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Performance Evaluation of Common Effluent Treatment Plant for Tanneries at Pallavaram CETP

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The Pallavaram Tanners Industrial Effluent Treatment Company Limited has been a forerunner in ensuring cleaner and safe environment. The project was implemented by a company formed by the tanners of the Pallavaram area. Tamil Nadu Pollution Control Board (TNPCB) was the counterpart of UNIDO and took the overall responsibility for implementation of the project. The present study has been undertaken to evaluate performance efficiency of the treatment plant. Water samples were collected at different stages of treatment units and analysed for the major water quality parameters, such as pH, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) and total dissolved solids (TDS). The performance efficiency of each unit in treating the pollutants was calculated. The generated data presented evidence to that the common effluent treatment plant has been working with the norms of TNPCB and meeting the discharge standard limits.

Key words : *Tannery effluent, CETP, treatment, performance study, pollution.*

Introduction

With the increasing demand for leather and leather products, both for indigenous use as well as for export, large number of vegetable and chrome tanneries have mushroomed in India, especially in states like Tamil Nadu, Uttar Pradesh and West Bengal. Tannery wastewater is characterised by its strong colour, high COD, high BOD, and TDS. The levels of pollutants in tannery wastewater also vary depending upon the process adopted in leather making [1]. The unplanned manner in which these units have come up forces to think about their disposal of liquid effluents. The quality of discharged waters from tanneries is far from the desired level of acceptance into waterways (UNIDO)[2]. As a result, the tanneries are forced to construct a Common Effluent Treatment Plant (CETP). Tamil Nadu Pollution Control Board accorded permission to resume the operation of those tanneries, which put up full-fledged Effluent Treatment Plant (ETP) or CETP. The treatment of tannery effluent depends on the efficiency with which the CETP functions. Hence, the continuous evaluation is a prerequisite for up keeping of efficiency with which the CETP functions.

Pallavaram, now a part of CMDA and less than 3 kilometers from south of Chennai Airport, has cluster of 152 tanneries predominantly processing raw to wet blue. Though it was away from residential areas when the tanneries came up nearly a century ago, now it has become a part of the city with a substantial population residing there. The density of population is quite high and land is scarce. Therefore, designing and creating a CETP for tanneries in this location was an absolute need and challenge to protect the future needs of the environmental sustainability in that area. The PTIET has been a forerunner in ensuring cleaner and safer environment. The company was formed as early as in 1989, and set up the CETP in February 1995.

The design of the CETP based for the flow of 3000 m^3/day and the treated effluent to meet the inland surface water discharge standards of TNPCB. Chromium is found to be the only heavy metal present in chrome tanning wastewater. Chromium is known to be highly toxic to the living aquatic organisms in the hexavalent state and somewhat less toxic in the trivalent form. The effluents from chrome tanning industry should meet with the specific tolerance limits for chloride with 1000 mg/L, BOD with 30 mg/L, hexavalent chromium with 0.1 mg/L and pH 5.5 - 9.0.

Shahul Hameed [3] evaluated the performance of tannery effluent treatment plant at Tiruchirapalli. Water samples were collected at different stages of treatment plant and analyzed each for the major water quality parameters such as pH, TSS, TDS, BOD_5, COD, chloride and odour. The efficiency of each stage in removing the pollutants was calculated. The generated data presented evidence to that the effluent treatment plant

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has been working with the efficiency ranging from 90 to 92.7 % confirming to the norms of TNPCB.

Prakash [4] studied the chemical and biological treatment of chrome liquor. Based on the study, he concluded that the proper balance of alkalinity and BOD can increase the treatment efficiency. The maximum BOD reduction was obtained at an organic load of 0.80 kg BOD/m^3/day. Arumugam[5] has reported on the recovery of chromium from spent chrome tan liquor by chemical precipitation using lime. Pathe[6] has studied the properties of chromium sludge from chrome tan liquor and related the sludge volume, sludge settling rate, surface loading rate, etc. The present investigation has been undertaken as a case study in the evaluation of performance of a CETP functioning at Pallavaram, namely Pallavaram Tanners Industrial Effluent Treatment Company Ltd. (PTIET) and suggesting the possible remedy measures to improve the plant efficiency and to utilise the treated wastewater.

