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REMOVAL OF SOLIDS FROM THE TANNERY EFFLUENT BY A SUITABLE TECHNOLOGY: A CASE STUDY – VELLORE DISTRICT, TAMIL NADU, INDIA.

P.R. KAVITHA AND G.P.GANAPATHY*

Centre for Disaster Mitigation and Management, VIT University, Vellore 632 014, India.

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ABSTRACT

The Total Dissolved Solid (TDS) is a challenging parameter in the tannery effluent that cannot be treated by conventional method or by any simple treatment system. In Tamil Nadu, the tannery treatment plants are forced to find out a suitable technology that can control the Total Dissolved Solids. The pollution control boards are insisting the Effluent Treatment Plants (ETP) and the Common Effluent Treatment Plant (CETP) to meet out the standards for the basic parameters as well as the TDS. Many technologies were tried in the ETP and CETP to control TDS, such as dilution with sewage, relocation of the industry to sea shore, adoption of salt free raw material, leather processing, desalting of hides & skins, segregation of salt laden liquor and its separate treatment, membrane technologies such as electro dialysis (ED), electro dialysis reversal (EDR) and reverse osmosis (RO). Practical viability of the technology was also considered while conducting the pilot studies. Though quite costly and technology challenging, Reverse Osmosis option is being increasingly looked into by the tanneries of India, particularly in Tamil Nadu, mainly owing to two factors: (a) it can solve the problem of salt in the effluent by avoiding the effluent discharge and (b) the recovery of good quality of process water is a big attraction to the water scarce tannery clusters. The objective of the present study is to analyze various technologies followed by the ETPs and CETPs in the country and adopt a suitable technology to remove solids from the effluent. In this connection the reject handling of the RO system was also studied. Tannery effluent contains multi-salt and purification of reject using Nano-filtration and reuse is not possible, hence evaporation of reject can be done using mechanical means and natural means. Natural evaporation can be carried out for the RO system capacity below 500 m_3 per day and mechanical evaporation can be done for the RO system capacity above 500 m^3 per day. Cost analysis also carried out and the economics of evaporation of reject is crucial for viability of the technology.

INTRODUCTION

The emerging need of the tannery effluent treatment plants is to control the basic parameters especially the solids. The Total Dissolved Solid (TDS) in the tannery effluent mainly consists of chlorides and sulphates (Jamal Mohammed,et.al, 2004). The Pollution Control Board norm for the surface water dis-

* **Corresponding author's email :** seismogans@yahoo.com

charge TDS is 2100 mg/L (AWWA, 1998) and the current conventional systems could not achieve this standard because there is no simple treatment system for TDS like in the case of organics removal and perceived systems were all found costly (Suntharajan *et al.*, 2004). Totally 18 Common Effluent Treatment Plants for tanneries (CETP's) in India (CPCB, 2006) viz., Uttarpradesh (3), West Bengal (1), Punjab (2) and Tamil Nadu (12)- (Figure 1 a). The high TDS has become a major issue in Indian states such as Tamil Nadu, because of the reducing fertility of soil due to contamination by chlorides and the scarcity of the water resources (Sahasranaman and Buljan, 2000). To reduce salinity in waste water, various alternative techniques (David and Hayden, 2009) were considered and some were tried. As applying chlorides for preservation of raw hides and skins is the main source of salinity in waste water, alternative preservation techniques such drying of hides and skins, cooling and chilling, etc. can help reduce or eliminate use of salt in preservation (Catherine A Money, 2009). To an extent TDS in tannery effluent can be controlled by adoption of cleaner process technologies. However, a significant part of the salinity in the effluent still remains and cannot be removed through such cleaner technologies (Jan Tiest and Page, 2010), among the treatment adopted in developed countries, dilution of such high TDS effluent by domestic sewage is a popular method. This option is simply not available in many tannery clusters as in such places there is neither the required volume of domestic sewage nor treatment facility for such waste. The present study is to find out the suitable method to control TDS in the effluent.

Vellore district (Fig. 1) has an area of 6077 sq.km and is one of the 31 districts in the Tamil Nadu state of India. Vellore city is the headquarters of this district. It lies between 12°15' to 13°15' North latitudes and 78° 20' to 79° 50' East longitudes in South Indian state, Tamil Nadu. Palar River is one of the major water sources running west to East located at downstream of the industrial complex. Vellore district has the major tannery clusters (Fig. 2) in Tamil Nadu. Out of 12 Common Effluent Treatment Plants (CETPs) in Tamil Nadu for tannery effluent, 10 CETPs are located at Vellore district (Figure 1b).

