

C.O.D REDUCTION OF REACTIVE DYEING EFFLUENT FROM COTTON TEXTILE INDUSTRY

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ABSTRACT

The present study focuses on the improvement in the effluent treatment for the effluent generated from a cotton textile industry employing three reactive dyeing methods viz., Exhaust method, Pad-Dry-Cure method, and Pad-Batch method. Stabilisation pond, aeration tank, and aerobic biological treatment (using E-Coli type bacteria) are simulated in the laboratory in a series operation. Results revealed an overall COD reduction of 80%, 90%, and 62% respectively for the effluent generated from each of the three above mentioned reactive dyeing methods. A subsequent polishing treatment with activated carbon can further bring down the COD levels of the effluents from the three reactive dyeing methods to well below 250 mg/L, which is the upper limit for disposal of effluents into surface water. A flow diagram incorporating the results of present study and the polishing treatment technique is proposed for better results.

Key words: Textile industry, Reactive dyeing method, COD, Polishing treatment

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INTRODUCTION

Textile industry can be classified into three categories viz., cotton, woolen, and synthetic fibers depending upon the raw materials used. The cotton textile industry is one of the oldest industries in the country with over 1000 industries (or mills) mainly centered in Mumbai, Surat, Ahmedabad, Coimbatore, and Kanpur. The water consumption and wastewater generation from a textile industry depends upon the processing operations employed during the conversion of fiber to textile fabric. On the basis of waste and wastewater (or effluent) generation, the textile mills can be classified (ISPCH, 1995) into two main groups viz., Dry processing mill and Woven fabric finishing mills. In the dry processing mill, mainly solid waste is generated due to the rejects of cotton. In the other group, desizing, scouring, bleaching, mercerising, dyeing, printing, and packing are the main processing stages. These stages consume approximately 2400 to 2700 m³/day of raw water (ISPCH, 1995). The wastewater characteristics depend upon the processing stages. In general, the wastewater from a typical cotton textile industry is characterised by high values of BOD, COD, color, and pH (ISPCH, 1995). Because of the high BOD, the untreated textile wastewater can cause rapid depletion of dissolved oxygen if it is directly discharged into the surface water sources. The effluents with high levels of COD are toxic to biological life (Metcalf & Eddy, 1991). The high alkalinity and traces of chromium (employed in dyes) adversely affect the aquatic life and also interfere with the biological treatment process. The high color renders the water unfit for use at the downstream of the disposal point (Rao and Datta, 1987).

In view of the above adverse effects, the textile industry effluent is to be treated and discharged according to the standards prescribed under Central Water (Prevention and Control of Pollution) Act, 1974. The present study focuses on the improvement in wastewater treatment for the wastewater generated by a cotton textile industry located in Mumbai. The industry produces 5 lakh square meter of cloth per day with 100% cotton from 82,000 kg of cotton yarn. The wastewater generation is 2500 m³/day. The inlet BOD and COD concentrations are 600 mg/L and 1200 mg/L respectively whereas the desired concentrations of these two parameters are < 30 mg/L and < 250 mg/L respectively for disposal into surface water sources (TEDDY, 1998). The existing treatment units comprise of Neutralisation/equalisation tank, Aeration tank, Reactor-I employing anaerobic biological treatment, Reactor-II employing aerobic biological treatment, and secondary clarifier. It is observed that, presently no particular bacteria is being developed (Hitesh, 1998) and employed either in Reactor-I or Reactor-II. The industry is able to bring down the COD and BOD levels of the treated effluent below the permissible limits for disposal into surface water by employing the above mentioned unit operations. Hence, the industry is not facing any problem from the State Pollution Control Board with regard to discharge of wastewater into surface water sources. However, in view of no systematic development of bacteria at Effluent Treatment Plant (ETP), it is felt appropriate to study the effect of bacteria developed specifically for the biological treatment of wastewater from this industry. High levels of COD are expected (Hitesh, 1998) from dyeing section due to the nature of chemicals employed in the operation. Escherichia Coli (E-Coli) type bacteria is developed in the laboratory and tested for removal of COD from the effluents generated due to the usage of three different types of reactive dyeing methods viz., Exhaust, Pad-Dry-Cure, and Pad-Batch. In addition to the biological treatment, experimental study is also carried out to simulate

stabilisation pond and aeration tank in the lab in a series operation. Recommendations for further polishing treatment of the effluent are also addressed in the present study.

