Effect of HRT on the biodegradability of textile wastewater in an Anaerobic Baffled Reactor

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Abstract: The effect of operational parameters such as HRT, influent COD concentration, co-substrate was investigated to achieve the maximum COD removal efficiency in the reactor. Results indicated that anaerobic treatment of textile wastewater studied was possible with the supplementation of an external carbon source in the form of glucose (about 3g/l) to achieve a maximum COD removal efficiency of 91.67% with a HRT of 1.748 h and OLR of 7.962kg COD/m3. day. The present study was conducted to evaluate the potential applicability of ABR system for the treatment of textile wastewater with varying HRT from 1.748,1.165,0.874,0.699 and 0.582 days.

Keywords: Anaerobic Baffled Reactor, Chemical Oxidation Demand, Flow Rate, Hydraulic Retention Time, Textile wastewater.

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Introduction:

Now a days, many researches have focused on anaerobic reactors for the treatment of wastewater. The ABR was initially developed at Stanford University and it can be described as a series of upflow anaerobic sludge blanket reactors. It consists of a series of vertical baffles to force the wastewater to flow. Under and over them as it passes from the inlet to the outlet. The wastewater can then come into intimate contact with a large amount of active biomass, while the effluent remains relatively free of biological solids (Wang J.L et al., 2004; Krishna GVT et al., 2007). The significant advantage of the ABR is its ability to separate acidogenesis and methanogenesis longitudinally down the reactor (Barber W.P and Stuckey D.C,1999; Plumb J et al., 2001; Uyanik S et al., 2002a). This can permit different bacterial population to dominate each compartment, acidification predominating in the first compartment section and methanogenesis dominant in the subsequent section (Barber W.P and Stuckey D.C, 1999; Plumb J and Stuckey D.C, 2001; Uyanik S et al.2002 b).The up-flow velocity is the most crucial parameter for dimensioning, especially with high hydraulic loading. It should not exceed 2.0 m/h (Sasse.L 1998; Morel and Dinner 2006). Based on a given HRT, Up-flow velocity increases in direct relation to the reactor height. Therefore, the reactor height cannot serve as a variable parameter to design the reactor for the required HRT. The limited upstream velocity results in large but shallow tanks. Higher loading-rates are possible with higher temperature and for easily degradable substrates (Sasse 1998).

Anaerobic treatment of textile sludge has an additional benefit of producing biogas as fuel (Asia I.O et al., 2006). Microbial population was associated with treatment of an industrial dye effluent in ABR (Jason P.J et al., 2001). Ioannis D.M and Sotirios G.G,(2002) studied three chambered ABR (14.7*l*) for the treatment of low strength synthetic wastewater (COD,300-400 mg/l) at 24h and 12h of hydraulic retention times.

The textile industries as pretreatment (desizing-scouring-bleaching) and dyeing processes generate large quantity of wastewater containing unreactive dyes, suspended solids, dissolved solids, and biodegradable and non-biodegradable other auxiliary chemicals (Raju G.B, et al., 2008, Somasiri W, et al., 2008,Georgiou D et al., 2005,Isik M and Sponza D.T 2004). The discharge of these textile wastewater is viewed to have negative effect on the environment in this area,also damaging the quality of water sources and may be toxic to treatment processes, to food chain organisms and to aquatic life (Talarposhti A.M et al., 2001). Therefore,it is of paramount importance to know its exact nature, in order to implement an appropriate treatment process (Marmagne O and Coste C,1999). The textile industry consumes approximately two thirds of the total production of dyes. During textile processing, inefficiencies in dyeing result in large amounts of the dyestuff being directely lost to the wastewater, which ultimately find its way into the environment. The amount of dye lost is dependent on the class of dye application used, varying from 2% loss when using basic dyes to a 50% loss when reactive azo dyes are used (McMullan G et al.,2001). These residual of dyes are unloaded in residual water of the systems of treatment or to the environment in form of dispersion or true solution in industrial effluents causing a severe contamination of rivers and groundwater in the areas with high concentration of textile industries (Stolz,2001).