MATERIALS AND METHODS

Two specific areas are traced as the origin of the TDS problem- curing raw hides and skins by applying common salt (wet/dry salting); and pickling (preparing the pelt for chrome tannage). Other operations which contribute to TDS are chrome-tanning, re-tanning using synthetic tanning agents and dyeing (Ludvik, 2000). Doing away with common salt in curing would considerably reduce the TDS load (Buljan, *et al.*, 2011). Therefore, alternative curing techniques

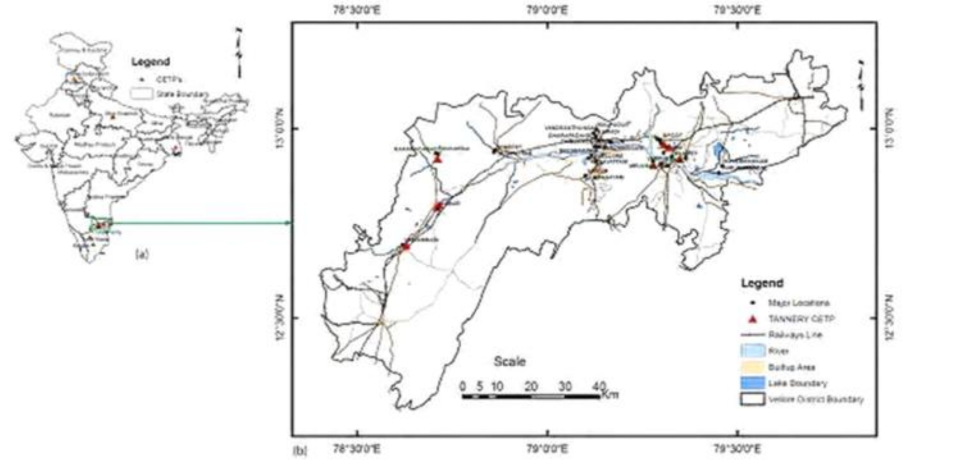

Fig 1. Map showing the a) locations of Common effluent Treatment Plants (CETP's) India and b) CETP's in the study area and nearby built up land.

have to be devised. However, in a country like India, where the supply of hides and skins originate in organised and unorganised slaughterhouses spread all over the country, with village level slaughter taking place in isolated spots, little headway has been made with the above techniques (Sahasranaman and Buljan, 2000). The possible measures to control salt in the effluent viz., Dilution with sewage, Relocation of the industry to sea shore, Adoption of salt free raw material and leather processing, Desalting of hides and skins, Segregation of salt laden liquor and its separate treatment and Membrane Technologies. The approach followed in this paper is given in Figure 2.

RESULTS AND DISCUSSION

RO unit testing in tannery effluent

An RO plant of 1000 litres per hour capacity was tested for two years. The main objectives were to evaluate the technical viability of reverse osmosis technology for reducing the TDS in the tannery effluent to make it fit for reuse in the tannery and to establish a satisfactory mode of disposal of the concentrated reject. The unit could achieve recovery of clean water, containing an average TDS value of less than 500 mg/L, is in the range of 70-75%. The experiments with the system