Materials and methods

The samples were collected at the inlet and outlet of all the treatment units and analysed as outlined in the standard methods for the examination of water and wastewater[7]. The samples were analysed for various parameters like pH, BOD, COD, TSS, TDS and depending on the results, performance of each unit was evaluated. The quantities of wastewater collected from the tanneries for treatment were quantified through a digital electronic flow meter.

Treatment units

The Pallavaram CETP was designed to provide combination of physical, chemical and biological processes, which involves all important units such as screening chamber, equalization tank, clariflocculator, aeration tank, secondary clarifier, sand filters, carbon filter, etc. A schematic flow diagram of the treatment plant is shown in **Fig.1**. The units are designed so that one half of the CETP could be operated when it receives a lower volume of effluent. The details of mechanical equipments, carrying capacity and retention time in various units of the CETP are presented in **Table 1.**

Seven collection wells located in various places receive effluent from 152 tanneries, which is pumped to the receiving sump of the CETP. 8 tanneries discharge effluent directly into the receiving sump by gravity. Small volume of sewage is mixed with the wastewater to bring the waste amenable for biological degradation. In each tannery, pretreatment unit of size 1.5 m x 1.0 m x 1.0 m and two coarse bar screens of 10 mm bar spacing are present. Screenings are removed manually and disposed in the dumping site of the CETP. The present mode of tannery wastewater includes primary treatment, such as screening for the removal of coarse solids and settling followed by clariflocculation eliminating higher percentage of organic and inorganic impurities in solid phase[8]. The primary treated effluent is then treated in biological treatment system, the extended aeration process being the normally adopted one, where the wastewater is brought into contact with micro organisms in an aeration basin and the organic matter is metabolized for energy and synthesis requirements [9].

Results and discussion

The results of treatment efficiency for major pollutants in untreated and treated water with respect to each treatment unit operations in the Pallavaram CETP are discussed below.

Physical treatment

The effluent collected in to the receiving sump is pumped through a mechanically cleaned screen, which is more effective in reducing the suspended solids, BOD and COD. The effluent is then passed through a grit chamber and collected in two numbers of equalization tanks provided with submerged ejector aerators. The aerator sucks air from atmospheric medium and passes into the bottom of the tank and it facilitates the disturbance of settling, reduction of BOD and COD in subsequent treatment units. The ejector aerators homogenize the effluent, besides oxidizing sulfides present in the raw effluent and facilitate the bacterial breakdown of oxygen demanding wastes.

The purpose of equalization is to minimize the wide fluctuation in effluent flow rate and variation in composition of the effluent. No treatment is achieved in equalization itself. However, the uniformity of effluent produced by this process improves the consistency of performance in subsequent treatment [10]. Here the concentrations of BOD, COD, TSS and TDS are 1380, 4639, 2368 and 6402 mg/L respectively as shown in **Table 2.** It is homogenised character of effluent obtained from time to time during the flow and also the filtrate from dewatering unit that mixes with the equalization tank. Here the pH values lies within a range of 5.8 - 6.1.

Chemical treatment

The equalized effluent is then pumped to the flash mixer, where alum, lime and polyelectrolyte slurry is added. The detention time in flash mixer is calculated to be 3.8 min. In this unit, wastewater reacts with alum and coagulates the suspended solids. Studies carried out in the laboratory and

