. INTRODUCTION

Waste water is any type of water that has been affected by human use. Waste water is used water from any combination of domestic, industrial, commercial or agriculture activities, surface run off or storm water and any sewer inflow or sewer infiltration.

Waste water is discharged to the environment without suitable treatment cause water pollution. The composition of wastewater varies widely that are Chemical or physical pollutant, Biological pollutants and Quality indicators.

The aerobic submerged packed bed reactor is made with a specific area of 760-1,200 m2/m3. When operated down flow in a continuous regime, have high degradation rates and allow obtaining of reclaimed water for reuse in public services. The determined specific COD removal rates were very similar in all reactors when they were operated at low organic load [1].

Packed bed is very widely studied contact equipment for wastewater treatment. The studies are reported on effect of parameter like flow rate, contact time, bed height, initial concentration and PH on the break through curve with initial concentration and flow rate, the break through time decreases and it increase with bed height [2].

Microorganism immobilize on a support media is the principle of anaerobic fixed film fixed bed reactors. Its increased capacity of microorganism retention on the support media can cause the hydraulic retention time reduced considerably. There for these types of reactor are widely and easily applied for the various wastewater treatments.

The experiments were performed at hydraulic retention times of 1, 2 and 3 d based on empty reactor volume and the performance of the reactor was evaluated based on the removal of organic matter COD, SS, PH Changes and biogas production. The average COD and SS removal efficiencies for Domestic wastewater were 63.87, 70.85, 75.92 % and 75.24, 84.55, 94.25 % respectively. PH changes from 7.2 to 4.2. Biogas was produced 0.50 to 0.59 l/d. on same HRT. The relationship between the organic removal rate and HRT was linear at flow rates of 0.58, 0.29 and 0.19 l/h. The study demonstrated the influence of HRTs and suitability of UAPB reactor for treatment of domestic wastewater [3].

Wastewater in the present study showed high levels of all the tested parameters that poses high pollution potential and dangerous effects on the receiving environments and also creates many difficulties in the treatment facilities. Fixation of bacteria on solid medium as a biofilm showed many advantages over their planktonic free living counterparts. It enhances the bacterial growth, reduces wastewater toxicity and increase bacterial resistance towards the involved contaminants. Considering the very short time that biofilm runs for (5 h), it seems that the proposed biofilm system is very efficient for treating the wastewater effluent [4].

In the present study, the treatment of domestic waste water using packed bed reactor is analysed.

II. METHODOLOGY

A. Reactor

Packed bed reactor is used to treat the domestic waste water. The reactor is made of Acrylic Plastic Material. The dimension of the reactor is 0.3x0.3x0.6m. The reactor is divided into three layers. Each layer consists of flexible PVC Pipe. It is used as medium in the reactor. Each layer consists of 0.2m height. The Inlet pipe is provided in the top of the reactor of dimension 1.5inch dia x 4 inch

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height. The outlet is provided in each layer of dimension 0.5 inch dia. A special filter is provided in every layer to filter the inlet water. The medium flexible PVC pipe has dimension of 2 inches length and 0.5 inch dia.

The reactor provided higher surface area per unit volume. The influent was introduced from the top of the reactor. The influent was distributed through the three layers of packing media of the reactor. The effluent was collected from the bottom of every layer outlet of the reactor in bucket and disposed with a suitable pipe connected to it.

Fig. 1. Packed Bed Reactor and PVC pipes

B. Reactor Operation

The reactor was first inoculated with seed culture contained aerobic bacteria originated from the sludge which was obtained from domestic wastewater treatment plant, Coimbatore and allowed to stand in that position for about period of 10 days, so that a biological growth can take place inside the reactor. After this, the reactor was fed batch wise with the influent starting with a detention time of 1d which was gradually increased to 5days. HRT was kept constant throughout the operation. The reactor was operated for 25 days.

III.RESULT AND DISCUSSION

The Packed bed reactor was continuously operated with constant HRT of 1, 2 and 3days.