OPTIONS FOR TEXTILE WASTEWATER TREATMENT

Literature survey is carried out to study the different unit operations employed for treatment of wastewater from cotton textile industries. Pretreatment for removal of inorganic solids and floating material, flow equalisation and neutralisation, chemical coagulation, clarification, and biological treatment are the most common unit operations employed (Rao and Datta, 1987; ISPCH, 1995) in the textile wastewater treatment. Aerated lagoon or stabilisation pond with shallow depths are also reported in giving encouraging results (Arcievala and Mohanrao, 1969; Sastry, 1972; Rao and Datta, 1987). The dye wastes can be segregated, neutralised and can be successfully treated by chemical oxidation/precipitation (Rao and Datta, 1987). A COD removal of 45% and BOD removal of 75% is reported for a textile industry effluent employing primary and secondary treatment units (ISPCH, 1995). The unit operations employed are flow equalisation/neutralisation, clariflocculator using alum as coagulant, and activated sludge process with secondary clarifier. Enough literature is available (Babbit and Bauman, 1958; O'Connor and Eckenfelder, 1960; Arcievala and Mohanrao, 1969; Clarke et al., 1971; Kharker et al., 1972; Mc.Kinney, 1971; Ansari, 1972; Sastry, 1972; Bela, 1974; Berthouex and Rudd, 1976; Golterman and Clymo, 1978; Arcievala, 1981; Rao and Datta, 1987; Metcalf and Eddy, 1991, Elangovan and Saseetharan, 1997) on each of the above unit operations. Little literature is available pertaining to the study of COD generation from the earlier mentioned three reactive dyeing methods and its subsequent removal in a series operation consisting a combination of unit operations reported above. And hence, in the present study, emphasis is given to reduction of COD from the effluents generated due to the usage of three different types of reactive dyeing methods. The unit operations employed in the present study are:

- Stabilisation pond
- Aeration tank
- Biological (aerobic) treatment

The results of the present study are useful in understanding the COD generation from a reactive dyeing method *vis-a-vis* COD treatment technology.

EXPERIMENTAL PROCEDURE

Dyes are prepared using each of the three reactive dyeing methods (CTLM, 1986). The technical details pertaining to the various chemicals used in each of three reactive dyeing methods are given in Table-1. The reactive dyeing of the cotton cloth (100% cotton) is carried out by the following procedure:

5 gm of color was taken in a beaker. For laboratory purpose, the ratio of weight of the cloth to weight of the liquor (dyeing solution) was kept at 1:3. Depending upon the color, proper amount of either common salt or Glauber's salt was added to the beaker. Proper amount of suitable alkali was used for fixing of color. The dyed cloths were washed with water and soap soda solution (2% soap and 5% soda in water). Liquor left in the container and soap water remained after washing were mixed in 1:1 ratio and were collected in three different bottles and were analysed for COD levels. The initial COD levels of the three samples are given in Table-2. The sample is made to pass through a

series of the three unit operations mentioned above. All the unit operations employed in the laboratory are of batch studies only and are simulated in laboratory as follows:

