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Removal of Organics and Colour from the Wastewater of Denim Industry

Rajesh Singh and V. K. Choubey
Environmental Hydrology Division, National Institute of Hydrology, Roorkee – 247667, India

Abstract : Textile Industry consumes considerable amount of water for dyeing, finishing, and sizing. The wastewater from the manufacturing facility is high in color (10000-15000 Pt Co), COD (2000-5000 mg/L), TDS (7000 – 9000 mg/L), and TSS (1000-2000 mg/L). Management of wastewater from the facility was the subject of this study. Intensive treatability studies involving physico-chemical and biological treatment was performed. Coagulation and flocculation followed by sedimentation using magnesium sulfate, ferric chloride, and polyelectrolyte resulted in 65 - 70 % reduction in suspended solids and colloids. Upflow anaerobic sludge blanket reactor followed by fluidized media reactor was applied after physico-chemical treatment for reduction of organics and color. The study implied that about 94% color, 90% COD, and 98% TSS reduction is possible. A final process design as well as economic study based on the laboratory findings has been carried out.

Keywords - COD, Color, TSS, Textile, Upflow anaerobic sludge blanket reactor (UASBR), Fluidized media reactor (FMR)

INTRODUCTION

Textile industry is characterized by intensive use of water and wide spectrum of processing chemicals. The water is primarily employed in the dyeing and finishing operations. In a typical dyeing and finishing mill, about 100 L of water is consumed on the average for every ton of cloth processed (Lin et al., 1997). The water used in the process finally ends up as wastewater which needs to be treated for either recycling back or discharge. Wastewater generated by different production steps of a textile mills pose serious environmental problems because of high pH, temperature, color, detergents, suspended and dissolved solids, toxic and non biodegradable matter (Kumar et al., 2007). Consequently, textile industry effluents are characterized by high organics and presence of non biodegradable components such as dyes, pigments, sizing chemicals etc.

For the treatment of textile wastewater, physico-chemical treatment (Can et al., 2006; Allegre et al., 2006), chemical oxidation (Lin et al., 1997; Kuo 1992; Lin et al., 1993), biological treatment (Horoun et al., 2009; Shaw et al., 2002; Bell et al., 2003), and membrane based treatment (Porter, 1998; Lopes et al., 2005; Fersi et al., 2005; Yigit et al., 2009) have been widely explored. The research work till date is focussed on resolving a particular issue associated with wastewater of textile mill wastewater and not towards a solution in totality.

The present study was based on providing complete solution to Raymond UCO Denim Pvt. Ltd. (RUDPL), Yavatmal for the effluent management, achieve zero liquid discharge (ZLD), and recover water to fill the gap of demand and supply after manufacturing facility expansion. RUDPL was having full fledged effluent treatment plant (Figure 1) for treatment and recovery of water. One of the major constraints in achieving ZLD has been the difficulty in operating the evaporators satisfactorily due to presence of high color and COD present in the reject stream from the reverse osmosis (RO) units. The focus of the study, therefore, was to evaluate various options for removal of color and COD from the combined dyeing and finishing effluents such that the quality

