Tannery Wastewater Treatment in India towards Sustainability

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Tannery Wastewater Treatment in India towards Sustainability

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Abstract

Leather industry is one of important by-product industry in developing countries due to it’s employment and export potentials. However, leather processing results in generation of wastewater and solid waste which would affect the environment, if it is not properly collected, treated and disposed. In order to control the pollution, in India during earlier 90’s individual Effluent Treatment Plants (ETPs) or Common Effluent Treatment Plants (CETPs) were installed initially with physico-chemical treatment followed by biological treatment to meet the discharge norms of SS, BOD, COD and Chromium. In addition, chrome liquor generated from tannery is segregated and treated in the chrome recovery plant for reuse. Subsequently, in order to tackle the issue of Total Dissolved Solids (TDS) and to address the water scarcity in India (Tamil Nadu State), the Zero Liquid Discharge (ZLD) i.e., water recovery from secondary treated effluent through membrane system and evaporation of rejects has been implemented in ETPs/CETPs. However, the implementation of these systems required higher investment and O&M cost. This higher capital costs in ETPs/CETPs by tanneries were subsidized by the Central and or State governments under various schemes at regular intervals, resulted in the ensuring the sustainability of leather sector in operation of CETPs. In addition, various new treatment technologies were implemented or being implemented to recover more water from ZLD system. Successful implementation of upgradation measures in CETPs has resulted in meeting the compliance with local

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regulatory conditions. However, ZLD resulted in higher specific energy consumption and O&M cost which becomes burden to the tanneries and makes this option unviable and not sustainable. In order to reduce the O&M cost, various energy efficient equipment and use of solar photovoltaic energy system to meet the thermal and electrical energy requirements are implemented in CETPs. These CETP upgradation measures ensured reductions in O&M cost and also reduced the carbon footprint towards sustainability in leather sector.

Key words: Tannery wastewater, ZLD, Capital cost, O&M cost, pollution

1 Introduction

Indian tanning industry is one of the oldest and potential sectors which has major role in Indian economy. There

are about 1700 tanneries located in different parts of India with a total processing capacity of about 700,000 tons of

raw hides and skins per year. More than 80% of tanneries are under small and medium scale sector have processing

capacity less than 2 tons of hides / skins per day. To treat the wastewater generated these tanneries, about 150

individual Effluent Treatment Plants (ETPs) and 21 Common Effluent Treatment Plants (CETPs) have been

established in India.

To treat the wastewater generated, tanneries have installed

effluent treatment plants with state of art technologies. Some of the constraints faced in the design,

implementation and operation of ETPs / CETPs are variations in quality and quantity of wastewater, high capital investment, operation and maintenance cost, high power requirements, sludge disposal and difficulties in meeting feed water requirements for RO and disposal of evaporated residual mixed salt.

Wastewater from individual tanneries is treated either in individual effluent treatment plants (ETPs) or collectively treated in common effluent treatment plants (CETPs) in leather clusters. Mostly, the conventional treatment processes are generally adopted which comprises of physico-chemical treatment followed by biological treatment. Biological treatment includes anaerobic treatment using Upflow Anaerobic Sludge Blanket (UASB) followed by extended aeration process or two stage extended aeration process or single stage extended aeration processes . The conventional treatment system

Table. 1 Typical characteristic of composite wastewater for tanneries processing from raw hide to finished leather

Sl.

Parameter Value

No

1. pH 7.0-9.0 6.0-9.0 6.0-9.0

2. Suspended Solids 3000 - 4000 100 100

3. Biochemical Oxygen Demand (BOD) 1500 - 2300 30 100

4. Chemical Oxygen Demand (COD) 3500 - 5000 250 250

5. Ammoniacal Nitrogen 320 - 430 50 NS

6. Total Dissolved Solids 15000 - 22000 2100 2100

7. Chloride as Cl- 5000 - 7500 1000 1000

8. Sulphate as SO42- 2000 - 3000 1000 1000

9. Sulphide as S2- 300 - 350 2 2

10. Chromium as Cr 25 - 40 2 2

Note: All values except pH and flow are in mg/L.

*For CETPs, as per the Ministry of Environment Forestry and Climate Change Notification dated 1st January 2016.

are able to remove pollutants such as Suspended Solids (SS), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) and treated effluent is able to meet discharge standards of SS - 100 mg/L, BOD - 30 mg/L and COD - 250 mg/L etc., except for Total Dissolved Solid (TDS), Sulphates and chloride. It is to be noted that, as per Ministry of Environment Forestry and Climate Change Notification dated 1st January 2016, the discharge standard for TDS - 2100 mg/L; Sulphates -1000 mg/L and Chlorides – 1000 mg/L. But in most of the treatment plants the TDS concentration after conventional treatment were ranges between 5000 – 7000 mg/L for the tanneries processing from semi-finished to finished leather and 15000 to 22000 mg/L for the tanneries processing from raw skin/hide to finished leather. The major constituents those contribute towards TDS are chlorides and sulphates of sodium, calcium, magnesium etc.