- **Stabilisation pond:** Effluent generated from each of the three reactive dyeing methods is taken in three shallow circular trays of 45cm diameter and 2.5cm deep, and 180 mL of water containing algae is added to each of the trays. The effluent is mixed properly and is allowed to undergo degradation in open air in the laboratory for two days. Since the depth of the tray is very shallow, and subsequently to avoid excessive evaporation, trays are kept open to enough sunlight (Ansari, 1972) for only two hours (2 PM to 4 PM) in the day for the growth of algae. The effluent is tested for COD level after two days.
- **Aeration tank:** Three effluent samples of 650 mL from simulated stabilisation pond corresponding to those from each of the three reactive dyeing methods are collected in three different bottles and air is bubbled through all the bottles using air compressor at the rate of 0.566 m³/min. The samples are analysed for COD level after two hours.
- **Biological treatment:** E-Coli type bacteria is grown in the medium for 8 hours at 35⁰C and 8 to 10 mL of medium containing bacteria is added to each of the bottles containing effluent from aeration tank. The E-Coli type bacteria grow very fast, double after every 20 minutes under favorable conditions. They are predominantly aerobic bacteria in the favorable condition of pH in the range of 6 to 8. All the three bottles are kept at 35⁰C temperature to ensure bacterial growth. COD levels of effluent are measured after a bacterial residence time of 8 hours.

RESULTS AND DISCUSSION

The results of the overall reduction of COD levels in the effluent samples using the Exhaust, Pad-Dry-Cure, and Pad-Batch methods are given in Table-3. From Table-3, it is clearly seen that, the COD removal efficiency of stabilisation pond, aeration tank, and aerobic biological treatments is 80%, 90%, and 62% respectively for the above three methods of reactive dyeing. The percentage COD reduction after each stage of unit operations attempted in the present study is given in Figure-1. From Table-3 and Figure-1, it is to be noticed that, the overall COD removal efficiency is much higher in the samples from Exhaust and Pad-Dry-Cure methods than that of Pad-Batch sample. This could be due to the incomplete oxidation of effluent from Pad-Batch method treated in the present experimental set-up. A high COD removal efficiency is observed in the aerobic biological treatment for both Exhaust and Pad-Dry-Cure methods than that in Pad-Batch method. This can be attributed to the presence of Triple Super Phosphate (TSP) and Urea (see Table-1) and hence favorable environment for bacterial growth in the effluent from these two methods. Further, it is noticed that, the Pad-Batch sample has a high pH of 9.36, which is inhibiting the bacterial growth during biological treatment. Chemical precipitation using alum may be attempted before the Pad-Batch sample is subjected to aeration. This may help in precipitation of the chemicals present in the sample and thus encouraging further removal of COD.

Despite the encouraging results obtained in the present experimental set-up, the COD level of the samples from none of the three methods has been reduced to below 250 mg/L, which is the upper limit for disposal of effluent into inland surface water. Polishing

treatment using activated carbon can further reduce the COD levels of the textile industry effluents (ISPCH, 1995) by 81%. The COD levels of each of the three reactive dyeing methods after the experimental studies are 460 mg/L, 476 mg/L, and 1267 mg/L respectively (see Table-3). If the effluent is treated with activated carbon having 81% COD removal efficiency, the theoretical COD levels of the samples from each of the three reactive dyeing methods are expected to be 89.44 mg/L, 90.44 mg/L, and 241 mg/L respectively. It may be noted from the above results that, the COD levels of all the samples can be brought below 250 mg/L, which is the upper limit for disposal of effluent in surface water sources. Since the COD level of the sample from Pad-Batch method very closely matches (~ 241 mg/L) with the upper limit (250 mg/L) of COD for disposal into surface water sources, its exact COD removal efficiency after treatment with activated carbon is to be ascertained through a series of laboratory studies. A neutralisation tank may be provided to bring the variation in the pH of the effluent after biological treatment under control as per the prescribed limits (pH: 5.5 to 9) before it is safely disposed into surface water sources. A settling tank is to be provided to settle the biological solids from the biological treatment. Disinfection of bacteria remaining, if any, in the effluent renders the textile industry effluent harmless for safe disposal.