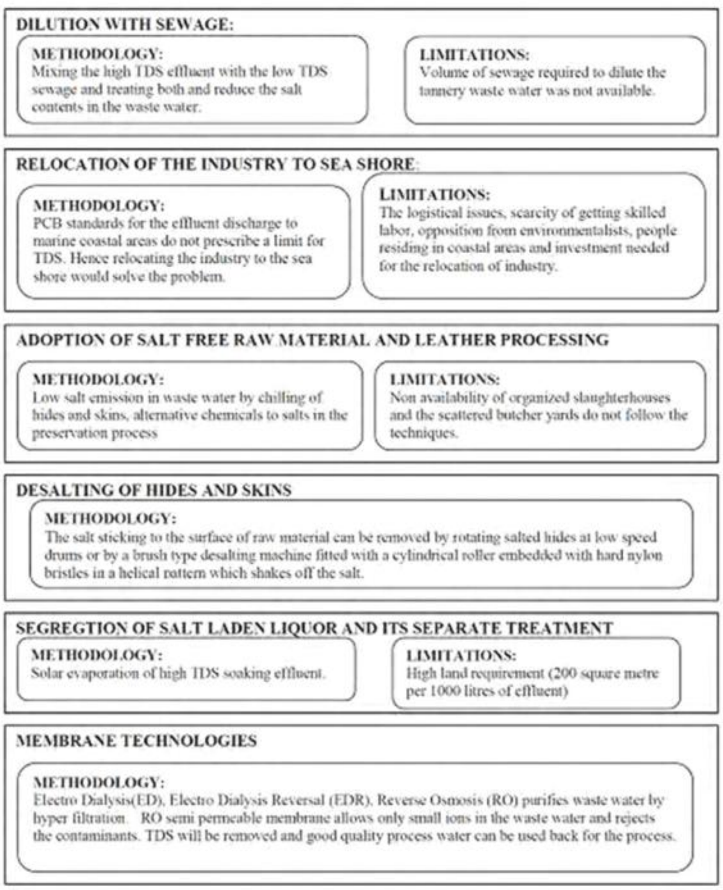

Fig. 2. Methodology adopted to remove solids from the tannery effluent

provided a wealth of data related to technical feasibility of the option. It has been shown clearly that pre-treatments such as photochemical oxidation may not be adequate to reduce the COD (Cassano, *et al.*, 2001) of the treated effluent to the level as required for RO tolerance. Similarly the study also revealed the importance of keeping the hardness of the treated effluent in check. It also indicated that it would be better to opt for conventional treatment techniques such as lime - soda softening than to provide a softener (Kiril Mert and Kestiflu, 2007), which add up to the total salt throughput in the system. The trials confirmed the technical viability of the technique even as it highlighted the enormity of the task and specific difficulties related to tannery effluent in RO operation was studied in detail.

Plant scale adoption of RO system

After careful assessment of the membrane inlet requirement (Shen, 1999) and the treated effluent characteristics, a suitable design has been evolved for adoption in individual ETPs. The issue of residual organics has been taken care of by a special Ultra filtration System and two stage RO membranes to obtain optimum recovery have been implemented (Cortese and Drioli, 1982). While the larger RO systems used spiral wound membrane configuration (Plate 1), many smaller units used membranes of Disc & Tube (DT) (Chandan Das, *et al.*, 2007) configuration (Plate 2).

Advantages of a RO system

The problem of TDS can be resolved fully and the tannery can achieve the zero liquid discharge status. In general, the permeate recovered from RO systems are better in quality than ground water available in most tannery clusters and therefore some savings in chemical consumption could be expected when this water is used (Azza I. Hafez, 2006). The tannery could avoid any production loss due to shortage of water, thus ensuring optimum production and avoids the difficulties related to disposal of effluent completely. The installation of RO unit and water recovery is eco-friendly and reduces consumption of valuable ground water resources (Aloy and Vulliermet, 2006). The quality of production in the tannery could be better when RO permeate is used in process. The tannery would have a better image and could attain certifications such as ISO 14000 with this installation.

Limits of RO system

The cost of installation of Reverse Osmosis and associated units as well as the operating cost would be quite high. The dried salt from evaporation of tannery RO reject cannot be re-used for any application & its disposal is still an issue. The RO and associated units need very careful operation and maintenance.

RO treatment rejects management

The RO operation does not destroy the salt and the salt removed from the main effluent will be concentrated into a reject stream (at present 15-30%) which needs proper disposal. The most popular method is evaporation of the same and disposal of the evaporated matter (Shen 1999). In case of only one type of salt in effluent (say, sodium chloride), purification of reject using nano-filtration and re-use in process is feasible. However, effluents such as tannery effluent

Plate 1 View of RO system

Plate 2 An RO system based on DT membrane

contain multi-salt and hence this option is not viable and only evaporation and safe dumping yard appears realistic.

Evaporation of reject can be done using mechanical means and natural means. For natural evaporation, the general choice is the improved solar evaporation technique. Evaporation in open pans is not generally feasible due to the large area requirement. Pictures below show (Plate 3) the sprinklers & crystallization pans as a part of the improved solar evaporation systems (Plate 4).