TABLE I CHARACTERISTICS OF DOMESTIC WASTE WATER

Sl.No.	Characteristics of domestic wastewater	
	Parameter	Value
1	pH	8.5
2	Alkalinity	700mg/L
3	Hardness	1050mg/L
4	Chloride	960mg/L
5	TDS	2140mg/L
6	Fluoride	5.0mg/L
7	Iron	0.3mg/L
8	Ammonia	5mg/L
9	Nitrite	2.0mg/L
10	Nitrate	150mg/L
11	Phosphate	5mg/L
12	Residual Chlorine	2.0mg/L
13	COD	3570mg/L
14	BOD	940 mg/l

TABLE III CHARACTERISTICS OF TREATED WATER – 1ST DAY (EFFLUENT)

Sl.No.	Characteristics of treated water (Effluent)			
	Parameter	1st outlet	2nd outlet	3rd outlet
1	pH	8.5	7.5	7.5
2	Alkalinity	280mg/L	260mg/L	250mg/L
3	Hardness	420mg/L	410mg/L	390mg/L
4	Chloride	380mg/L	370mg/L	350mg/L
5	TDS	860mg/L	852mg/L	846mg/L
6	Fluoride	2.0mg/L	1.8mg/L	1.7mg/L
7	Iron	0mg/L	0mg/L	0mg/L
8	Ammonia	2.0mg/L	1.8mg/L	1.7mg/L
9	Nitrite	0.8mg/L	0.7mg/L	0.6mg/L
10	Nitrate	60mg/L	55mg/L	50mg/L
11	Phosphate	2.5mg/L	2.4mg/L	2.3mg/L
12	Residual Chlorine	1mg/L	0.8mg/L	0.6mg/L
13	COD	1430mg/L	1400mg/L	1390mg/L
14	BOD	400 mg/l	380mg/L	370mg/L

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TABLE IIIII Characteristics of treated water – 2nd day (Effluent)

Sl. No.	Characteristics of treated water (Effluent)			
	Parameter	1st outlet	2nd outlet	3rd outlet
1	pH	8.5	7.5	7
2	Alkalinity	210mg /L	200mg /L	180mg /L
3	Hardness	360mg /L	350mg /L	340mg /L
4	Chloride	290mg /L	270mg /L	260mg /L
5	TDS	780mg /L	762mg /L	746mg /L
6	Fluoride	1.0mg/ L	0.8mg/ L	0.7mg/ L
7	Iron	0mg/L	0mg/L	0mg/L
8	Ammonia	1.0mg/ L	0.8mg/ L	0.7mg/ L
9	Nitrite	0.5mg/ L	0.4mg/ L	0.3mg/ L
10	Nitrate	45mg/ L	40mg/ L	35mg/ L
11	Phosphate	1.5mg/ L	1.4mg/ L	1.3mg/ L
12	Residual Chlorine	0.5mg/ L	0.4mg/ L	0.4mg/ L
13	COD	1130m g/L	1100m g/L	1092m g/L
14	BOD	240 mg/l	230mg /L	230mg /L

TABLE IVV characteristics of treated water – 3rd day (Effluent)

Sl. No.	Characteristics of treated water (Effluent)			
	Parameter	1st outlet	2nd outlet	3rd outlet
1	pH	7.5	7	6.5
2	Alkalinity	160mg/ L	150mg/ L	140mg/ L
3	Hardness	290mg/ L	270mg/ L	260mg/ L
4	Chloride	290mg/ L	270mg/ L	260mg/ L
5	TDS	690mg/ L	672mg/ L	656mg/ L
6	Fluoride	0.5mg/ L	0.4mg/ L	0.3mg/ L
7	Iron	0mg/L	0mg/L	0mg/L
8	Ammonia	0.5mg/ L	0.4mg/ L	0.4mg/ L
9	Nitrite	0.2mg/ L	0.1mg/ L	0.1mg/ L
10	Nitrate	20mg/L	10mg/L	10mg/L
11	Phosphate	0.5mg/ L	0.4mg/ L	0.3mg/ L
12	Residual Chlorine	0.2mg/ L	0.1mg/ L	0.4mg/ L
13	COD	930mg/ L	920mg/ L	890mg/ L
14	BOD	240 mg/l	230mg/ L	230mg/ L

