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Removal of Biological Organic Matter and Suspended Solid from Textile Wastewater Using Anaerobic-Aerobic Process: A Review of an Industrial Implementation

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Abstract

Effective and cost efficient wastewater treatment is one of the major challenges for textile sectors of Bangladesh. The present study was an attempt to address the removal efficiency of organic matter and suspended solid of textile waste water by industrial scale combined anaerobic and aerobic treatment system. The experiments were performed at 6, 12, 18 and 24 hr hydraulic retention times (HRTs) and removal efficiency of different parameters (BOD5, COD and TSS) was measured. The average BOD_5 and COD removal efficiency were in the range of 71% to 91% and 52% to 75% respectively at different HRTs in this plant. 73% - 82% range of TSS of wastewater was reduced by this method. Maximum BOD_5 (88.2-92.5%) removal was occurred in aerobic treatment system whereas, high amount of COD (49.2-71.7%) removal efficiency reported in the anaerobic treatment system at different HRTs. The result indicated that the industrial scale combined treatment system can treat wastewater effectively.

Keywords: Textile wastewater; Wastewater treatment; Anaerobic method; Aerobic procedure; Combined method.

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1. Introduction

Textile industry is one of the rapid growing industries in Bangladesh. This industry becomes the main foreign currency earning source of this country [1]. However, textile industries generate large amount of hazardous wastewater which is able to cause serious environmental pollution. This wastewater deteriorates the quality of soil and surface water and poses the threat to human health and ecosystem. However, appropriate management of this wastewater is one of the major challenges all over the world including Bangladesh [2,3].

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At present, there are various types of treatment methods are practiced to manage this harmful wastewater. Physical, chemical, absorption, membrane filtration, ion exchange and radiation treatment are widely used all over the world [4]. Most of these methods are expensive in nature and generate significant amount of sludge which is difficult to manage. Moreover, improper sludge disposal may cause soil contamination [5].

In recent days, aerobic treatment system gains popularity to treat wastewater due to its effectiveness and low maintenance and operational cost [6]. However, a single aerobic method is unable to treat textile wastewater within shortest period of time as it requires high retention time [7]. On the other hand, anaerobic digestion system is a newly prevalent method to remove organic matter from wastewater. This method requires less energy to breakdown complex chemical compound and produces low sludge which is less harmful for environment [8]. Moreover, anaerobic treatment system is very effective to remove COD and TSS within short time. Combination of anaerobic and aerobic treatment method is very effective system to treat the textile wastewater. Through this combined method, N=N bond of azo dyes initially deformed into colorless amines in anaerobic reactor and followed by complete mineralization in aerobic reactor [4].

Various scientific papers have discussed the effectivity of the anaerobic and aerobic treatment system. Through this combined method the textile wastewater was initially discolored by anaerobic microbes and followed by biodegradation through aerobic organism [4,8,9]. However, related study about the industrial implementation of combined treatment system for textile effluent is very limited. Thus, the present paper is an attempt to identify the effectivity of industrial scale combined anaerobic and aerobic treatment method to treat the textile wastewater.

2. Experimental

2.1. *Characteristics of textile water and design of reactors*

The industrial scale combined treatment method was constructed in a knit processing textile industry of Gazipur, Bangladesh. Indigo dyes were widely used by this factory to dye the fabric. 8.6 pH was observed in the influent wastewater. Thus, pH adjusted to 7.1-7.5 using sulfuric acid (96% w/w) to minimize the toxic/inhibitory effects of biomass [1].

A lagoon was built in front of anaerobic reactor and flowrate was regulated into 20 m^3/h.

2.2. *Anaerobic reactor*

Steel made tank of capacity of 100 L, diameter of 6 feet and height of 9.2 feet was used as an anaerobic reactor. The tank was partially filled up with cosmo ball which acted as supporting particles for immobilization of microorganism. 12 L of active sludge of treating effluent of a textile mill was used as an initial inoculum of anaerobic reactors [8,9].

2.3. *Aerobic reactor*

Similar specification of tank was used for aerobic treatment. 12 L of sewage sludge was used as initial inoculum of aerobic reactor. 2 disk type diffusers were installed to provide air supply. The air flow was regulated into 120 mg/L/min by a flow meter. The schematic diagram of plant set up and industrial scale establishment are shown on Figs. 1(a) and (b).

