Journal of Ecobiotechnology 2012, 4(1): 25-28
ISSN: 2077-0464
Available Online: http://journal-ecobiotechnology.com/

Performance evaluation of a common effluent treatment plant for tannery industries

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Abstract
Tannery is one of the oldest industries in the world and is one of the fastest developing industries in India. It is one of the problematic industries in India which generate high quantum of wastewater with high TDS and toxicity due to chromium. Hence, discharge of tannery effluent is a very serious issue. Many conventional treatment processes has been carried out in these industry before the discharge of effluent. One of the most common treatment process applied is biological treatment process by activated sludge process and upflow anaerobic sludge blanket process. Due to the high cost of installation for this treatment process, in many of the small scale tannery industries in India, the wastewater treatment is carried out in common effluent treatment plant (CETP). In the present study the performance of CETP for tannery effluent in terms of Biological oxygen demand (BOD), Chemical oxygen demand (COD), Total suspended solids (TSS), Total dissolved solids (TDS), and by water tracer studies using Rhodamine. ETP showed a removal efficiency of BOD-66%, COD- 21%, TSS-21% and TDS-5%. The study revealed that ETP has to be redesigned based on the characteristics of influent wastewater in order to meet the Pollution Control Board prescribed standard limits for ETP.

Keywords: Tannery effluent, water tracer, activated sludge process, common effluent treatment plant, performance evaluation.

INTRODUCTION

Small scale industries (SSI) have a very important role in the overall development in India. Tamilnadu is one of the state undergoing rapid urbanization and is the most urbanized state in India and growth of SSI units has been actively promoted by the government to induce balance economic growth and to distribute the benefits of industrial development in equitable manner. It is difficult for each industrial unit to provide and operate individual wastewater treatment plant because of the scale of operations or lack of space or technical manpower. However, the quantum of pollutants discharged by SSI cluster may be more than or equivalent to large scale industries, hence the treatment of wastewater in a common treatment system was promoted by Indian government. In India there are about 88 CETP s of which 33 units are operated in Tamilnadu (CPCB, 2005). The present study was carried out in a CETP for tannery Industries. Tanning industry is one of the oldest and fast growing industries in India. The process of tanning is closely associated with pollution as larger quantities of water are used. In the present study area about 138 tanneries are located which are all in small scale sectors. The total wastewater generated from these industries is 2400 m^3/ day and is treated in a common effluent treatment plant.

Tanneries are typically characterized as pollution intensive complexes which generate widely varying high strength wastewater. Tanning industry has one of the highest toxic intensity per unit of output (Khan *et al*, 1999) and is one of the hazardous industries. Tannery wastewater is highly complex is characterized by high organic, inorganic and nitrogenous compounds, chromium, sulfides, suspended solids and dissolved solids. In general, tannery wastewater is dark brown in colour and has high content of organic substances (Kongjao *et al* 2008). Treatment of tannery wastewater is carried out by physical, chemical, biological or combination of all these method. The most commonly opted biological treatment processes in India are USAB and ASP (Jawahar *et al*, 1998, Rajam *et al*, 1995). Biodegradation of tannery wastewater has been reported by many workers (Jawahar *et al*, 1998, Elangoan, 1994, Eckenfelder, 2002, Tare *et al*, 2003).

The performance of ASP is affected by many factors like mean cell residence time, mixed liquor volatile solids, hydraulic retention time, food to microorganism ratio (F/M ratio) and dissolved oxygen in the reactor (Durai and Rajasimman, 2011). Hayadar *et al* , 2007 reported a removal efficiency of 90 and 80 % for BOD and COD operated at HRT 0f 12 h and MLVSS of 3500 mg/L in an ASP for the treatment of tannery effluent. In the present study the performance of common effluent treatment plant treating tannery effluent by ASP was evaluated. The main objective of the study, was to evaluate the performance based on removal of BOD, COD, TSS, TDS and by water tracer Rhodamine.