Azo dyes are organic compounds difficult to biodegrade due to their high stability to the light and the microbial attack. They are resistant to the aerobic biodegradation in conventional plants of treatment (Pagga U and Brown D 1986; Shaul et al., 1991) and under anaerobic conditions it has been observed the generation of reduced colorless compounds. In the initial stage of the anaerobic degradation of azo dyes a reductive cleavage of the linkage azo takes place, orginating aromatic amines considered as potentially toxic, mutagenic and carcinogenic products. Some of these amines have been reported as recalcitrant to the anaerobic bacteria (Zaoyan Y et al., 1992; Weber E.J and Adams R.L, 1995) with exception of few aromatic amines substituted with hydroxyl and carboxyl groups

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which were degraded under methanogenic conditions (Razo-Flores E et al., 1996).

The aim of this study was to investigate the anaerobic treatablity of a real textile wastewater in an Anaerobic Baffled Reactor. The effect of operational conditions such as HRT, influent COD and glucose concentration as the co-substrate was also investigated.

MATERIALS AND METHODS

In the present study an experimental model of Anaerobic baffled Reactor was fabricated to conduct experiment for real time waste streams of textile industry to evaluate the treatment efficiency under varying experimental conditions. The experimental laboratory model was made up of Plexiglass. The size of the anaerobic baffled reactor was: length 50cm, width 24cm, depth 30cm and working volume of the reactor was 36 liters. A proper construction of the baffles allowed wastewater to flow through the sludge bed from bottom up. The model have five compartments and the distance of the upper edge of baffles between the ascending and descending compartments from the water level was 3cm above the reactor's base at a 45° angle to direct the flow evenly through the up-corners. The physical feature of the experimental set up was shown in **Table. 1** .The liquid flow is alternatively upwards and downwards between compartment partitions. This produced effective mixing and contact between the wastewater and biosolids at the base of each up-corners. Sampling ports were used for drawing biological sludge and liquid samples. A variable speed Peristaltic Pump (PP -30) was used to control flow rate. The schematic of the experimental setup is shown in **Figure 1.1**