Table 1: Technical details of the Pallavaram CETP

Units	Sizes	Design details based on design flow
Flow	3000 m^3 /day	–
Screen chamber	0.7m x 3m x 2m	15mm bar spacing
Receiving sump	6m dia x 5m deep	HRT : 30 min
Fine screen	Drum type- Konica model	3mm bar spacing Capacity : 450 m^3/h
Grit chamber	3m x 3m x 1.2m	HRT : 5-0 seconds Capacity : 3/h
Equalization basin Flash mixer	40m x 11m x 3 m, 2 Nos. 2m x 2m x 2m	HRT : 21 h HRT : 8 min
Clariflocculator- Flocculator	6m dia x 1.5m deep, 2 Nos., 12m dia x 3.0m deep, 2 Nos.	Clarifier .8 h Flocculator HRT : 40min
Clariflocculator- Clarifier	12 m dia x 3m SWD, 2 Nos.	SOR : 3/m^2/day WLR : 38 m^3/m/day HRT : 2h each
Aeration tank, 2 Nos.	40m x 15m x 4m SWD Type operation: Diffused aeration Blowers: 37.5kW, 5Nos.	F/M:0.18 MLSS:4000 mg/L HRT:38.4h OLR: 0.375kg. BOD/ m^3/day
Secondary clarifier, 2Nos.	12m dia x 2.2m SWD	SOR : 9.9 m^3/m^2/day WLR : 39.8mn^3/m/day SLR : 54kg/m^2/dday HRT : 3h 7min.
Sludge thickener Plate filter press Sludge drying press	12m dia x 3.0m SWD Plate size : 1m x 1m 52 Nos 16m x 10m 1No.	Thickening from 3-4 %to 5-6 % Capacity : 70105 m^3/day Capacity : 24-32 m^3/day
Belt filter press	1No.	Capacity : 20-40 m^3/day
Tertiary flash mixer	2m x 2m x 2m	HRT : 3.8m
Tertiary Clariflocculator	6 m dia x 1.5 m deep, 1No. 15 m dia x 3.0 m deep, 1No.	Clariflocculator HRT : 4.5 m^3/h
Pressure sand filter	2.5 m dia x 3.0 m deep vessel	Capacity : 125 m^3/day
Activated carbon filter	2.5 m dia x 3.0 m deep vessel	Capacity : 125 m^3 /day