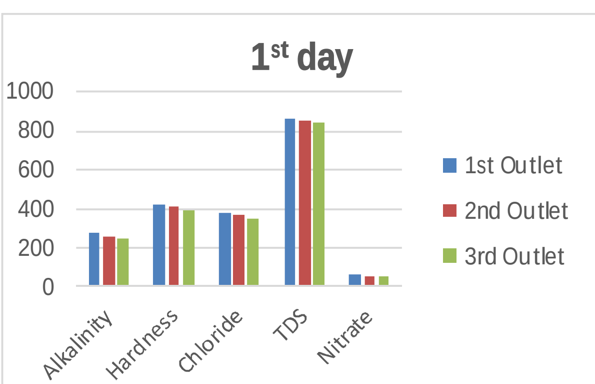

Fig. 2 Characteristics of treated effluent (Day 1)

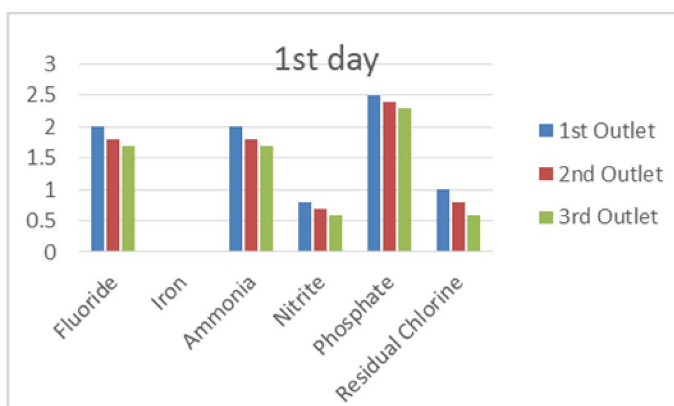

Fig. 3 Characteristics of treated effluent (Day 1)

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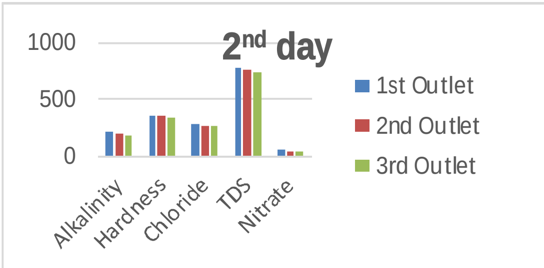

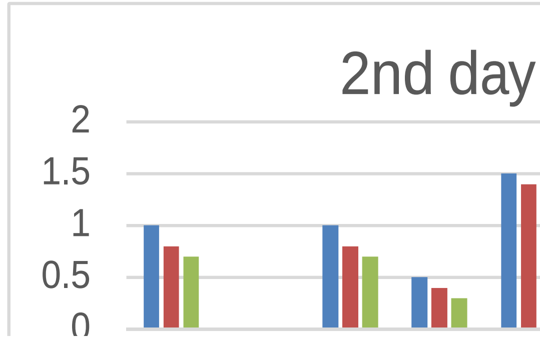

Fig. 4 Characteristics of treated effluent (Day 2) Fig. 5 Characteristics of treated effluent (Day 2)

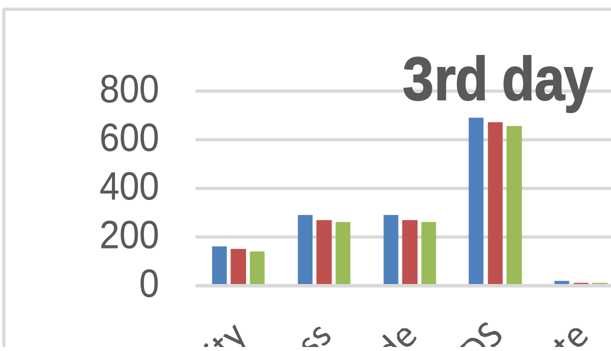

Fig. 6 Characteristics of treated effluent (Day 3)

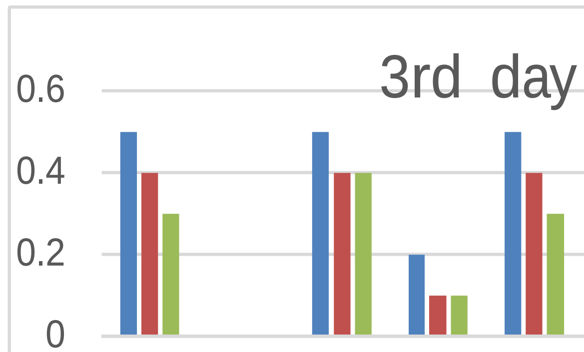

Fig. 7 Characteristics of treated effluent (Day 3)