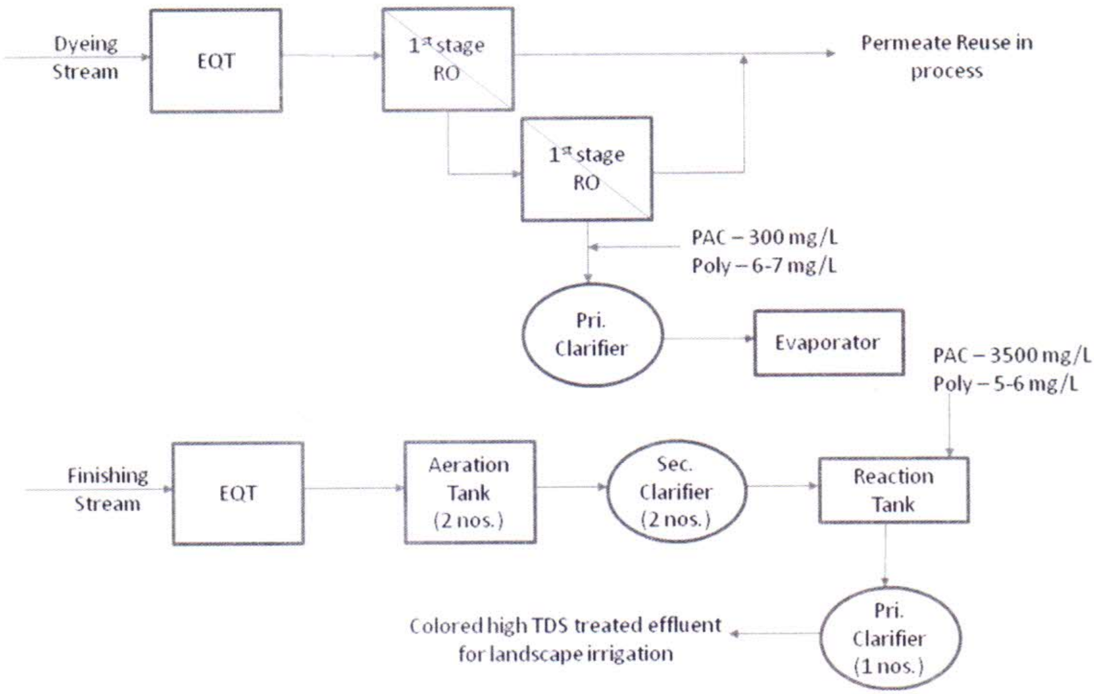

Fig. 1. Block diagram of the existing effluent treatment and recycle plant

of the reject stream from the RO units can be significantly improved in terms of color and COD and in turn minimize the problem associated with the operation of the evaporator.

MATERIAL AND METHODS

Pilot Scale Treatment Unit – Continuously stirred tank reactor (20 L), anaerobic reactor (150 L), and aerobic reactor (150 L) were constructed from MS-FRP sheet. CSTR was utilized for the removal of suspended solids, anaerobic reactor and aerobic reactor was utilized for the reduction of COD / organics. Jar test apparatus was utilized for assessing the requirement of coagulants and flocculants.

Seed and Inoculation – The reactors were initially seeded with inoculum from anaerobically digested sludge and aeration tank of a sewage treatment plant. On subsequent days, jaggery solution along with urea and DAP was added to obtain the desired mixed liquor suspended solids (MLSS) and mixed liquor volatile suspended solids (MLVSS) in the reactors. After achieving desired MLSS and 0.75 MLVSS/MLSS ratio, effluent injection in incremental manner along with jaggery solution started for acclimatization of the micro organisms. The acclimation period for anaerobic reactor in this study was 60 days and 20 days for aerobic reactor.

Sampling and Analysis – The functioning of reactors over monitored over a period of three months. The samples at the feed and outlet of the reactors were collected and analyzed on regular basis to monitor the performance of the reactors.

Chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), MLSS, and MLVSS were regularly performed for the untreated and treated effluent as well as sludge according to the standard methods (APHA, 2005).

Operating Conditions – CSTR was operated in fill, react, and withdrawal mode throughout the experimental period. The biological reactors were operated in fill, react, and withdrawal during initial period of operation. After stabilization of the process, the reactors were operated in continuous mode for a period of three months.

RESULT AND DISCUSSION

Characterization of Wastewater – RUDPL was having two effluent streams – one from the dyeing and finishing department and the other from rope and old finishing department. The characteristics of the effluent stream samples are given in table 1.

Preparation of Stock Solution – Dyeing section contribute 30-40 % of the total effluent generated from the denim manufacturing facility. The remaining contribution is from finishing section. Preliminary trials indicated that biodegradability of the finishing unit effluents was much better than dyeing effluent. Keeping is view of this fact, stock solution was prepared by mixing the dyeing and finishing effluent in 1:1 ratio and used for treatment. The ratio was selected to ensure the workability of proposed solution in the worst scenario.

Treatability Study – Out of the various treatment options (physico chemical, electro coagulation, ozonation, membrane, and biological) available for color and organic reduction from textile mill effluent, the biological treatment process has been

Table 1: Wastewater characteristics

Sr. No.	Parameters	Unit	Steam 1	Stream 2
1	pH	--	10.0 - 11.0	10.0 - 11.0
2	Conductivity	µS/cm	9000 – 10000	27000 - 29000
3	Total dissolved solids	mg/L	6000 - 7000	8000 - 10000
4	Total suspended solids	mg/L	1000 - 2000	1000 - 2000
5	Color	PtCo	20000 - 25000	3000 - 5000
6	COD	mg/L	1200 - 5000	3500 - 5500
7	BOD	mg/L	350 - 1400	900 - 1500
8	BOD / COD	-----	0.3	0.26

found to be both technically and commercially viable and accordingly the treatment process optimized.

Aerobic Biological Treatment – The combined effluent was consisting of an appreciable amount of suspended solids with high pH. The pH of stock solution was brought down to 8 with the help of hydrochloric acid. Acid treated effluent was fed to the aerobic reactor with acclimatized bacteria. After almost 48 hours of operation it was observed that the activity of bacteria started reducing and the reduction in COD was almost negligible. Keeping in view the above observation, it was concluded that the effluent in virgin form is toxic to bacteria.

