Influence of pH in an Anaerobic Baffled Reactor for Treating Real Textile Dye Wastewater

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Abstract: The wastewater discharged from the textile dyeing units contains the toxic level of chemicals in large quantity and cause severe setbacks in the healthy life of an eco system. The proper technologies need to be used for the treatment of wastewater before discharge into land or water course. The objective of this study is to evaluate the effective pH on microbial activity of anaerobic baffled reactor for treating textile wastewater. The pH is an important parameter which influenced the performance of the reactor. An experimental model was designed and conducted to study the impact of pH in the textile effluent. The pH acts as an important role for the efficient removal of COD which attains 91.67% with a HRT of 1.748 days at an OLR of 2.745 Kg COD/m^3.day.

Keywords: Anaerobic Baffled Reactor, Anaerobic digestion, Chemical Oxidation Demand, Hydraulic retention time, Organic loading rate, pH, Textile wastewater.

1. Introduction

Indian textile industry is one of the leading textile industries in the world. It is also one of the highly polluting industries in the state having potential for creating pollution of water and air. Taking into account the volume and composition of effluent, the textile wastewater is rated as the most polluting among all in the industrial sectors (Awomeso et al., 2010; Vilaseca et al., 2010). Textile industry is a very diverse sector in term of raw materials, processes, products and equipment and has very complicated industrial chain (Irina-Isabella Savin and Romen Butnaru, 2008). Untreated effluent are highly toxic to the plant, fish or other aquatic organisms at higher pH and the sulphide in the effluent are of environmental concern (WHO 2000) because they can lead to poor air quality of an area if not properly taken care of thus becoming threat to vegetation, human, and materials. The same is applicable to other parameters such as BOD_5, COD that has been identified to raise health issue if water available for human use is not of the required level (WHO 1993).

Wastewater from industrial, municipal, and agricultural sources has been utilized for micro algae cultivation and nutrients removal, therefore it has been proposed as an alternative to organic carbon sources (Abreu et al., 2012). In wastewater facilities, the anaerobic digester, wherein anaerobic microorganisms consume organic carbon, is essential component of wastewater treatment systems (Farooq et al., 2013). Anaerobic bioprocesses are very sensitive to environmental changes, and this sensitivity makes their maintenance complex (Gholamreza et al., 2014). The anaerobic reactors (ABR and UASB) showed good buffering conditions, which according to Campos et al. (2010), is very important when considered the maintenance cost, because under pH variations, it is required the addition of chemicals for buffering. Anaerobic processes are normally operated at a pH near 7 which is in favour for methane formers, responsible for the final conversion of organic acids into methane gas. The final stage of anaerobic digestion is called methanogenesis.

Moreover, at lower pH (<6.0) methanogenesis of acetate is also inhibited, which results in the degradation of fatty acids (especially propionate). Thus, for the industrial effluents the system must contain adequate buffering capacity to neutralize the production of Volatile acids and Carbon dioxide. High strength wastewater is more likely to expose sensitive bacteria in front compartment to toxic levels of inorganic and organic compounds (Baloch et al., 2007; Yu Hq et al., 2002). The methane-producing microorganisms have optimum growth in the pH range between 6.6 and 7.6 (Rittmann and McCarty, 2001), although stability may be achieved in the formation of methane over a wider pH range (6.0-8.0). The pH values below 6.0 and above 8.3 should be avoided, as they can inhibit the methane-forming microorganism (Chernicharo, 2007). Moreover, the hydrodynamic pattern reduces bacterial washout and enables it to retain biomass without the use of any fixed media (Grover et al., 1999; Vossoughi et al., 2003). An important objective of this study is the impact of pH on Anaerobic Baffled Reactor during anaerobic digestion process to attain the maximum treatment efficiency.

2. Material and Methods

2.1 Reactor Configuration

An experimental model of anaerobic baffled reactor was fabricated to conduct the 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 Plexi glass. The size of the reactor has the length of 50cm, width 24cm, depth 30cm and working volume of the reactor was 36 liters. A proper construction of the baffles allowed the wastewater flow through the sludge bed from bottom up. The model has five compartments and the distance of the upper edge of baffles, between the ascending and descending compartments from the water level is 3cm above the reactor's base at an angle 45° 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 bio solids 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.