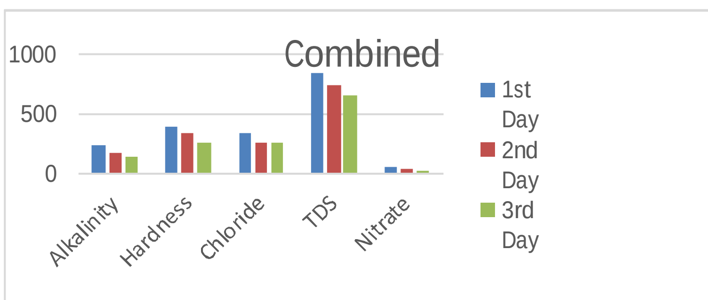

Fig. 8 Characteristics of treated effluent (Day 1,2,3- 3rd outlet)

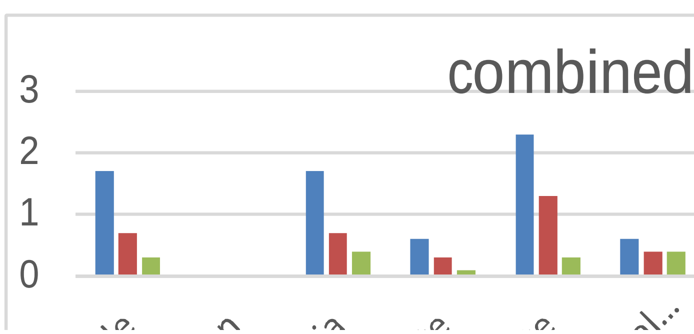

Fig. 9 Characteristics of treated effluent (Day 1,2,3- 3rd outlet)

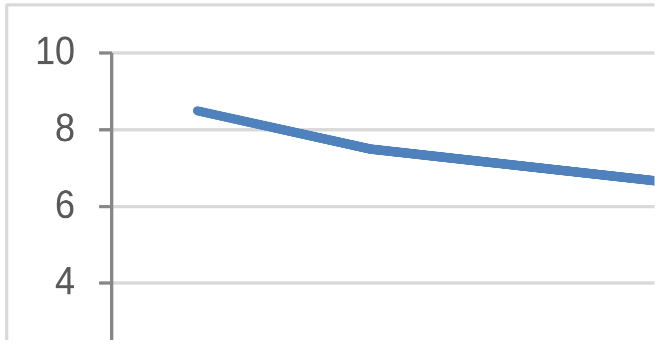

Fig. 10 Influence of HRT on pH (Day 1,2,3)

Figure -9 indicated the influence of HRTs on PH. The dark blue line is related to influent (original) pH and effluent pH (1st day, 2nd day, 3rd day). The pH of the effluent is showing a low value and this may be due to a longer detention time being provided to the domestic wastewater. Effluent pH decreased from 8.5 to 6.5 with increased in HRTs from 1day to 3day.

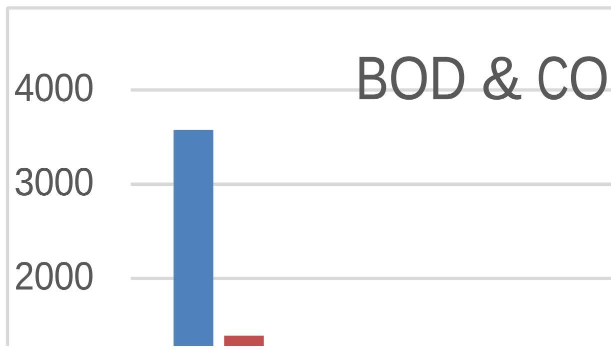

Fig. 11 BOD and COD removal (Day 1,2,3)

COD removal was decreased from 3570 to 890 mg/l. and BOD removal was decreased from 940 to 230 mg/l. COD and BOD removal efficiency was increased as 61%, 69%, 75% and 61%, 76%, 76% respectively as the HRTs increased 1, 2, 3 days. Fig. 11 shows the COD removal 75% and the BOD removal 76% on the 3rd day. After 3rd day, COD removal efficiency was increased from 75% and BOD removal efficiency was increased from 76%.

IV. CONCLUSIONS

The present research work was successfully conducted for the treatment of domestic wastewater and investigated the influence of the various HRTs on COD, BOD and pH in the Packed Bed Reactor successfully.