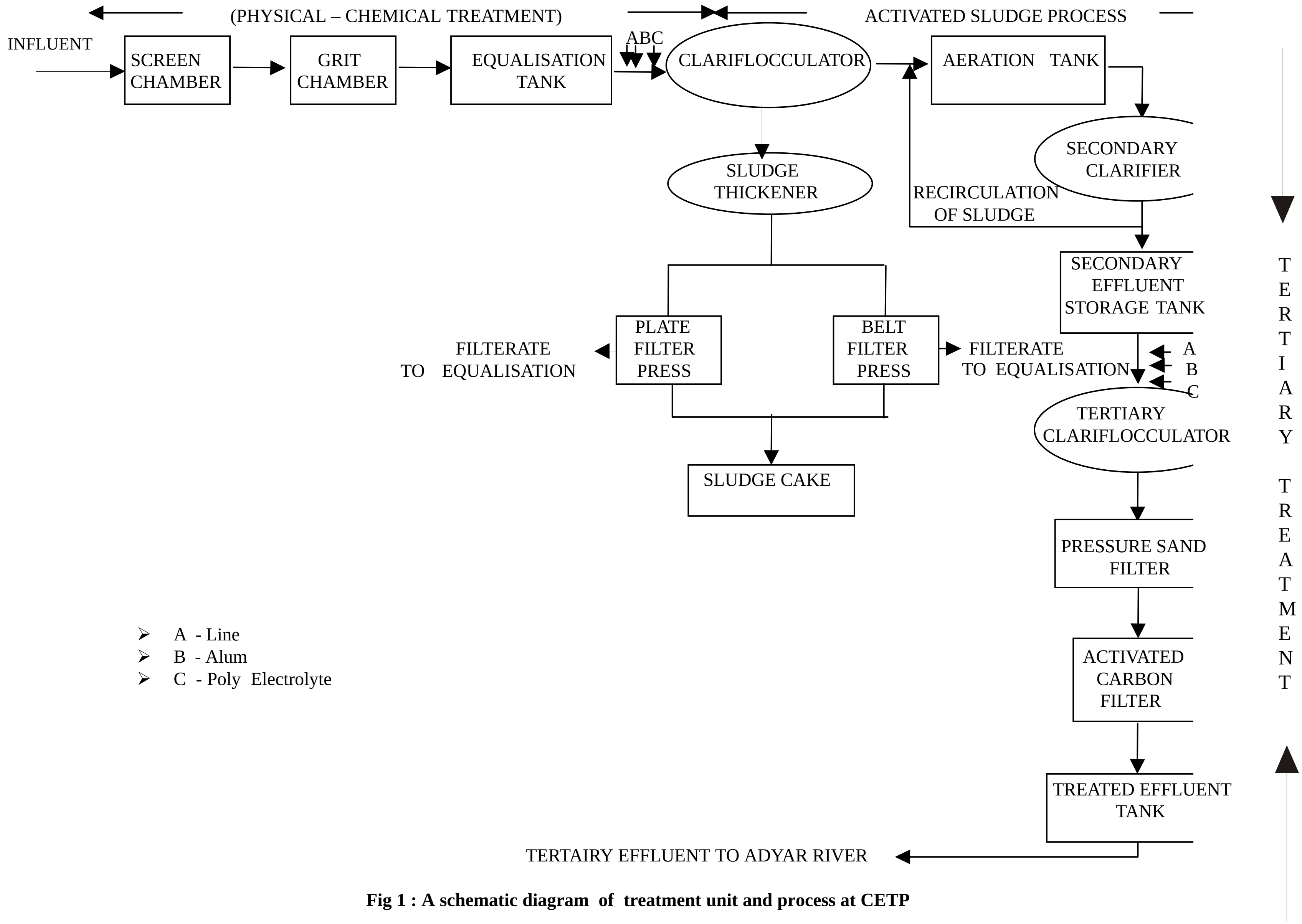

Fig 1 : A schematic diagram of treatment unit and process at CETP

Table 2 : Characters of tannery effluent in different units of CETP

Parameter	Raw	Equalisation	Chemical treatment	Secondary treatment	Tertiary treatment
pH	6.1	5.8	6.6	7.2	7.5
BOD (mg/L)	1100	1380	650	31	27
COD (mg/L)	4117	4639	1617	462	250
TSS (mg/L)	1410	2368	220	82	42
TDS (mg/L)	7668	6402	7032	6532	6212

full scale plant have shown that alum, the most commonly used coagulant chemical, can serve as an excellent tracer [11,12]. Charles Peters[13] reported that polyelectrolyte themselves are poor coagulants, however, maximum settling rates are achieved when alum and polyelectrolyte work together at an optimum pH. According to Kaussen[14], linking solid particles with 10000 of active groups along the polyelectrolyte molecules result in the formation of large molecules.

The results showed that total suspended solids were drastically reduced from 2368 to 220 mg/L achieving a removal percentage of 90.68 in chemical treatment alone. The TDS level increased from 6402 to 7032 mg/L due to the coagulants that are added to the wastewater. The percentage removal of BOD, COD is calculated to be 52.89 and 65.14 respectively as given in **Table 3**. The amounts of lime consumed are calculated to be 0.96, 0.26, 0.31 kg for 1 kg of BOD, COD, TSS removal respectively, whereas 0.75, 0.20, 0.24 kg of alum required for 1 kg of BOD, COD and TSS removal respectively. The effluent thereafter enters into two clariflocculators, where the chemical sludge settles in the bottom.

Biological treatment

Generally biological treatments are designed on the basis of hydraulic parameters, such as flow rate, HRT, solids loading rate, etc. A hydraulic consideration alone is not adequate to ensure sufficient operation. The design of biological treatment systems based on biokinetic parameters will have a better control over the biological community in the system and the process so as to achieve better treatment efficiency [15, 16]. The overflow from the clariflocculator is admitted into two aeration tanks and subjected to mechanical aeration for 38.4 hours with fine bubble diffused aeration system, which comprises of 1200 tubular membrane diffusers, the air supply for which is provided by 5 positive displacement blowers. Activated sludge is introduced in the aeration tank 1 and 2 for the digestion of organic wastes present in the effluent. Activated sludge is biologically active and can oxidize organic matter [17]. It is obtained by settling sewage and contains numerous aerobic bacteria and other form of microorganisms that facilitate the digestion of organic matter present in the wastewater. These microorganisms are capable of aerobically decomposing organic matter into CO_2 and H_2O. Sulphur containing compounds are oxidized into sulphate and nitrogen containing components into nitrates [18]. Peavy [19] reported that mechanical aerators produce turbulence at the air and liquid interface and this turbulence entrain air into the liquid. BOD and COD are reduced at shorter period by the aeration process.[20] Here the removal of BOD and COD is found to be maximum. The biological treatment removes 90 - 95 % of BOD and 85 - 90 % of COD.

