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A Study on the Removal of COD Using Laboratory Scale Fluidized Bed Bioreactor

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Abstract*—The organic component of the wastewater is generally be removed in biological methods of wastewater treatment. This paper presents the application of Fluidized Bed Bioreactor (FBBR) to study the removal of Chemical Oxygen Demand (COD) from synthetic wastewater using a laboratory scale model of fluidized bed bioreactor. The Reactor consists of Perspex glass column of dia. 7.5cm and length 120cm erected in the laboratory. Small rings of thickness 2.5mm and dia. 19mm made of PVC are used as a bed material. The bed material is acclimatized with organic feed for about a week. Synthetic wastewater with COD ranging from 500-1500 mg/l is taken as a stock solution for conducting the study. From the experiment it is observed that, there is an increase in the percent removal of COD with an increase in the operation times. Further, it is observed that, maximum percent removals of COD are obtained at lesser experiment periods with the increase in operation times. Also, it is observed that the reactor gets stabilized and maximum percentage removal of COD is achieved within lesser periods of time with an increase in COD values of stock solutions.

Keywords— ***Fluidized Bed Bio Reactor (FBBR), bed material, Synthetic Waste water,Operating Time, Chemical Oxygen Demand (COD)***

I. INTRODUCTION

The dumping of industrial and domestic wastewaters into natural water bodies, without proper treatment, is making the natural water bodies get polluted and damaging the environment. In order to avoid the pollution of water bodies, the wastewaters released from the industries and domestic activities should be well treated and the concentration of their constituents should be brought down to the permissible limits as specified by various international organizations, prior to their disposal into the natural water bodies.

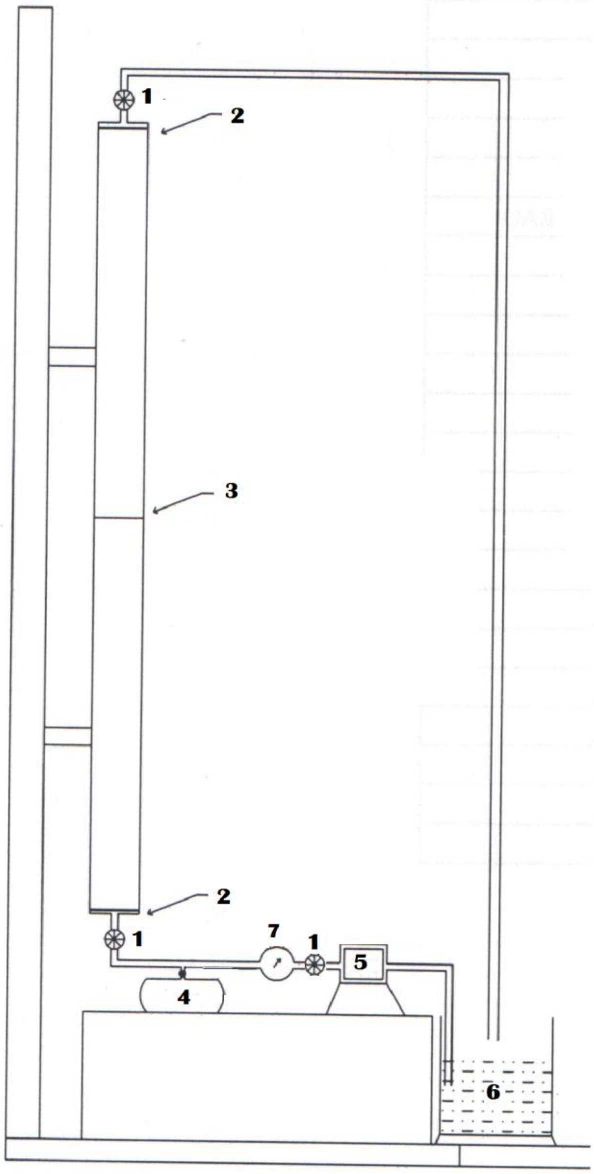
Thus there is a need for the efficient and environmentally safe wastewater treatment technologies to reduce the natural water body contamination. One such technology is, the biological treatment mechanism that removes the most harmful component of the wastewater viz.., organic matter. The biological wastewater treatment mechanism for the removal of Chemical Oxygen Demand (COD), can be conducted on a wide variety of treatment units and reactors, and one such reactor is Fluidized Bed Bioreactor (FBBR).