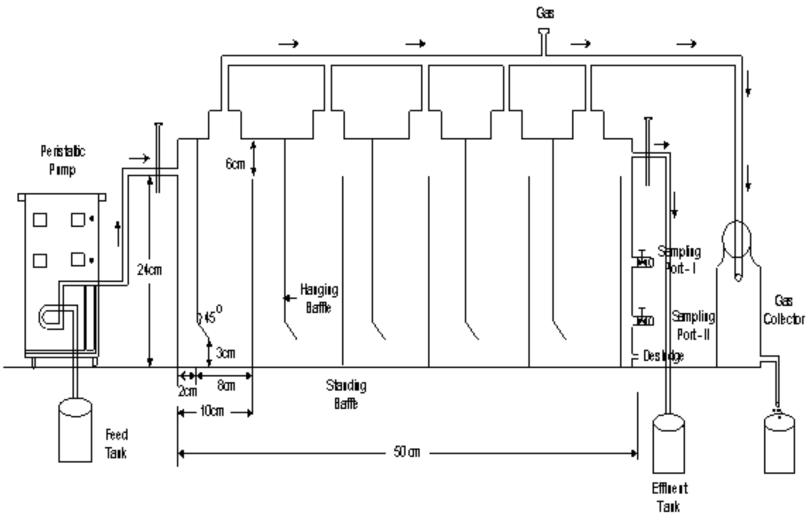

Figure.1 Schematic of experimental setup

2.2 Study Area

The samples were randomly collected from different area of Tirupur city (S1, S2 & S3). The tirpur city is located between 11.1075°N, 77.3398°E. The Noyal river, a branch of Cauvery originates from Velliyangiri hillocks on the western Ghats flow through tirupur city, in which the untreated textile dye effluents directly released (Fig. 2).

2.3 Sample Collection

The textile effluent samples were collected on once in three days basis and were analyzed immediately.

2.4 Preservation of samples

The textile industrial wastewater samples were collected in pre-cleaned poly-propylene bottles with necessary precautions and are preserved by refrigeration @4°C without chemical addition.

2.5 Process stability

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/s 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.

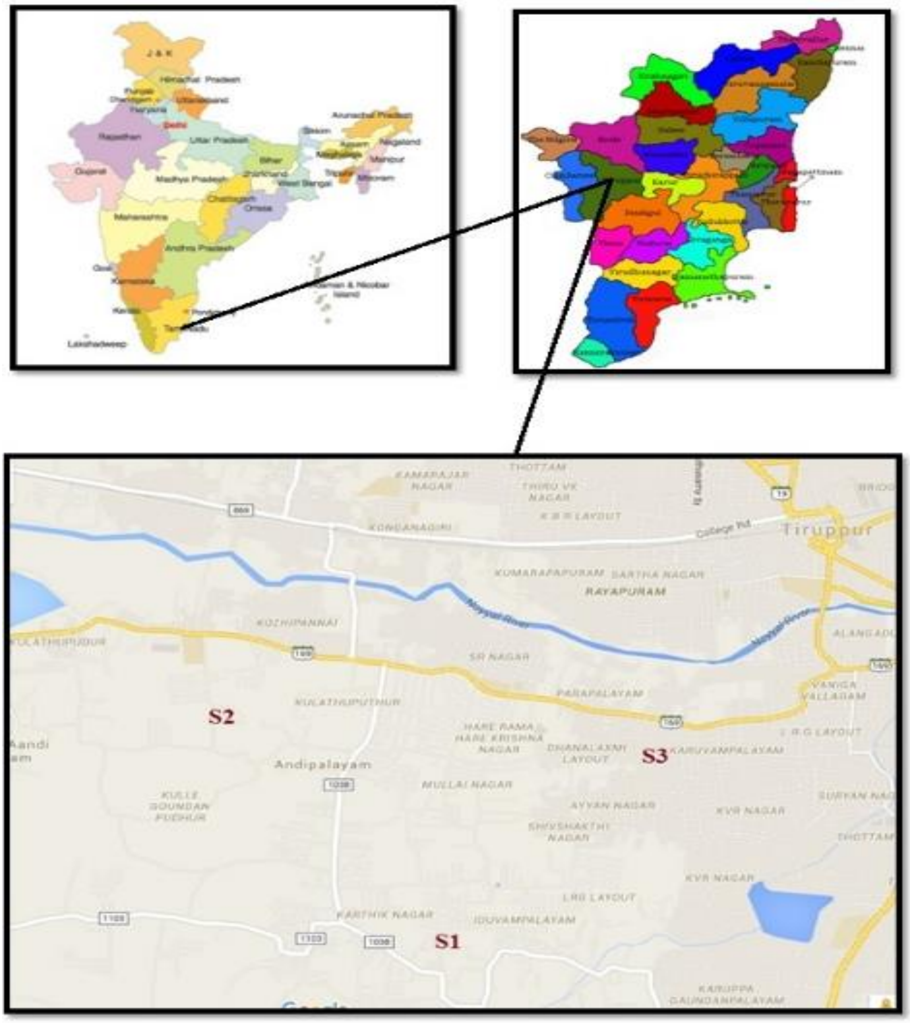

Figure.2 Map showing Tirupur location and textile dye effluent collection sites

Table.1. Physical features and process parameters 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