2.4. *Reactor operation*

To address the proper retention time, four different hydraulic retention times (HRTs) (6, 12, 18 and 24 hr) were set for effluent water. Sludge retention time (SRT) was 14 days for each of the samples for development of biomass flocs for biodegradation. Nitrogen and phosphorus were supplied in 20:1 and 40:1 ratio respectively for aerobic reactor [10]. Oxygen free nitrogen was supplied in the ratio of 20:1 for the development of anaerobic microorganism [9].

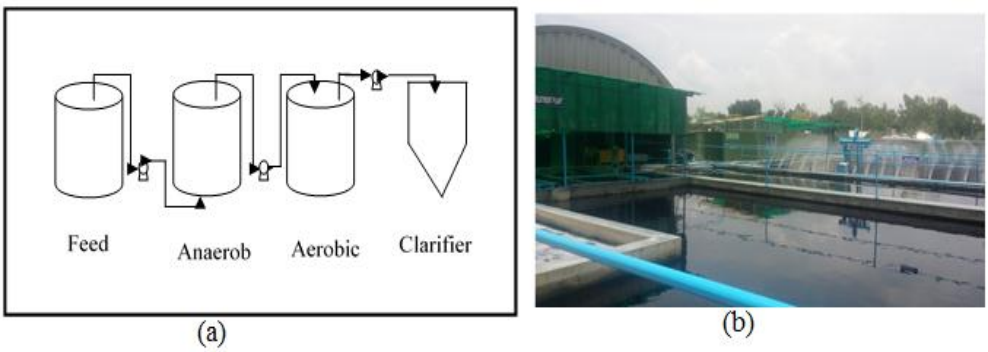

Fig. 1. (a) Schematic drawing of combined anaerobic and aerobic treatment system.
(b) Industrial scale implementation.

2.5. *Analytical procedure*

The influent and effluents were collected and analyzed to measure the pH, COD, BOD_5 and TSS concentration according to Standard Methods of Examination [11]. Removal efficiency was calculated by following formula:

Removal Efficiency (%) = $(C_{inf} – C_{eff})$ x 100

Where,

C_{inf} = Initial parameter concentration

C_{eff} = Final parameter concentration

3. Results

In the present study, BOD_5/COD ratio of influent of textile waste water was measured. Table 1 describes the ratio of BOD_5/COD in influent at different HRT of the treatment system. The efficiency of the plant was evaluated by the removal of organic matter (BOD_5 and COD) and TSS. Efficiency and concentration reduction of BOD_5, COD and TSS are shown in Figs. 2-4. Table 2 illustrates the average reduction percentage and concentration of BOD_5, COD and TSS. The removal efficiency of BOD_5 and COD was increased with HRT 6 to 24 hr.

71% to 91% BOD_5 reduction (Fig. 2) and 52% to 75% COD removal (Fig. 3) efficiency were measured after treating the wastewater through combined treatment system. There was 73% to 82% TSS removal effectiveness was reported during the study. Removal of BOD_5 and COD were related with organic loading rate (OLR). 83.8-89.9% and 85.2-89.8% of removal of COD and BOD_5 was obtained for 1-4 kg/m^3.day of OLR at HRT 6.

OLR was very important to remove COD in anaerobic treatment system. Fig. 5 illustrates the relationship of BOD_5 and COD removal with OLR. Maximum 92.5% of BOD_5 and 34.9% of COD reduction were noted in aerobic process. Similarly, maximum 34.9% of BOD_5 and 71.7% of COD removal efficiency were addressed in anaerobic reactor (Figs. 6 and 7).

Table 1. The average BOD_5/COD ratio in influent waste water in different retention time.