The fluidized bed bioreactor is a fixed-film reactor column that fosters the growth of micro-organisms on a hydraulically fluidized bed of media. In this reactor the liquid to be treated is pumped upwards through a bed of small biofilm coated particles at a flow rate sufficient to cause fluidization of bed i.e. a state in which the particles, though retained within the reactor, are able to move to one another in the liquid rather than being sediment and immobile.

In fluidized bed bioreactors, it is possible to achieve a high concentration of biomass depending on the operational conditions used in the process and the type of support used to immobilize the micro-organism which is found within a complex structure of cells and their extra-cellular products, referred to as biofilm. The Pilot Plant studies conducted on Fluidized Bed Bio Reactors has demonstrated that the FBBR has the capacity to handle high hydraulic and organic loadings with corresponding low detention times[4],[5],[6]. Similarly various operating variables affect the effectiveness of the FBBR[2].In order to achieve aerobic degradation in this reactor, support particles are fluidized by the flowing wastewater, which must have been previously oxygenated or flow co-currently together with an air system.In fluidized bed bioreactors, effluent recirculation is necessary to provide the fluid velocity within the necessary treatment detention times. Performance of the reactor is normally site specific and depends on ambient conditions, type and quality of the wastewater and nitrate and dissolved oxygen concentration etc. The experiments conducted on Laboratory scale models confirmed the efficient removal of phenols, organic compounds, parameters like COD etc., with a high level of efficiency[1],[3],[7],[8],[9],[10].A variety of Fluidizing particles like PVC discs can be effectively used in the column studies on FBBR [11].

II. METHODOLOGY

The experimental setup consists of a Perspex glass column of diameter 7.5 cm, and length 120 cm as shown in Fig.1. The flexible tube made up of PVC of dia. 19mm is cut into small rings of thickness 0.25cm and is used as a bed material. The inlet and outlet zone are separated with wire mesh. An arrangement for sending compressed air is provided at the bottom of the column. The glass column is filled with these rings to 40% volume of the reactor. Synthetic wastewater (the stock solutions) is prepared using sugar solution, by adding 30 to 50 gm of sugar to about 30 liters of water every day to prepare the stock solution with COD content varying from 500 mg/l to 1500 mg/l. These stock solutions are used in the experimental program subsequently.The slurry containing crushings of tomatoes with water is transferred into the reactor occupying the entire bed material, and kept in aerobic conditions. The slurry is allowed to develop into a biomass attached to the bed material, till the gas bubbles indicating acclimatization are visualized. This process has taken 5 to 7 days.



(1)Valve (2)Stainless Steel Mesh (3)Perspex column 120 cm height 7.5 cm OD and 5 mm thick (4)Air compressor (5) 2.5 HP Motor (6) Reservoir (7) Flow meter

Fig.1 Laboratory Setup of Fluidized Bed Bioreactor

III. EXPERIMENTATION

The experimental process is started soon after completion of acclimatization of the biomass over the bed material. The stock solution is now fed into the reactor through the inlet in the upward direction. Before feeding into the reactor, the COD content present in the stock solution is measured in the standard methods. The flow rate is adjusted by operating a valve and maintained at a constant level i.e. 8-10 l/hr as is measured using the flow meter. Simultaneously the compressed air is allowed into the bed for continuous aeration of the bed. Care is taken that the bed material occupies the entire length of the reactor. The treated wastewater samples are collected from the outlet of the reactor at regular intervals of time i.e., 15, 30, 45, 60, minutes. The samples are analyzed for their COD values in the standard method and the percent removal of COD is calculated. The entire experiment is repeated everyday for a period of 2 to 3 weeks till a constant percent removal of COD is obtained.