After failure of aerobic biological treatment on virgin effluent, biological treatment was given after chemical coagulation and flocculation in order to remove part of COD contributing contaminants. Our previous trials had clearly indicated that coagulation and flocculation improves the BOD / COD ratio. So, taking advantage of the high pH, magnesium sulfate was used as coagulant along with flocculent to remove suspended solids. 3000 - 5000 mg/L of magnesium sulfate and 2 mg/L flocculent dosage was required to remove reduce the SS and color. As a result of coagulation and flocculation activities, the COD came down to 2000 – 2200 mg/L. The pH of chemically treated effluent reduced to 9 – 10 resulting in reduction in consumption of acid for neutralization of feed to aeration tank.

The chemically treated effluent after pH correction was than routed through aeration tank containing acclimatized micro organisms for treatment of textile mill effluents. COD and color of treated effluents was found to be in the range of 400 – 800 mg/L and 500 – 1000 PtCo units respectively.

Although the process is able to provide appreciable reduction in COD & color, it results in a large quantity of sludge and dosage chemicals making the process non viable.

Anaerobic - Aerobic Biological Treatment – Keeping in view of the disadvantages of above process, anaerobic biological treatment followed by aerobic biological treatment was assessed. The advantages of anaerobic process is that the facultative micro organisms present in the reactor releases certain enzymes which are able to convert high molecular aliphatic / aromatic compounds into smaller linear chain molecules which are easily biodegradable and improves the efficiency. The proposed scheme not only reduced sludge generation but also the size of aeration tank and the air requirement. The qualitative and quantitative characteristics of sludge generated from various units of the proposed scheme will be as provided in Table 2. The results of treatability study are shown in Figure 2 and Figure 3.

Table 2. Sludge generation from various processes in proposed scheme

Sr. No.	Equipments	Sludge Consistency (%)	Flow (m3/hr)
1	Solids contact clarifier	2 - 3	7 - 9
2	Anaerobic reactor	6 - 7	0.8 – 1.0
3	Aerobic reactor	1 – 1.2	0.7 – 0.9

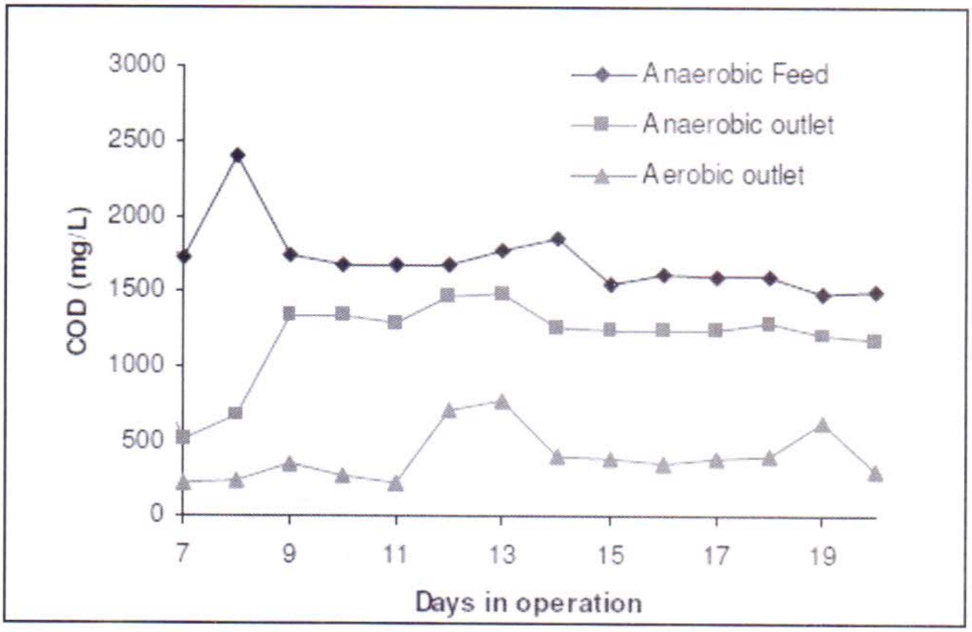

Fig. 2. Results of COD after anaerobic followed by aerobic biological treatment of combined effluent.