HRT	BOD_5/COD ratio in influent
6	0.31
12	0.27
18	0.29
24	0.32

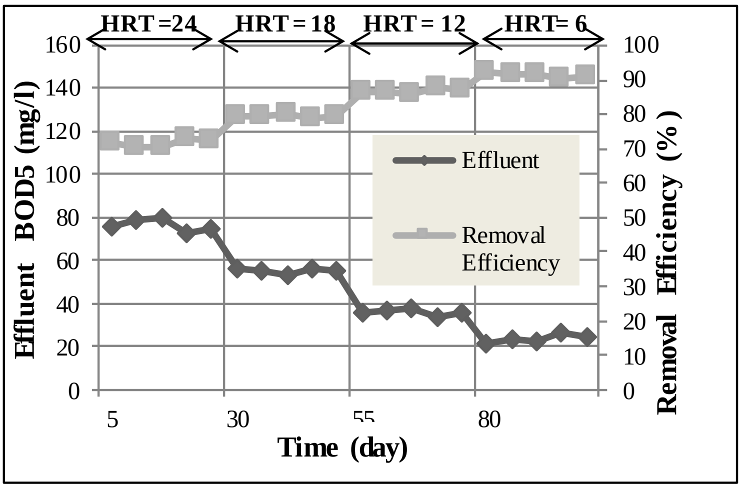

Fig. 2. BOD_5 concentration in effluent and removal efficiency in combined treatment system.

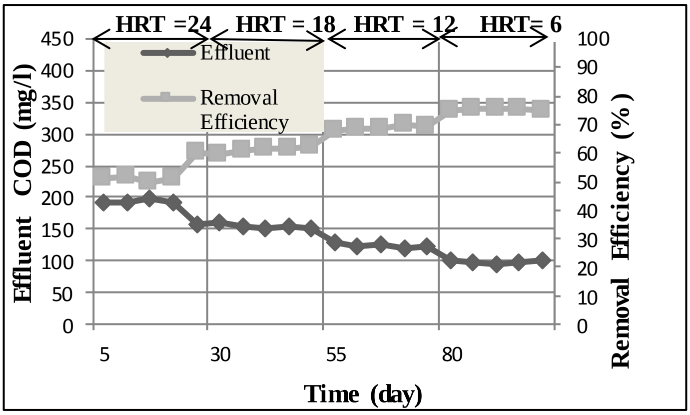

Fig. 3. COD concentration in effluent and removal efficiency in combined treatment system.

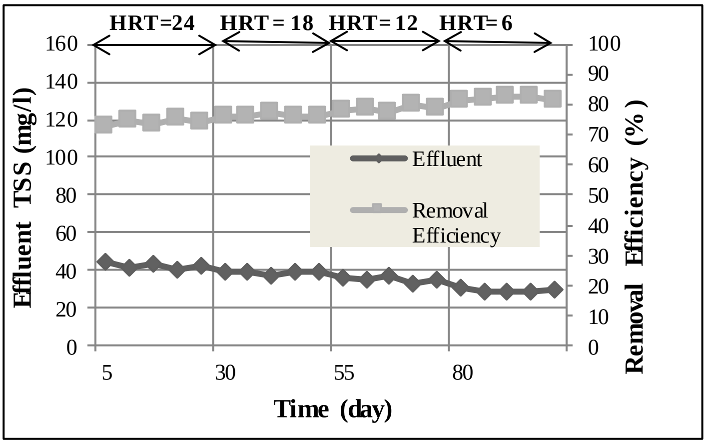

Fig. 4. TSS concentration in effluent and removal efficiency in combined treatment system.

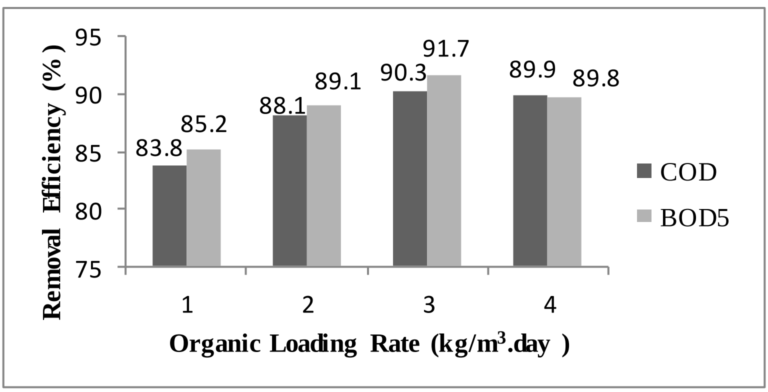

Fig. 5. COD and BOD_5 removal efficiency with increasing organic loading rate.