From the present research work, the following conclusions can be drawn:

A. At 3 day HRT, the COD, BOD removal of 890mg/l and 230 mg/l, and removal efficiency was obtained 75% and 76% respectively.

B. By increasing the HRT, the removal efficiency is also increasing.

C. High removal efficiency with minimum cost of Packed Bed Reactor.

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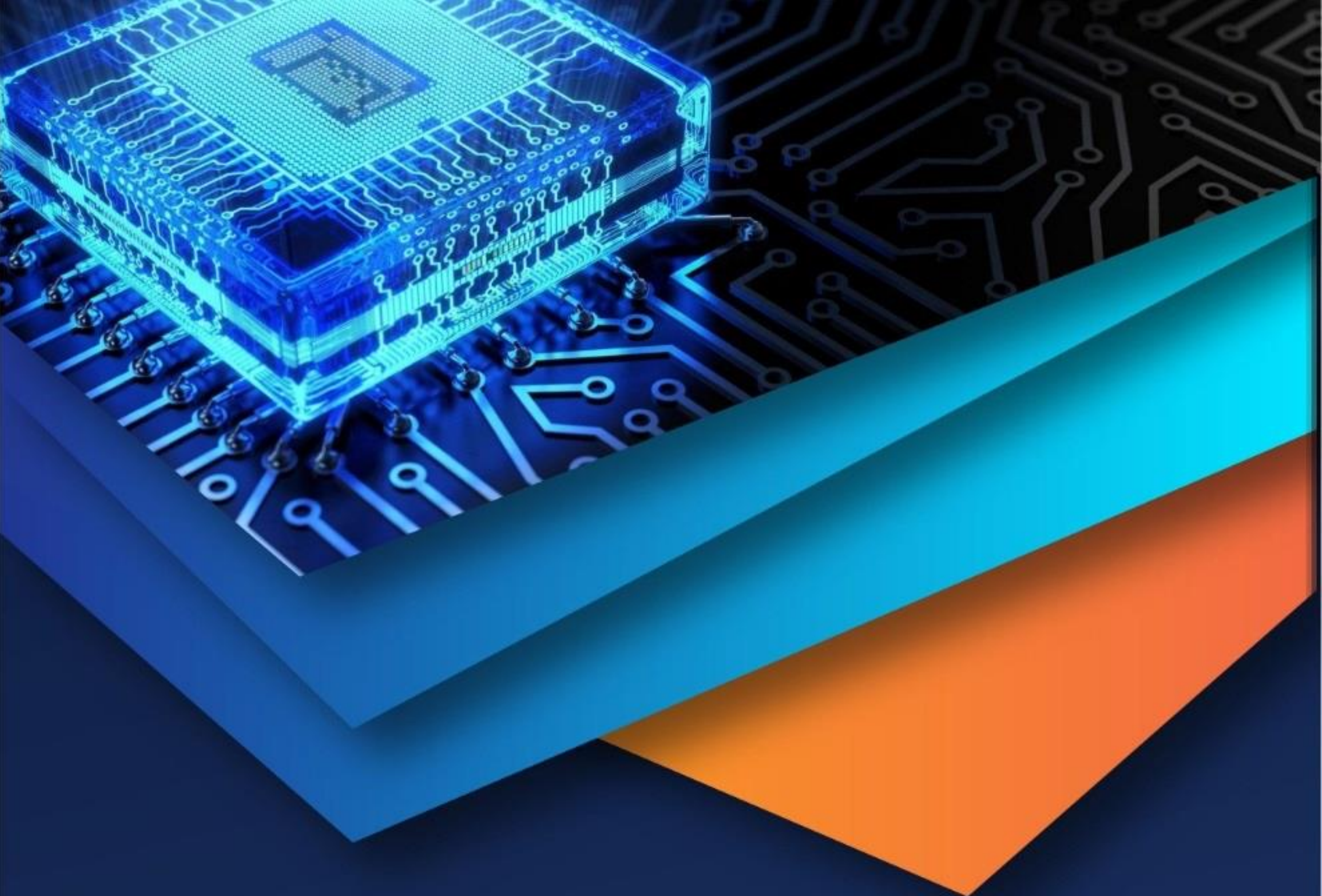

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