MATERIALS AND METHODS

Wastewater characterization

The study was conducted in CETP at Pammal in Chennai district. The treatment plant treats tannery effluent from tannery industries located in and around Pallavaram municipality. The treatment system adopts activated sludge process. Wastewater was collected from the equalization tank, primary clarifier, aeration tank, secondary clarifier and treated effluent and was characterized for pH, TDS, TSS, COD, BOD, chloride, sulphate, chromium as per standard methods of wastewater analysis (APHA, 2005).

Received: Nov 12, 2011; Revised: Dec 18, 2011; Accepted: Jan 15, 2012.

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Performance Evaluation of CETP

Samples were collected from the equalization tank, primary clarifier, aeration tank, secondary clarifier and treated effluent of the CETP and Performance evaluation of CETP was carried out based on the removal efficiency of BOD, COD, TDS, TSS. Further the performance evaluation was carried out using Rhodamine –B water tracer. Rhodamine was mixed with 5L of water and was injected to the inlet of aeration tank of CETP during inflow of industrial wastewater to the treatment system. The wastewater was collected at a regular time interval of 2h for 48 h and were analyzed for the concentration of the tracer.

RESULTS AND DISCUSSION

Wastewater characterestics

Physiochemical characteristics of the tannery effluent from the equalization tank of CETP were given in table-1. pH of the wastewater ranged form 7.0 to 8.1., TDS ranged from 500- 2000 mg/L, TSS was in the range of 1000-2000 mg/L, COD rangeD from 3500-5000mg/L , BOD ranged from 1100-1600 mg/L, Chloride ranged from 1000-2000 mg/L Sulphate ranged from 40-50 mg/L Chromium ranged from 0.01-0.02 mg/L. Raw effluent characteristics were above the CPCB tolerance limit for effluent discharge.

Table 1. Characteristics of the wastewater (CETP)

Parameters	Influent Characteristics of CETP	Tolerance Limits according to TNPCB
pH	7.0 – 8.1	6.0-9.0
TDS	5500-8300 mg/L	2100 mg/L
TSS	1000-2000 mg/L	100 mg/L
COD	3500-5000 mg/L	250 mg/L
BOD	1100-1600 mg/L	30 mg/L
Chloride	1000-2000 mg/L	750-2000 mg/L
Sulphate	40-50 mg/L	2 mg/L
Chromium	0.01-0.02 mg/L	2 mg/L

Performance evaluation of the individual units in the CETP

BOD and COD removal in the CETP

BOD and COD of the tannery effluent during the various stages of treatment were represented in the fig-1 & 2. BOD of the wastewater in the various treatment units varied from higher BOD of 1400 mg/L to a lowest BOD of 40 mg/L. There was a considerable reduction in the BOD during the treatment process. BOD removal during the study varied from 95% to 98% and the treatment system was able to achieve a maximum BOD removal of 98.5%. BOD removal of 98.5% can be attributed to the decomposition and mineralization of organic and inorganic compounds (Reed, 1995). The Biochemical Oxygen Demand (BOD) is the most important parameter in the treatment process design and effluent discharge or reuse (Qasim, 1999). Higher BOD removal may be mainly due to the higher volumetric loading rate higher than 0.3 to 0.7 Kg BOD/m^3-d (Metcalf & Eddy). Similar removal efficiency for BOD was reported by Shanmugasundharam and Murthy, 2000 for a CETP in the treatment of tannery effluent.