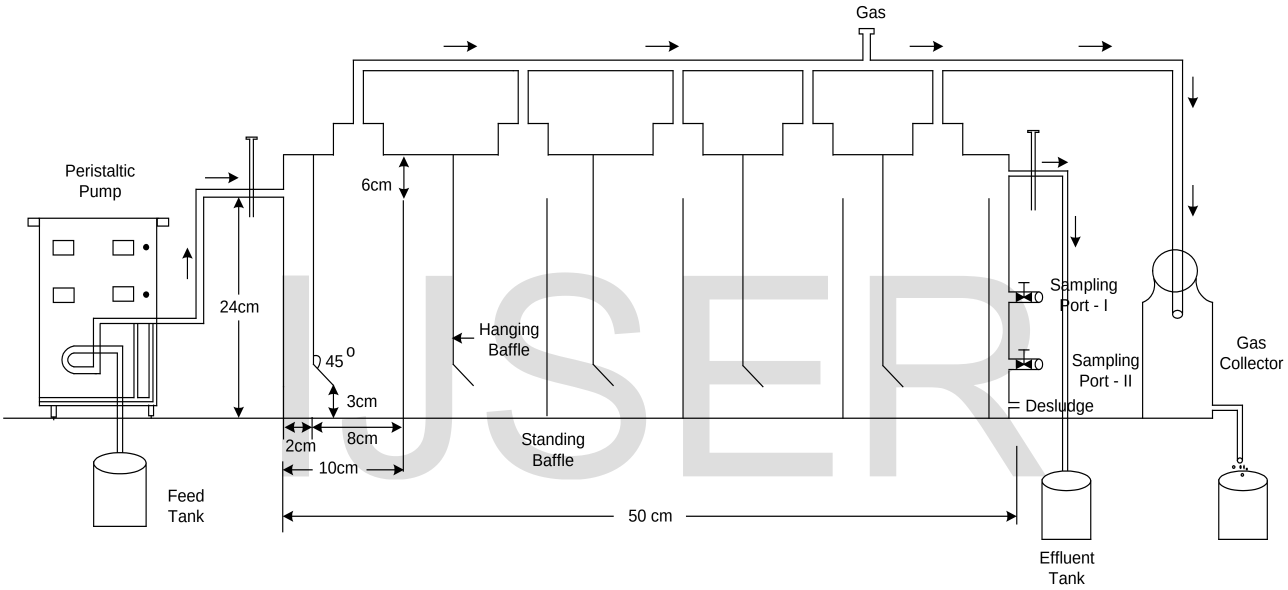

Fig. 1.1 Schematic of Anaerobic Baffled Reactor

Table: 1 Physical features of Experimental setup

Reactor configuration	Dimensions
Length	50cm
Depth	30cm
Width	24cm
Compartment free board	6cm top, 3cm bottom
The sample port from the Top of the reactor	6cm
The sample port from the bottom of the reactor	3cm
Working volume	36 liters
Number of compartment	5
Each compartment length	2 to 8cm
Peristaltic pump	PP-30

The treatment process for acclimation was achieved by operating the plant with screened seed sludge drawn from the treatment facilities of Annamalai University. The textile effluent was collected from M R S Dyeing private limited, Avinashi road, Tirupur, Tamil Nadu. The samples were analyzed and characterized as per the Standard Procedure (APHA 2005) which are presented in **Table 2.**The textile wastewater was allowed to the reactor in gradual addition of 20%, 40%,60%,80% and 100%. After allowing 100% textile wastewater to the reactor, the COD removal efficiency was monitored.

Table 2 Characteristics of wastewater parameters from Textile industry

S.N	Parameters	Sample-I	Sample-II	Sample-III	Desirable limit of IS 10500
1	pH	8.90	8.60	9.2	6.5 to 8.5
2	Total solids, mg/l	2670	2680	2850	500
3	Total suspended solids, mg/l	600	550	650	100
4	Total dissolved solids, mg/l	2070	2130	2200	500
7	BOD_5@ 20°C, mg/l	1750	1206	1658	30
8	COD, mg/l	4400	3880	4160	250
9	Ammonical Nitrogen, mg/l	73.00	85.60	84.20	50
10	Chlorides, mg/l	4320	4005	4125	250
11	Turbidity(NTU) , mg/l	14.8	16.60	12.50	1
12	Temperature, °C	28	29	28	< 40
13	Sulphates, mg/l	2250	2050	2180	200
14	Phosphate, mg/l	68.8	72.8	85	NA
15	Hardness, mg/l	1800	1900	1750	200
16	Sodium, mg/l	2833	2900	2710	200
17	Potassium, mg/l	2524.5	2685	2490	NA
18	Calcium, mg/l	2378.5	2321.7	2185	75
19	Lithium, mg/l	83.6	75.5	68.0	2.5

RESULT AND DISCUSSIONS

The textile wastewater samples with an average COD concentration of 2912,3224,4200,4576 and 4744mg/l was allowed to the reactor with HRT of 1.748, 1.165, 0.874, 0.699 and 0.582days.

The HRT was gradually decreased from 1.748 to 0.582 days. The result indicated that at a HRT between 0.874 to 1.748 days the COD removal efficiency was greater than 85.00% for an average influent COD of 4774mg/l.

In the intial stage the real time textile wastewater was fed into the reactor without any addition of co-substrate for an average COD concentration of 2912mg/l. During this stage, OLR was kept from 1.670 to 5.148 Kg COD/ m^3.day. HRT applied to the reactor was from 1.748 to 0.582 days. The COD removal efficiency was achieved from 53.33 to 64.38% only even the reactor was in mesophilic range with an alkaline condition.