IV. ANALYSIS OF SAMPLES

The influent and effluent samples were analyzed for COD value using standard reflux method. The samples collected at the outlet of the reactor at 15, 30, 45, 60 minutes of experimentation are analyzed for COD content as mentioned above.

V. EXPERIMENTAL RESULTS

The Percent removal of COD, for various Initial COD concentrations, and for a Flow rate of 10 lit/hr and operating time of 45 min are given below in the table I and are shown graphically in Fig. 2,3,4. The percent removals for the same initial concentrations and flow rate for other operating times were similarly obtained.

Table I : Percent removal of COD (Flow rate: 10 l/hrs, Operating time : 45 Min)

Days	Initial COD 500mg/l		Initial COD 1000 mg/l		Initial COD 1500 mg/l	
	Final COD (mg/l)	Percentage removal	Final COD (mg/l)	Percentage removal	Final COD (mg/l)	Percentage removal
1	469	6	868	14	1012	33
2	462	14	818	21	866	43
3	437	19	749	29	747	51
4	445	17	760	25	697	54
5	453	21	680	32	572	62
6	361	27	633	37	530	65
7	370	31	574	44	485	68
8	353	34	533	48	328	78
9	269	50	429	59	247	84
10	202	62	346	63	169	89
11	151	72	256	65	148	90
12	126	77	346	67	118	92
13	118	78	256	75	118	94
14	84	84	127	88	117	94
15	76	86	80	90	---	---
16	67	87	78	90	---	---
17	42	92	74	93	---	---
18	42	92	---	---	---	---

VI. ANALYSIS OF RESULTS

The maximum percent removals obtained against different operation times (OT) along with the number of days of experiment, for different stock solutions of varying initial COD values are presented in the Tables II and III. From the experimental results it is observed that, there is an increase in the percent removal of COD with an increase in the operation times. Further, it is observed that, maximum percent removals of COD are obtained at lesser experimental periods with the increase in operation times. Also, it is observed that the reactor gets stabilized and maximum percentage removal of COD is achieved within lesser periods of time with an increase in COD values of stock solutions.

Table II : Maximum percent removals obtained against different operation times (OT)

S.No.	OT (Min)	Experimental Period (Days)	Max % removal of COD for Initial COD Conc. 500 mg/l	Experimental Period (Days)	Max % removal of COD for Initial COD Conc. 1000 mg/l	Experimental Period (Days)	Max % removal of COD for Initial COD Conc. 1500 mg/l
1	30	18	89	17	90	14	92
2	45	17	92	17	93	14	94
3	60	14	94	17	96	14	96

Table III : Maximum percent removals of COD for different operation times

S.No	Initial COD mg/l	No of days	Maximum Percent removal of COD achieved		
			OT: 30 Min	OT: 45 Min	OT: 60 Min
1	500	18	89	92	94
2	1000	17	90	93	96
3	1500	14	92	94	96