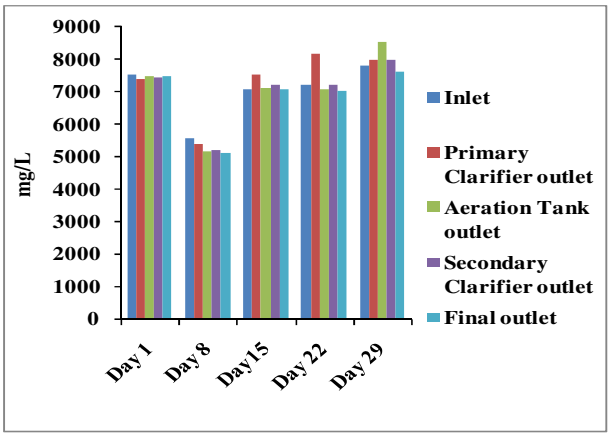

Fig1. BOD of the tannery effluent in the various units of CETP

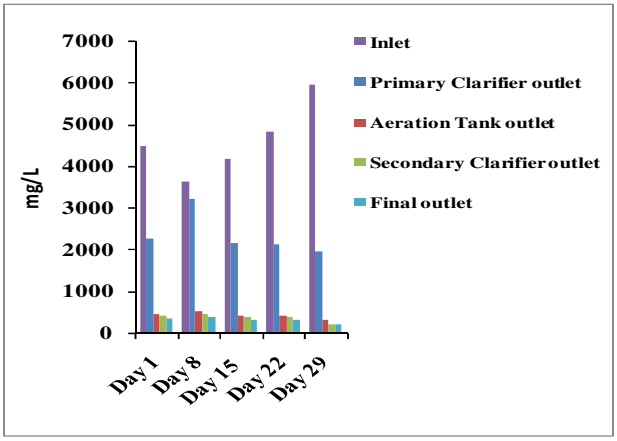

Fig 2. COD of the tannery effluent in various units of CETP

COD of the tannery effluent in the various unit of CETP also showed a reduction up to 200 mg/L. COD of the wastewater in the various treatment unit varied from a COD of 5940 mg/L to a COD of 200 mg/L. A maximum COD removal of 96.63% was achieved during the study period. Similarly about 95% COD removal was observed during the treatment of tannery effluent by using halophillic bacterial consortium (Lefebvre *et al*, 2005). COD/BOD ratio of the treated effluent was about 3.5 which show a substantial portion of organic matter is nonbiodegradable (Hyder *et al*, 2007). This nonbiodegradable organics may due to the high dye content in the tannery effluent which can be removed by using UV-Ozonation.

TSS and TDS removal in the CETP

TSS and TDS removal in the various units of CETP is represented in the fig-3 & fig-4. TSS of the tannery effluent in the various unit of CETP also showed a reduction from 2000 mg/L to 60 mg/L. A maximum removal efficiency of 96.58% was observed during the study. TDS of the tannery effluent in the various units of CETP didn't show that much reduction comparing the other parameters. TDS of the wastewater in the various treatment units varied from 8200 mg/L to 5100 mg/L. A removal efficiency of only 8.6% was observed.

The plant is originally designed to treat water with TDS of little above 2100 mg/L whereas the TDS level of the wastewater at present is 5000-7000 mg/l which is mainly due to the use of the salts in the tanneries. Generally TDS cannot be reduced in the biological wastewater treatment system. The norms for the discharge of trade

effluent as prescribed by TNPCB are 2100 mg/L. Hence it is suggested to reduce the TDS level to 2100 mg/l (TNPCB standard) by reverse osmosis process.

The parameters like BOD, COD and TSS in the treated effluent were found to be higher than those prescribed by TNPCB for most of the time during the study period (fig.4). The BOD and TSS removal efficiency have increased due to the addition of lime, alum and polyelectrolyte in the primary clariflocculator. On the basis of actual operating data from the CETP, it has been found that the F/M ratio varies from 0.23 to 0.32 kg BOD/kg MLVSS day and Θc varies from 7.01 to 36.07 days (Table-2 &3). F/M ratio should be maintained properly which could be achieved by increasing or decreasing the MLSS levels in the aeration tank to suit the influent BOD levels. To have the higher treatment efficiency Θc must be longer. By adjusting the sludge wasting rate the desired Θc value can be achieved which may result in the production of a stable, high quality effluent and sludge with excellent settling characteristics.