After assessing the results of the present study and other technical aspects involved in further polishing the COD removal of the effluents from the three reactive dyeing methods employed in the cotton textile industry under consideration, a flow diagram (Figure-2) is proposed with a combination of unit operations for better results. The polishing treatment using activated carbon can also reduce the BOD and color of the textile industry effluents by 81% and 99.4% respectively (ISPCH, 1995). When the proposed experimental set-up is compared with that of the existing unit operations at the ETP of the industry, it is to be noticed that, Reactor-I employing anaerobic biological treatment is mainly being used for COD reduction. The results of present study revealed that, satisfactory results can be achieved with aerobic biological treatment and polishing treatment. Since the dye house effluents contribute more COD load in the overall effluent from the industry, the present study is advantageous in the cost reduction of ETP. The present study thus emphasises the significance of *minimising* the pollutant (COD) load in the effluent to be treated at the *end-of-pipe* i.e., at ETP. This will help the industry in *minimising* the *cost* and *space requirements* needed for effluent treatment.

SUMMARY AND CONCLUSIONS

High levels of COD will be generated during the reactive dyeing methods employed in cotton textile industries. Cloth dyeing using three reactive dyeing methods viz., Exhaust method, Pad-Dry-Cure method, and Pad-Batch method is employed in the laboratory and the effluents generated are analysed for COD levels. The process of bringing down the COD levels of waste below 250 mg/L before discharging into surface water sources is studied in detail in the present work. The overall efficiencies of COD removal of the stabilisation pond, aeration tank, and aerobic biological treatment are found to be 80%, 90%, and 62% respectively for the effluents from each of the three reactive dyeing methods. It can be noticed from the results that, a high COD removal efficiency of 90% is recorded for the effluent from Pad-Dry-Cure method of reactive dyeing. It is also recommended to use specific bacterial feed instead of using a mix bacterial feed for

efficient biological treatment. The selection of bacterial species for biological treatment depends upon the following factors:

- Chemical composition of the dye
- Alkalis and salts used in dyeing methods

In the present study, it is also suggested that, subsequent polishing treatment of the effluent with activated carbon would further reduce the COD levels well below the upper limit of 250 mg/L stipulated for disposal into surface water sources. A flow diagram incorporating the results of present study and the polishing treatment technique is proposed for achieving better results.

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Table-1 Technical details pertaining to the three reactive dyeing methods

Sr. No	Parameter	Exhaust method	Pad-Dry-Cure method	Pad-Batch method
1	Color	Red M ₈ B	Red M ₈ B	Red M ₈ B
2	Color concentration	--	10 gm/L	10 gm/L
3	Salt	NaCl	--	--
4	Salt concentration	20%	--	--
5	Salt volume	72 mL	--	--
6	Alkali	TSP	Na ₂ CO ₃	Na ₂ CO ₃
7	Alkali concentration	20%	10 gm/L	10 gm/L
8	Alkali volume	18 mL	--	--
9	Urea concentration	--	100 gm/L	--
10	Dyeing temperature	60 ⁰ C	--	--
11	Curing temperature	--	150 ⁰ C	--

Table-2 Initial COD levels of the effluent

Sample	COD, mg/L
Exhaust method	2304
Pad-Dry-Cure method	4992
Pad-Batch method	3340

Table-3 Overall percentage reduction of COD

Sample	Initial COD mg/L	Final COD mg/L	Overall percentage reduction
Exhaust method	2304	460	80
Pad-Dry-Cure method	4992	476	90
Pad-Batch method	3340	1267	62