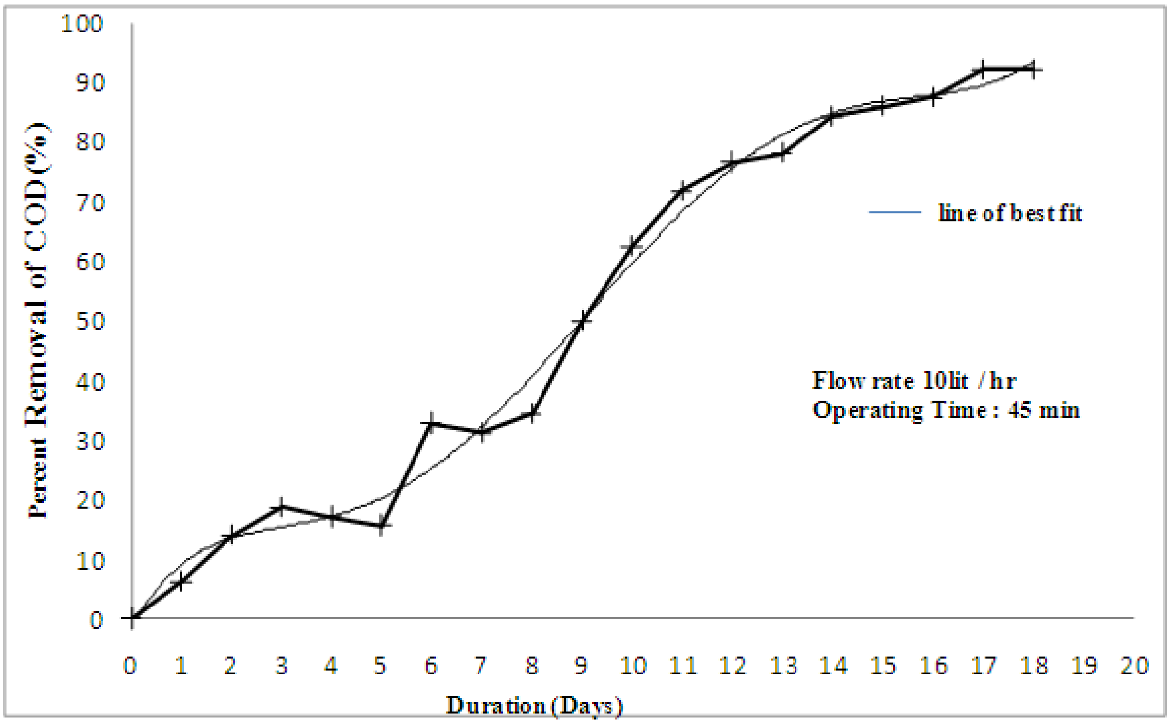


Fig 2. Percent Removal of COD (Initial COD: 500mg/l)