For beyond 500 m^3 per day of RO capacity, the evaporation may need to be necessarily done in mechanical evaporator (Plate 5). The mechanical evaporation can also be accomplished in different ways. A newer form of evaporation is through the use of mechanical vapour re-compression (MVR) instead of the thermal evaporator and it is reported that though MVR is costlier than conventional thermal evaporator in installation, it is cheaper in operation (Plate 6). The additional advantage of MVR is that it does not require cooling water which would be a decisive factor in a water scarce scenario.

Cost analysis of RO treatment

The economics of RO system in tanneries are governed by the following factors: i) The extent of post treatment needed in ETP, particularly the softening, prior to the RO unit, ii) The membrane configuration selected for the system, iii) Evaporation technology adopted for handling the reject from the system, iv) Likely savings in chemicals when using the recovered water for processing (Azza Hafez, 2006).

The cost of post treatment in ETP depends to a greater extent, the requirement of softening (Azza Hafez, 2006). Most treated tannery effluent contains calcium hardness in the range of 0.8- 1.2 g/L and

Plate 3 The sprinklers in improved evaporation system

Plate 4 The crystallization pans

Plate 5 A view of mechanical evaporation system

Plate 6 Mechanical Vapour Recompression (File Photo)

Table 1. Treatment cost analysis of ETP and CETPs at various stages

Process	ETP (Rs.)	CETP (Rs.)
Basic Effluent treatment cost	$53\text{-}63/m^3$	$40\text{-}44/m^3$
Effluent softening cost	$22\text{-}30/m^3$	$18\text{-}25/m^3$
RO operation cost	$50\text{-}60/m^3$	$50\text{-}55/m^3$
Reject handling cost	$35\text{-}38/m^3$	$120\text{-}150/m^3$
Net treatment cost	$160\text{-}191/m^3$	$228\text{-}274/m^3$

sulphates in the range of 1.2-3.2 g/L. It is well known that calcium sulphate will start precipitating at above 2 g/L concentration and this means for trouble free operation of RO, the reject concentration of calcium sulphate should be less than 1.6 g/L and this means even at 75% recovery, the inlet concentration of calcium sulphate should not be more than 0.4 g/L. This level of calcium sulphate can be achieved only by (a) selective segregation and separate handling of certain effluent streams, for e.g., re-tanning, rich in sulphates or (b) by softening: zeolite resin based softening is not preferred due to the salt addition to the system from it and lime-soda softening is the commonly adopted one. The different membrane configurations such as DT, tubular, vibratory, etc. require lower pre-treatment, its installation and operation is quite costly compared to the common spiral wound configurations.

The evaporation technique influences the system cost significantly. While an improved evaporation cost around 5 paise per litre of the saline liquor to be evaporated, the mechanical evaporation costs in between 20-35 paise per litre of salt liquor, depending on the number of evaporation stages and capacity of the unit. The treatment cost analysis of ETP and CETPs at various stages are presented in Table 1.

Currently almost all tanneries use water of 1200-2000 parts per million of TDS and other impurities for its process and naturally the absorption of chemicals would be low, resulting in higher chemical consumption and production cost. Utilizing the permeate water with lower TDS (generally in the range of 300-500 parts per million) with low hardness in the process results in better uptake and lower chemical consumption. This saving, however, varies from tannery to tannery depending on the process, recipe, process control and the quality of water currently used. The last two points viz, the type of evaporation and savings in chemicals are very important and may virtually decide the economic feasibility of the implementation of RO system.

CONCLUSION

Application of reverse osmosis for the control of total dissolved solids in tannery effluent, though costly, appears to be the only practical option at the moment. The trials with bench scale, pilot and plant scale units revealed that it is feasible to apply RO systems, with necessary precautions, for tannery effluent. The recovery rate ranges from 70-85% depending on input TDS, the softening appears to be a must to reduce the calcium hardness to 200 - 300 mg/L in inlet. For removal of difficult to degrade organics, segregation of effluent streams rich in such COD (re-tanning, neutralisation etc.) appears to be a feasible option. Where such segregation is not possible, advanced oxidation or filtration through speciality UF (Ultra Filtration) appears to be the feasible solution. Economics of evaporation of reject is crucial for viability of the technology. The experimental results show that the impact of TDS on the environment will be greatly reduced by the RO treatment and the evaporation of the reject from the RO system. The hikes in the treatment charges will be matched with the usage of permeate water from the RO system, resulting in the saving of process chemicals and water in the tanneries.

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