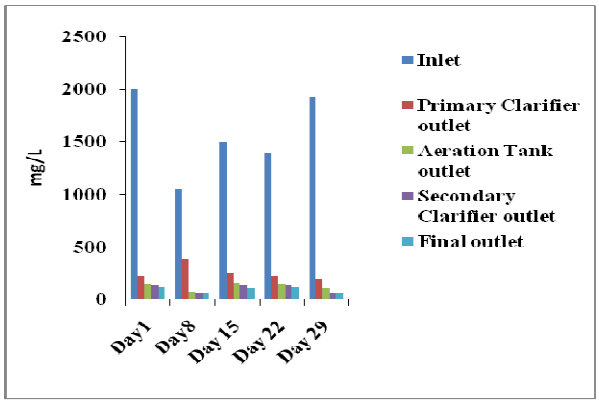

Fig 3. TSS of the tannery effluent in various units of CRTP

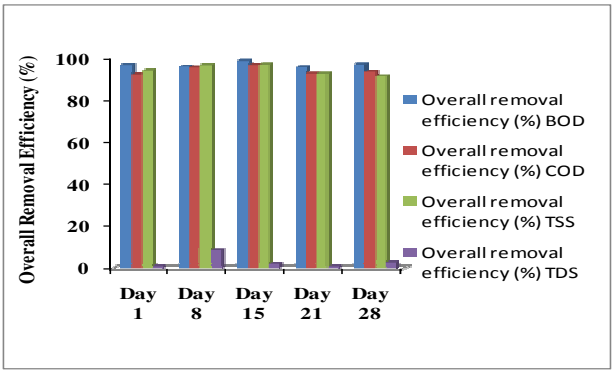

Fig 4. Removal efficiency of various units in CETP

Table 2. MLVSS and MLSS Ratio for CETP

Date of sampling	MLSS (mg/L)	MLVSS (mg/L)	Ratio	Desirable ratio
Day 1	2300	1334	0.58	0.60
Day 2	2200	1320	0.60	0.60
Day 12	2350	1363	0.58	0.60

Table 3. F/M Ratio for CETP

Date of sampling	F/M Ratio	Desirable ratio
Day 1	0.20	0.18
Day 2	0.20	0.18
Day 12	0.27	0.18

Rhodamine B water tracer study

Performance of aeration tank was evaluated using water tracer Rhodamine B. Experimental mean residence time (MRT) was calculated based on the fluro spectrophotometric quantification of the dye Rhodamine B (Table-4). Theoretical mean residence time was 2240 where as the experimental mean residence time was found to be 1920 with a higher dead volume of 19.6%. Hence, suitable remedial measures have to be taken for the aeration tank in CETP.

Table 4. Experimental Mean Residence Time

System under investigation	Volume (Cum)	Flow rate (m^3/min)	Theoretical MRT (Min)	Experimental MRT (min)	Dead volume (%)
CETP	2400	1.04	2240	1920	19.6

Performance evaluation has the benefit of assessing the performance of the wastewater treatment plants after commissioning the plant based on the removal efficiency of major parameters such as BOD, COD, TSS and TDS. Suitable remedial measures can be adopted to improve the performance of treatment plant. All the individual units in the CETP were checked for their efficiency in the design for treating the wastewater and no flaws were found and hence the performance of the CETP based on the design is found to be satisfactory.

The effluent flow into the equalization tank and the primary clarifier should be admitted equally in order to get an even distribution of suspended solids. Based on the study on the performance of the CETP, the following conclusions and recommendations are made. The volumetric loading was found to be in the range of 0.46-0.65 kg BOD/m3-d. The normal range is from 0.30 to 0.7 kg BOD/m3-d (Metcalf & Eddy). The loading rates have been considerably increased due to the presence of the more fleshing organic matters in the tannery effluent, which has resulted in lower BOD removal efficiencies in the present study. The removal efficiency can be increased by increasing the concentration of microorganisms and maintaining the food to micro organism (F/M) ratio at 0.18 and maintaining higher mean cell residence time(Θc) The levels can be maintained by effectively monitoring the inflow characteristic of the wastewater and the other required parameters such as MLSS concentration, F/M ratio and DO levels in the aeration tank to treat the wastewater and achieve the treated effluent standards prescribed by the TNPCB. The study revealed that the wastewater treatment can be improved by optimizing some major wastewater treatment plant operating parameters like volumetric loading rate, F/M ratio and MLVSS. For improving the TDS removal it is recommended to go for reverse osmosis since TDS cannot be removed by biological treatment system.

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