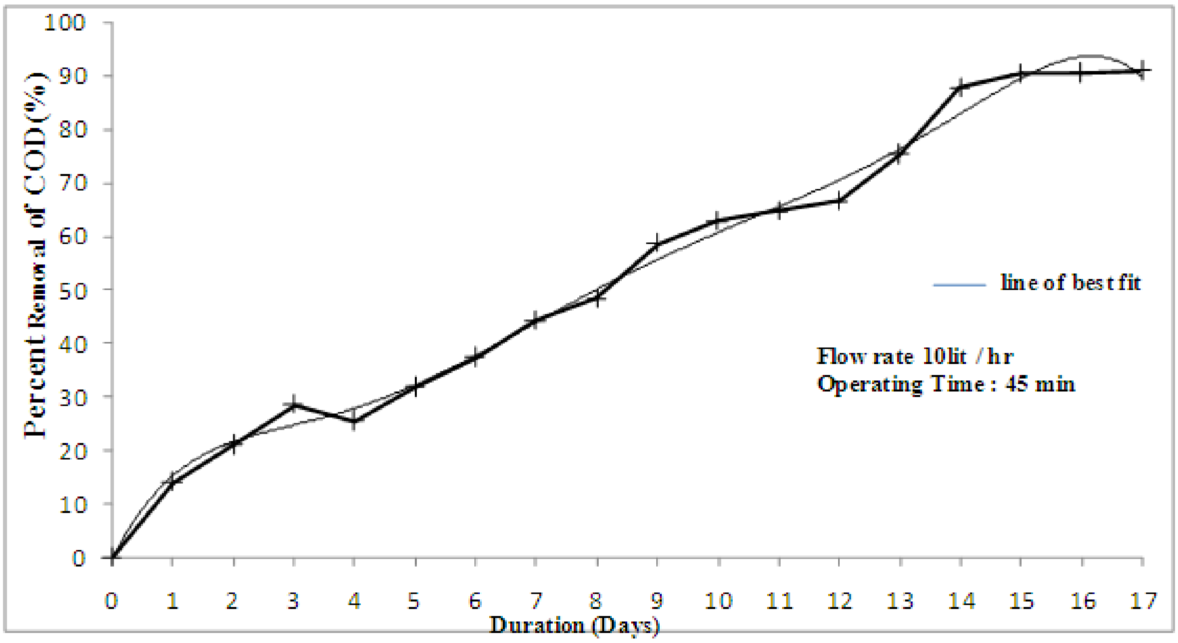


Fig. 3 Percent Removal of COD (Initial COD: 1000mg/l)

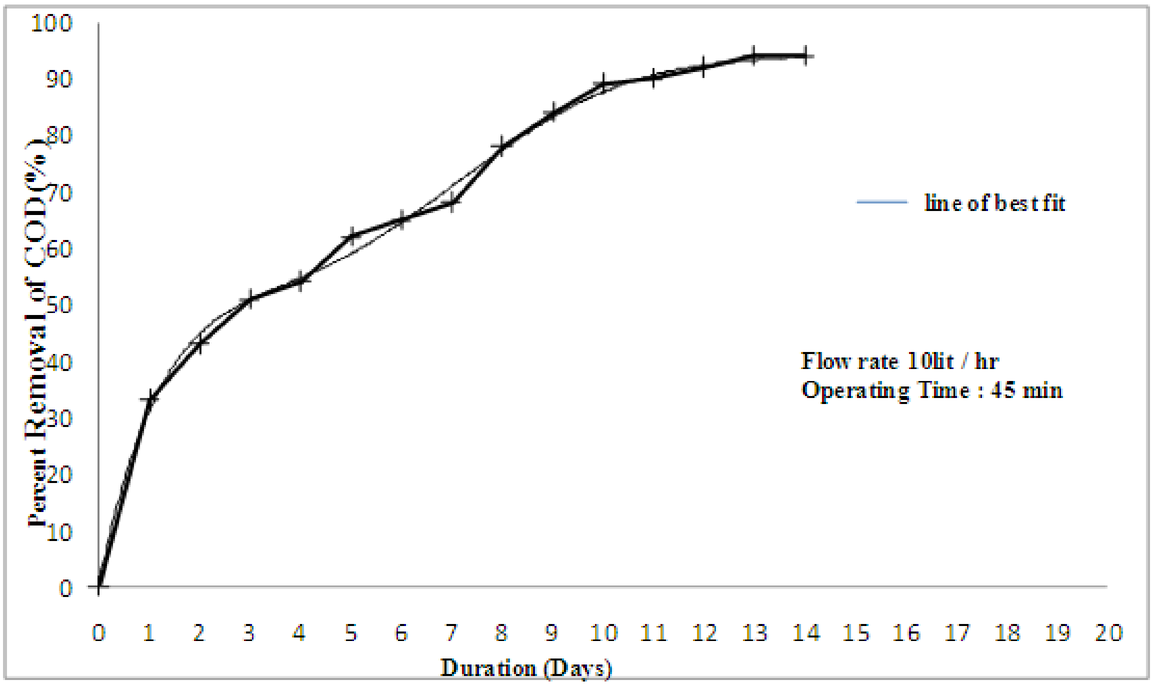


Fig. 4 Percent Removal of COD (Initial COD: 1500mg/l)

VII. CONCLUSIONS

1) From the experimental program it is observed that there is an increase in percentage removal of COD with an increase in the operation time periods of the reactor.
2) Maximum percentage removal of COD achieved is in increasing trend with respective to the increase of initial COD values of the stock solution taken.
3) The experimental results shows that the reactor gets stabilized and maximum percentage removal of COD is achieved within lesser periods of time with an increase in COD values of stock solutions.

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