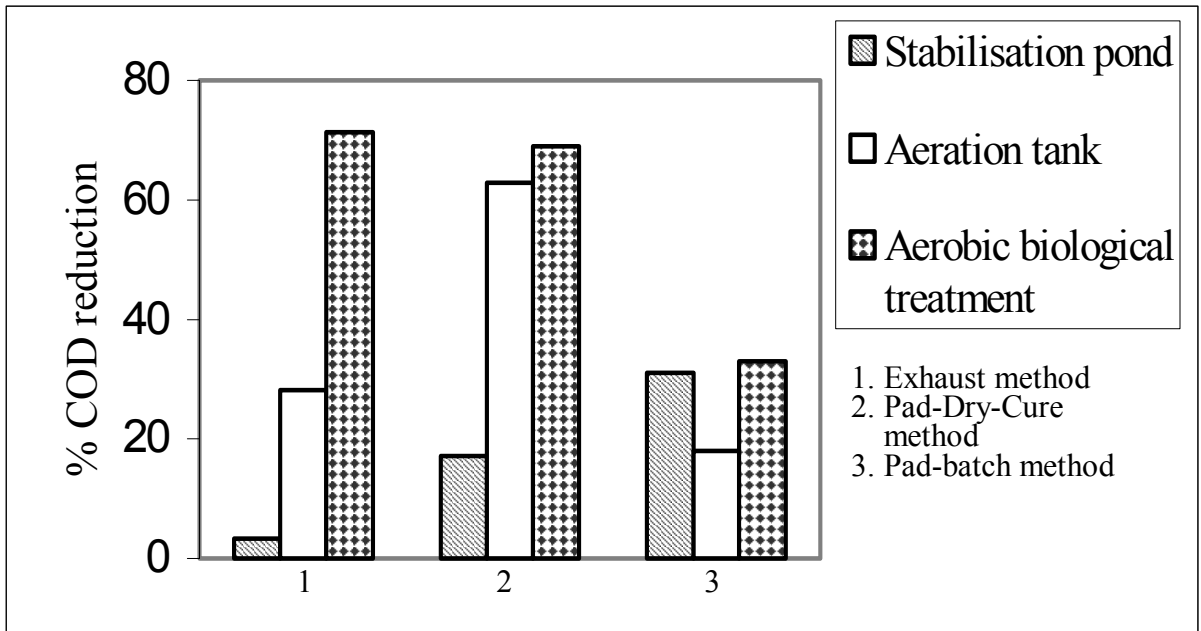


Figure-1. Percentage COD Reduction in the three Reactive Dyeing Methods

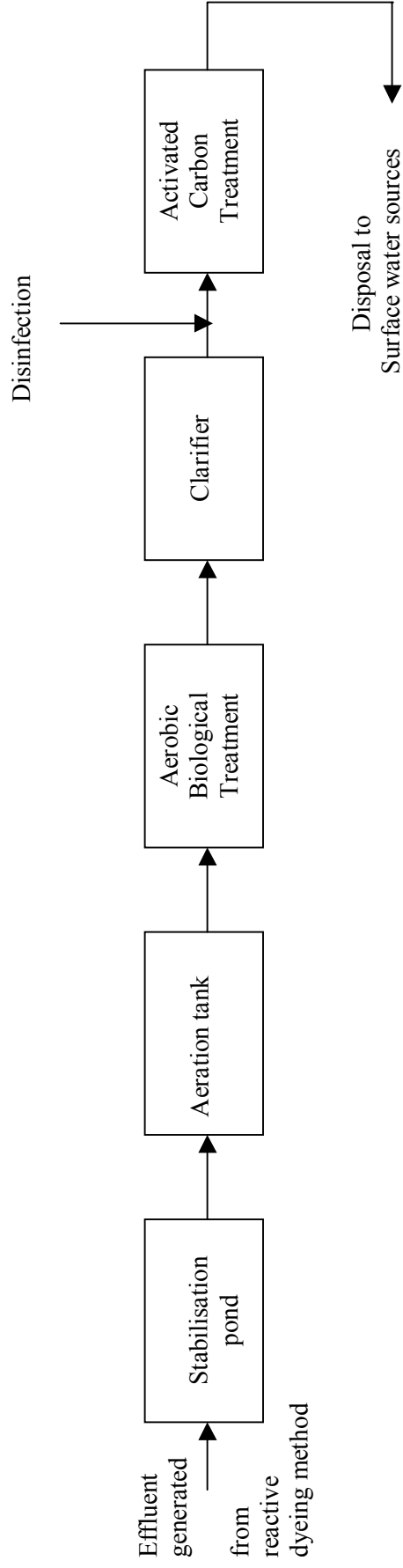


Figure-2 Flow diagram for COD reduction for the effluents generated from a cotton textile industry employing reactive dyeing methods.