The levels of BOD and COD are 31 and 432 mg/L in aeration tank-1, 32 and 427 mg/L in aeration tank-2, which were initially 650 and 1617 mg/L **(Table 2**). In chemical treatment, it is calculated that about 1.790 kwh of power is consumed for 1 kg of BOD removal in aeration tank. While carrying out aeration tank performance analysis, various aspects were covered using the guidelines given by in Metcalf and Eddy.[21] MLVSS/MLSS, food to microorganism ratio, mean cell residence time, and recirculation ratio were calculated as 0.69, 0.13, 9.71 and 2 respectively.

Table 3 : Efficiency of different treatment units

Parameter (mg/L)	Chemical treatment	Secondary treatment	Tertiary treatment	Overall treatment
BOD	52.89	95.23	12.9	97.54 %
COD	65.14	71.42	45.88	93.92 %
TSS	90.7	62.72	48.78	97.02 %
TDS	—	—	—	18.98 %

Table 4 : Comparison of treated effluent with the discharge limits of TNPCB

Parameters	Raw wastewater	Treated wastewater	TNPCB discharge limits
pH	6.1	7.5	5.5-9.0
BOD (mg/L)	1110	27	10-30
COD (mg/L)	4117	250	200-250
TSS (mg/L)	1410	42	80-100
TDS (mg/L)	7668	6212	2100

The overflow from the aeration tanks with active biological solids is admitted into two secondary clarifiers. The settled sludge in the clarifier is pumped back to the aerations tank to maintain the bacteriological population. High reductions in BOD, COD, and TSS were observed and the percentages of removal were calculated to be 95.23, 71.42 and 62.72 respectively at the end of secondary treatment.

Some quantity of sludge is wasted by diversion to the sludge thickener. In the clarifier tanks, the microorganisms come into contact with both soluble and insoluble organic materials. The soluble material passes through bacterial cell walls and the solid material sticks to the surface of the cells. The overflow from the clarifier is the partially treated effluent, which is admitted into tertiary treatment process as shown in **Table 3**. The effluent from the clarifier is collected on separate collection tank. It is pumped to flash mixer for precipitation and apparent colour removal. Then the treated effluent is sent to the clariflocculator for solid liquid separation by settling. It is again collected in separate tank and pumped to polishing units, which consists of : pressure sand filter - for removal of residual suspended solids and activated carbon filter - for colour and residual BOD removal.

The pressure sand filter is filled with sand and water, which is allowed to pass through under pressure. The application of pressure over the sand facilitates the settlement of solids and organic matter in the sand and the percentages of reduction are found to be 23.68 for COD and 48.78 for TSS. The organic compounds in the effluent can be removed by primary and secondary treatment but complete removal is not possible in these processes and hence the effluent is passed through the adsorbing medium like activated carbon filter. Activated carbon has the ability to reduce the level of organic matter as well as levels of specific trace organics. Hence, considerable amount of organic matter is removed from the effluent, when it is passed through the activated carbon filter. Percentages of reduction in tertiary treatment for BOD, COD and TSS are found to be 12.90, 45.58 and 48.78 respectively as shown in **Table 3**.

The presence of sulphide in effluent causes obnoxious odour and hence removal of sulphide makes the effluent odourless. This removal can be achieved in aeration tank, clarifiers, pressure sand filters and activated carbon filter. The activated carbon filter acts as an excellent medium for absorbing odourents. This is mainly due to the diffusion of sulphide ions to surface of the activated carbon, which makes oxidation of sulphide at the carbon surface [22]. A part of the treated effluent is filtered using pressure sand filter and used for process applications in the CETP.

The sludge settled in the primary clariflocculator, tertiary clariflocculator and wasted sludge is taken to sludge well and then pumped to the sludge thickener. The thickened sludge is dewatered in a belt press filter and a portion of the sludge is dewatered in plate filter press. The dewatered sludge is disposed of in a sludge-dumping site. Treated effluent from the tertiary treatment units is discharged into Adyar river through a pressure pipeline, which is below the TNPCB discharge limit (**Table 4**) for industrial wastewaters. The overall treatment of BOD, COD and TSS in the CETP is shown in **Fig. 2, 3 and 4** respectively.