In stage 2, also the textile wastewater was allowed into the reactor without any addition of co-substrate for an average COD concentration of 3224mg/l. During this stage, OLR was kept from 1.968 to 5.834 Kg COD/m^3.day with same HRT. The COD removal efficiency was achieved from 55.29 to 69.76%. The COD removal efficiency was littlebit higher as compared to the first stage.

In stage 3, an external carbon source was added to the textile wastewater in the form of glucose at a concentration of 1g/l for an average influent COD of 4200mg/l with same HRT resulting in an increase in the OLR from 2.379 to 6.864 Kg COD/m^3. day. The COD removal efficiency was increased from 65.00 to 75.96% as compared to earlier stages. Because it contains all the necessary micro and macro-nutrients for an optium anaerobic microbial growth. The compositions of these elements were as follows: Calcium 170mg;Phosphorus 100mg; Vitamin D 300 L.U; Energy value 360 K cal; Protein 0g; Carbohydrates of which sugar (Sucrose) 90g; Fat and all types of fatty acids 0g respectively.

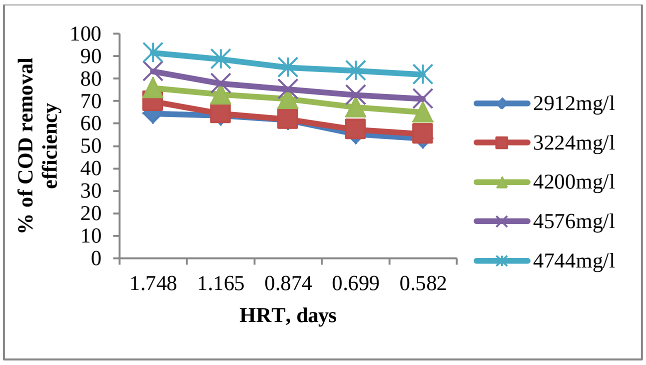

Fig. 1.2 HRT in days with respect to % of COD removal efficiency

After observing the stimulative effect of the addition of 1g/l of glucose as the external carbon source in stage 3, glucose concentration was increased from 1 to 2g/l in stage 4. Now the average influent COD concentration was 4576mg/l and OLR applied to the reactor from 2.745 to 7.825 Kg COD/m^3. day respectively. The pH remained alkaline in mesophilic range which are very well suitable for *Methanogenesic* organisam. At an HRT of 0.582days, the reactor received peak organic loads of 7.825 Kg COD/m^3.day. From the **Figure(1.2)** it was clear that increasing the glucose concentration from 1g/l to 2g/l resulted in significantly better performance of the ABR in terms of organic removal.

Now in stage 5, 3g/l of glucose as a external carbon source was added to the textile wastewater and the performance of ABR reactor was monitored. The changes in the glucose concentration increased the influent COD 4744mg/l and the OLR vary from 2.745 to 7.962 Kg COD/m^3. day. In this stage the COD removal efficiency was achieved at 91.67%.

Due to the increment addition of glucose the COD removal efficiency was achieved at a maximum of 91.67% with an OLR of 2.745 Kg COD/m^3. day at a HRT of 1.748 days.

CONCLUSIONS

It was cocluded that the ABR system was quite efficient for the removal of textile wastewater. Without addition of co-substrate the COD removal efficiency was achieved from Stage 1 and 2 are 53.33 to 69.76% only. With addition of co-substrate 3g/l glucose (with the influent COD concentration of 4774mg/l), COD removal efficiency was achieved at a maximum of 91.67% with an OLR of 2.745 Kg COD/m^3.days at a HRT of 1.748 days. Maintaining a suitable and stable pH within the reactor is

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very much helpful for ensuring efficient *methanogenic* digestion. Finally, the requirement of glucose addition as an external carbon source to the textile wastewater with a concentration of 3g/l might be a concern in terms of the practical applicability of anaerobic treatment process.

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