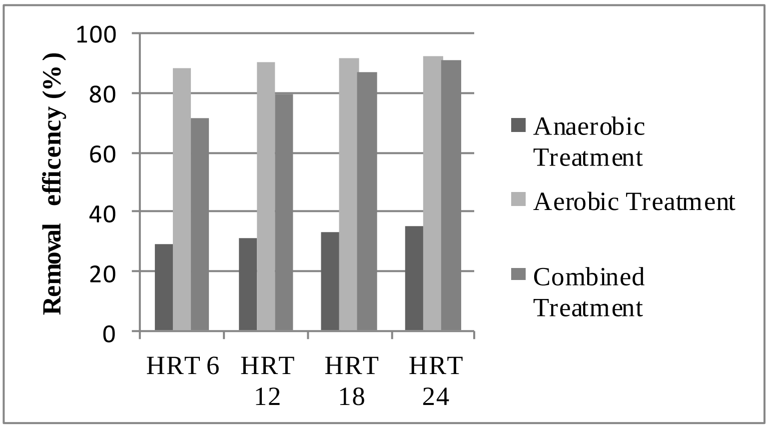

Fig. 6. BOD_5 removal efficiency in different treatment system.

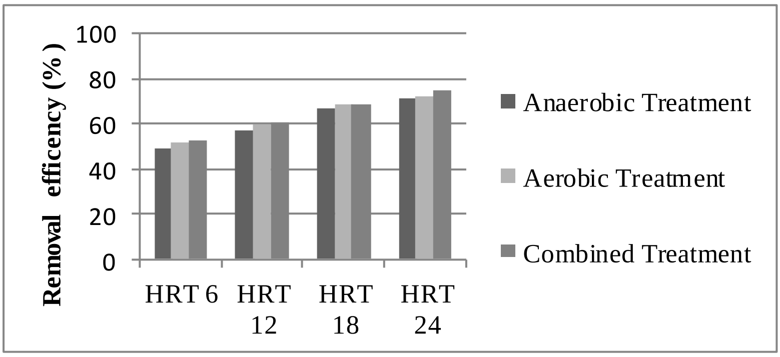

Fig.7. COD removal efficiency in different treatment system.

Table 2. Performance data of combined treatment system.

HRT (hr)	BOD_5		COD		TSS	
	Average Effluent (mg/L)	Reduction (%)	Average Effluent (mg/L)	Reduction (%)	Average Effluent (mg/L)	Reduction (%)
6	55.8	71.52	186.6	52.72	42.6	73.92
12	65.73	79.46	153.82	61.02	40.57	76.41
18	35.78	86.75	123.66	68.67	35.14	78.49
24	23.14	91.37	97.6	75.27	29.4	82.01

4. Discussion

Dyes, starch and cellulose are the main organic compound present in the wastewater of textiles. Microorganisms use these organic compounds to decompose or turn them into small compound and convert wastewater into more environmental friendly compounds [12]. BOD_5 and COD ratio is important for aerobic and anaerobic treatment. If the ratio of

BOD_5 and COD is less than 0.25 then, it is very difficult to treat in aerobic and anaerobic treatment system [13]. BOD_5/COD ratio of influent of the present study was 0.25 which was suitable for existing combined system.

Low amount of removal efficiency of BOD_5 was observed in anaerobic treatment. To reduce BOD_5, it is necessary to supply enough aeration for aerobic bacteria. Methane forming bacteria is not able to live in small quantity of oxygen presence. Therefore, aeration was regulated in anaerobic system for having better growth of anaerobic bacteria. Thus, high BOD_5 removal efficiency was observed in aerobic treatment system in compare to anaerobic treatment. Average 90% BOD_5 removal was addressed by various researchers through aerobic and anaerobic treatment system. Tjandra [9] found similar result while implementing combined treatment method in industry. He also noted the maximum BOD_5 removal efficiency found in aerobic treatment system in comparison with anaerobic treatment. Moreover, 93% BOD_5 removal efficiency was measured by Tjandra in combined treatment system [9]. Broglin *et al.* [14] were found similar result while treating wastewater through combined treatment system. They noted that BOD_5 reduced into 4 mg/L from 200 mg/L while passing through anaerobic and aerobic treatment procedures [14].