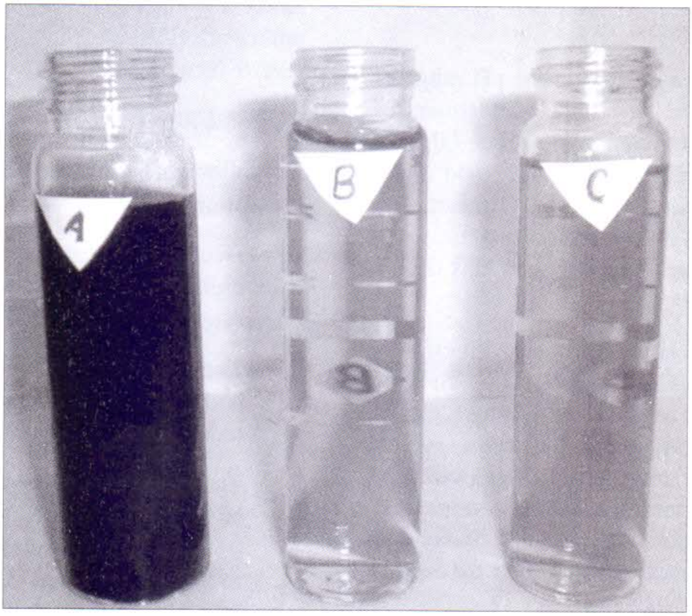

Fig. 3. Picture of untreated and treated effluents – (a) Filtered sample after coagulation and flocculation, (b) Filtered sample after anaerobic reactor, and (c) Filtered sample after aerobic reactor

Design of ETP and Recycle Plant - Based on the extensive treatability studies carried out on the combined dyeing and finishing effluents, the effluent treatment plant for the denim manufacturing facility will consist of chemical coagulation and flocculation to remove suspended solids followed by biological oxidation of organic matter and finally chemical oxidation to achieve desired COD and color levels as well as disinfection. The approach to achieve ZLD and make the textile complex a green textile zone is-

- Effluent treatment plant consisting primarily of equalization cum neutralization tank, high rate solids contact clarifier, anaerobic reactor, pre-aeration tank, aerobic reactor, secondary clarifier, chlorine contact tank and multi grade filter.
- Recycle plant consisting of UF and RO units of
- Zero discharge plant consisting of evaporator and centrifuge

The schematic of ETP and recycle plant to achieve ZLD is shown in figure 4.

Anaerobic processes operate in the pH range of 6.5 – 8.0 and hence, first step for treatment of effluent will be neutralization to a pH of 7.0. This will be done by dosing hydrochloric acid in the equalization tank equipped with pH meter. The outlet from solids contact clarifier feed pump will keep on recirculating to equalization tank till pH of 6.5 – 7.5 is achieved.

Anaerobic reactor can be operated with effluent having 250 – 300 mg/L suspended solids. To bring down the suspended solids below 400 mg/L, Solids Contact Clarifier is suggested. Laboratory studies with different coagulants and flocculants indicated that 100 mg/L magnesium sulfate in combination with 10 mg/L ferric chloride and 2 mg/L Indion 348 (polyelectrolyte) is required to achieve the desired suspended solids level.

The clarified water will be treated through anaerobic reactor and aerobic reactor with extended aeration to reduce color and COD. The HRT of anaerobic and aerobic reactor will be 20 and 22 hr respectively based on the feasibility studies. Part of anaerobic reactor outlet will be recirculated back to anaerobic reactor feed tank in order to achieve the desired upflow velocity (0.7 m/h) / organic loading rate (5.0 Kg COD / m3 / d). Both these reactors use micro organisms acclimatized to textile effluent. The success of the anaerobic treatment process depends on the specific enzymes released by the micro organisms which are able to break the macro-molecules into micromolecules and hence prior conditioning of micro organisms is desired. The treated effluent form anaerobic reactor will be routed to aerobic reactor through a pre aeration tank. The color and COD of an-aerobically treated effluent will be reduced to less than 1000 PtCo unit and 400 mg/L respectively after treatment through aerobic reactor and secondary clarifier. Further reduction in color and COD will be achieved in chlorine contact tank.

Effluent from chlorine contact tank will be fed to multi grade filter, ultrafiltration membrane unit, and reverse osmosis unit to recover almost 75% water.

CONCLUSION

The following conclusions can be drawn from the present study-

1. Denim manufacturing facility effluent is highly contaminated with color, organics, suspended solids, and dissolved solids.
2. The effluent is toxic to biological treatment and requires chemical pre-treatment for reduction of suspended solids.
3. The most feasible and economical scheme is chemical coagulation and flocculation (removal of suspended solids) followed by anaerobic and aerobic biological treatment. Effluent from aerobic biological treatment requires chemical oxidation by chlorine/chlorine dioxide for disinfection and final polishing.

4. 70-80% water can be recovered from the treated effluent with the help of UF and RO membranes.
5. The reject of RO will be less in organics and hence can be treated through evaporator and centrifuge to achieve ZLD.

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