Table. 2. Characteristics of real time Wastewater from Textile industry

Sl. No.	Parameters	Sample (S1)	Sample (S2)	Sample (S3)	Desirable limit of IS 10500
1	pH	8.9	8.6	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	16.6	12.5	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	2.5

3. Results and Discussions

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

The pH is the key parameter affecting both the anaerobic treatment efficiency and microbial community during anaerobic digestion (Mensah, K.A and Forster, C.F 2003, Ren N.Q et al., 2002). While treating domestic sewage, pH remains in this range without adding any chemical because of buffering capacity of the acid base system in an anaerobic digester. The optimum pH range for all methanogenic bacteria is 6.0 to 8.0, but the most appropriate pH for the group on the whole is close to 7.0. On the other hand, acidogenic bacteria are less sensitive to pH variations so at lower pH acid fermentation may predominate over methanogenic activity (Yavuz O and Aydin A.H, 2006). Bacteria producing methane have an optimal growth in the pH range 6.6-7.5, although the stabilization of methane production may be kept with pH between 6.0 and 8.0. The pH values below 6.0 and above 8.3 should be avoided so that methanogenic bacteria are not inhibited (Vonsperling, 2005).\

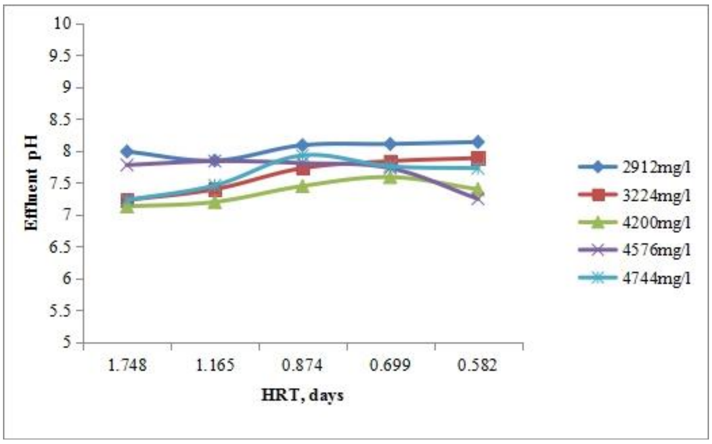

Figure.3 HRT in days with respect to Effluent pH

The characteristics curves were drawn for the influence of pH with respect to Hydraulic Retention Time (HRT) as shown in Figure 3. However, when the reactor HRT was gradually decreased between 1.748 to 0.582 days with an average COD of 2912 to 4744 mg/l, which is shown in Figure 3 and the maximum COD removal was achieved at 91.67% at a HRT of 1.748 days. The average effluent pH in Stage 1 dropped from 8.148 to 7.85 due to an increased methanogenic activity. During this period, there were slight changes in the pH of stage 2, 3, 4 and 5.

Further, the reduction in the HRT caused substantial change in the pH profile of the reactor system with average effluent pH in Stage 1 to stage 5 is being 8.03, 7.62, 7.35, 7.66 and 7.62. The value of pH slightly fell during the periods indicates the prevalence of acid fermentation over methanogens. It indicates healthy anaerobic environment, which is favourable for methanogenic organisms (Wheatley,1991).

The results showed that COD was effectively removed at pH of 7.23 to 7.93 with higher concentration COD of 4774mg/l, the results also indicated that the removal efficiency of COD was raised from 81.89% to 91.67% which influences the pH condition of the reactor. The influent pH was varied from 8.6 to 9.2, which was alkaline condition and it was strongly influenced the biodegradation of the reactor.

4. Conclusions

The results of this study revealed that the pH influences the performances of the biodegradation process and the organic removal efficiency of real time textile waste stream. The reactor was allowed to operate at an Organic Loading Rate of 2.745 Kg COD/m^3.day with the Hydraulic Retention Time of 1.748 days with a maximum COD removal efficiency was 91.67% with an alkaline condition. The pH plays an important role for effective growth of Alcaligenes Faecalis organism for the concentration of organic pollutants in the wastewater. The COD removal efficiency was highly influenced by the alkaline conditions of the wastewater. The pH concentration in the reactor was strongly affected by volatile fatty acids and the amount of CO2 produced. The results showed that pH range in the reactor made favourable condition for bacterial growth in the digester and produced better biogas yield.

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