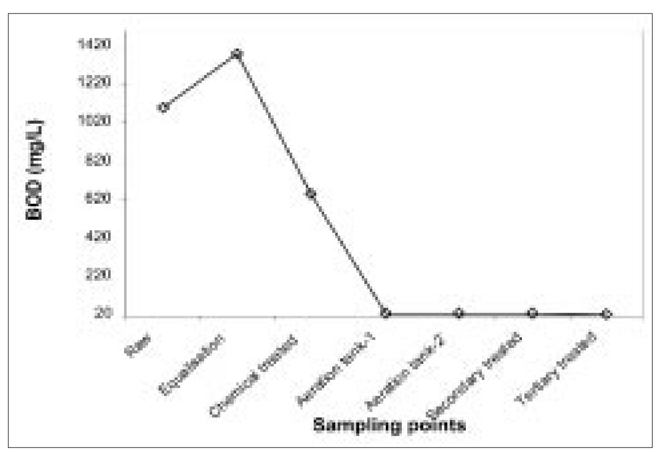

Fig 2 : BOD at different stages of treatment

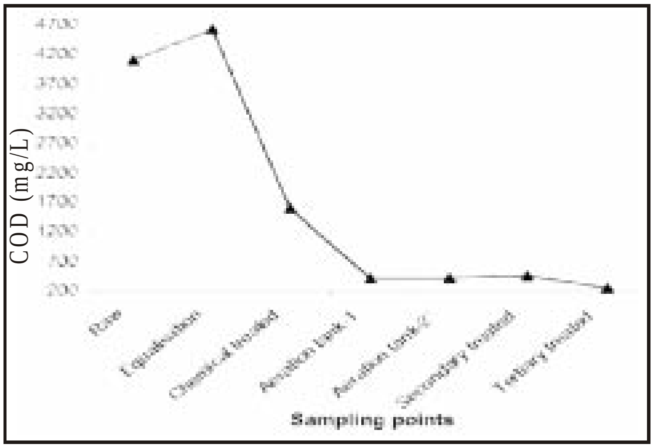

Fig 3 : COD at different stages of treatment

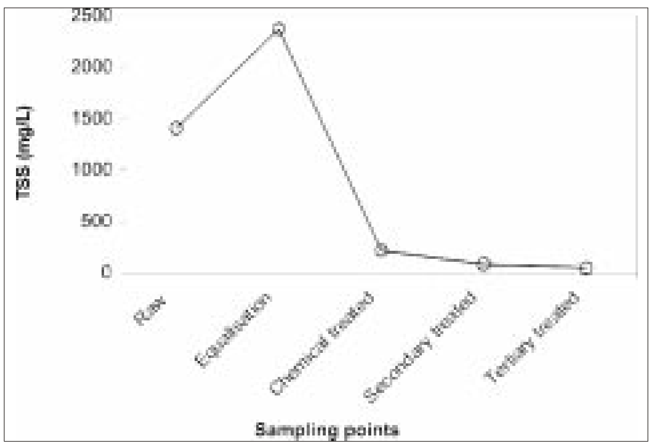

Fig 4 : TSS at different stages of treatment

Conclusions

The study indicates that all major pollutants including odour were drastically reduced in the wastewater during the treatment process. The pH, BOD, COD, TSS and TDS of raw effluents were recorded to be 6.1mg/L, 1100 mg/L, 4117mg/L, 1410mg/L and 7668 mg/L, while the mean values of the same parameters in the treated effluent estimated to be 7.5, 27mg/L, 250mg/L, 42mg/L and 6212 mg/L. BOD/COD ratio in the raw effluent was 0.32, which is drastically reduced to 0.108 in the treated effluent showing that all the organic matters were removed. The percentages of removal throughout the whole treatment are calculated to be BOD 98.86 mg/L, COD 91.99mg/L, TSS 98.25 and TDS 18.22. The percentage removal of TDS is found to be comparatively low than other parameters. Implementation of reverse osmosis (RO) plant, which can optimize the level of TDS, and an application study for the reuse of treated water for gardening etc., can be considered as suggestions for the improvement of the CETP.

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