In present study, 71% to 91% BOD_5 removal was noted at different HRTs. HRT is considered as one of the important factor for anaerobic digestion. It is acknowledged that higher efficiency can be achievable at higher HRT [15]. Similar result found by different researchers of this world. The average BOD_5 was reduced into 23.14 from 55.8 mg/L with augmentation of HRT 6 to 24 hr as organic matter reduced by biotransformation and mineralization of microorganism [16]. Ahmed *et al.* [8] found similar result while treating wastewater through the combined method. They noted that BOD_5 was significantly decreased by metabolic activity of microorganism of active sludge. Significant amount of nitrification was reported in their experiment which reduced the organic matter [8]. Driessen was reduced 80-85% of BOD_5 of waste water in the lab scale combined treatment system in Germany [17].

Significant amount of COD removal efficiency was observed in the existing study. 52% -75% of COD removal efficiency was noted at different HRTs in the combined treatment system. The removal efficiency of COD in the present study was comparable with the result obtained by Tjandra [9] (85.8-95% COD removal at different HRTs) and Ahmed *et al*. [8] (75.2-87.3% removal from the treatment of combined system). COD was reduced into 159 from 2200 mg/L by Broglin in aerobic-anaerobic treatment of textile waste water [14]. Misra *et al*. [10] were identified that stabilization obtained at aerobic system and biodegradation occurred in anaerobic treatment. Further, Isik & Sponza [18] carried out a study where COD removal was reported 80% in anaerobic and aerobic treatment system of cotton processing effluent treatment system. Similarly, 80-84.7% COD removal result was measured in combined treatment by Somasiri [19]. Khehra *et al.* [20] operated an up flow fixed-film column reactor (UFCR) and a continuously stirred aerobic reactor (CSAR) in their experiment which showed good response to remove COD.

They reported 95% of COD removal by anoxic-aerobic bio reactor process for synthetic textile waste water.

In present study, 49-71% and 52-72% of COD removal were occurred in the anaerobic and aerobic treatment system respectively. Anaerobic bacteria use organic matter to bio-transform and mineralization. Maximum amount of COD removed at anaerobic reactor. As a result, the treatability of BOD_5 improved remarkably for aerobic system. The present result is a good agreement with the previous investigation of different researchers of all over the world [12, 20, 21].

The BOD_5 removal was gradually increased with OLR. However, high OLR assisted the treatment system to reduce BOD_5 and COD removal. In the present experiment, BOD_5 removal efficiency was increased into 85.2% to 91.7% with OLR 1-3 kg/m^3.day. For OLR 4 kg/m^3.day, BOD removal slightly decreased into 89.8%. Similar scenario was obtained for COD removal. Likewise, maximum BOD_5 and COD removal was obtained for OLR of 2.5 kg/m^3.day by Ahmed *et al.* [1] in their experiment.

The quantity and performance of combined treatment system is depended on TSS. TSS is one of the major carbon and energy source for microorganism. Both aerobic and anaerobic microorganisms convert suspended solid into other product and increase the efficiency of treatment system [16]. 73%, 76%, 78% and 82% of TSS were removed at HRT 6, 12, 18 and 24 hr respectively in present study. The result indicated that there was no noticeable relationship present between HRTs and TSS removal. Comparable scenario was obtained by Ahmed *et al.* [8] as they removed 82.9-87.4% of TSS at different HRTs.

5. Conclusion

The present study was an attempt to address the effectivity of industrial scale combined treatment system to treat the knit processing textile wastewater. This technique showed good response to reduce organic matter and suspended solid. The present experiment reduced 71-91%, 52-75% and 73-82% of BOD_5, COD and TSS at different HRTs respectively. The anaerobic treatment system reduced most of the COD and improved the treatability of BOD_5 for aerobic treatment. Maximum amount of BOD_5 was reduced by the aeration system and microbial activity in aerobic reactor. The overall result of the combined treatment system showed that it may be a feasible procedure to improve BOD_5, COD and TSS concentration of textile wastewater.

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