Discharge standards*

Inland surface

On land irrigation land

water

Discharge of effluent, after conventional tretament, with high TDS leads to increase in TDS concentrations of the ground and surface water in the adjoining area making it unpalatable. Also, treated effluent from the treatment plants is not suitable for reuse becuase of high TDS content. Moreover, due to inadequate water source and poor quality of available ground water in leather clusters, many tanneries in South India transport water through tankers for wet finishing operations, at a higher cost. In this context, recovery and reuse of water in the process becomes essential for the tanneries. In addition, to meet Sustainable Development Goals (SDGs) i.e., ensure environmental sustainability by providing safe drinking water and basic sanitation for people, regulatory authorities have directed the CETPs to implement Zero Liquid Discharge (ZLD) i.e., recovery of water from wastewater for reuse and there shall not be any discharge of effluent outside their premises. Operation of Zero Liquid Discharge system cannot be done by optimising only one unit, but it should optimize the entire spectrum of treatment, starting

The different treatment schemes adopted in CETPs in India are given below:

Fig.1 (a). CETPs adopting extended aeration process

Fig. 1 (c). CETPs adopting MBR system

from tannery operations to tertiary treatment. It includes the choosing the correct membranes and optimizing the evaporation process also.

In some of the CETPs, the dilution of conventionally treated effluent with treated sewage has been implemented to meet the TDS standard of 2100 mg/L.

2. Treatment schemes adopted for tannery wastewater in India

2.1 Conventional method of treatment

The common effluent treatment plants in India for tanneires mostly adopts the conventional treatment method to meet the dischage norms. The normal conventional method of treatment comprises of physico-chemical treatment followed by secondary biological systems. After conventional method of treatment the secondary treated effluent is diluted with secondary treated sewge to meet the TDS norms of 2100 mg/L and discharge into local water bodies.

Fig.1 (b). CETPs adopting UASB followed by extended

aeration process

For example, the two stage biological treatment scheme is followed in Pallavaram CETP, Chennai and UASB followed by aerobic biological treatment scheme is followed in CETP, Dindigul while MBR based system is followed in new 20 MLD CETP being commissioned at Jajmau, Kanpur.

2.2 Zero Liquid Discharge

The Zero Liquid Discharge concept is to ensure that the wastewater does not enters the environment. The treatment facilitates by recycle, recover and reuse of the treated wastewater by means of advanced wastewater treatment technologies. Most of CETPs in Tamilnadu are

Process flow diagram of Zero liquid discharge (ZLD) in CETP

2.3 Challenges in Current ZLD system

The implementation of ZLD system needs very high investment and high operation & maintenance cost. The operation & maintenance cost of the ZLD system varies from Rs.700 – 900/m3 (7-9 Euros/m3) of wastewater treated. About 35-40% of O&M cost is towards the consumption of electricity. Mainly the power is consumed in equalization tank, aeration tank, membrane system and

in land-locked and water scarcity regions and they have implemented ZLD system which consists of pretreatment system with conventional physico-chemical treatment, secondary biological treatment, tertiary treatment and softening of the treated effluent, two stages Reverse Osmosis (RO) treatment for desalination of effluent and thermal evaporation of saline reject from RO to separate the salts. But Operation of ZLD system, set up at a huge cost, has been a very big challenge both technically and financially since ZLD systems for tanneries were being tried for the very first time in the world and the operation and maintenance cost of ZLD system is extremely higher than the conventional effluent treatment plant.

reject management system (MEE). In present ZLD system even after secondary and tertiary treatment there remains residual organics (COD) with colour which affects the performance of RO system. In addition, the residual salt after evaporation contains non-degradable organics which cannot be used for any purpose. Similarly, in current treatment scheme the ammonia present in the wastewater remains untreated and concentrated in RO reject. Due to this the ammonia concentration in the treated

effluent, evaporator condensate contains high amount of ammonia and the tanneries face some issues during the reuse of this condensate in the process.

About 65% to 70% of the water can be recovered from two stage RO systems and is reused in the process of tanning. However, the system leaves 30% to 35% of the water as highly concentrated saline reject that needs to be evaporated which leads to additional cost of treatment. Steam is used for evaporation to reduce the volume of the reject. For steam generation in boiler, wood, briquettes and coal are used as a fuel. This creates the carbon di oxide (CO2) emission during this process, increases the greenhouse effect and also contributes towards the O&M cost.

The concentrated reject from the multiple effect evaporator is crystallized and the mixed salt contains non-degradable organics. Currently there is no specific disposal option for this residual mixed salt and hence the CETPs have stored the salt in the storage yard at their premises over the years. This requires large area and shed with protective measures also contribute towards the capital cost.

3.0 Technological advancement in wastewater treatment

3.1 In-Process Control Measures at Sources

Prevention or reduction of pollution at source through in-process control measures assumes greater significance now in leather industry because it is seen in practice that the end-of-pipe treatment alone is not a solution to meet the norms.

In tanneries, processing chrome tanned leather cleaner technologies such as namely (a) low-sulfide enzymeassisted un-hairing (b) recycling of re-liming wastewater after partial treatment (c) waterless / dry chrome tanning etc., have been demonstrated. These measures reduce the usage of fresh water and chemical in the process. It also minimizes the pollution load in the wastewater.

3.2 Measures at CETP

i. Sulphide Oxidation

The process effluent generated from Raw to finished leather, the sulphide level in the raw effluent is about 300 mg/L to 350 mg/L. Hence, before feeding the primary treated effluent to aeration tank it is necessary to remove the sulphides. Sulphide oxidation can be done either by adding oxygen or by aeration with MnO_2 to ensure consistent reduction of toxic gases from the balancing tank and to reduce the loading of H_2S gases to the biological treatment. This also improves the efficiency of biological treatment.

ii. De-Nitrification and Nitrification

The ammonia present in the wastewater remains untreated and it is necessary to remove the ammonia in aerobic treatment. The residual ammonia could possibly carry over to evaporator condensate in MEE. Therefore, provision for DeNitrification and Nitrification system are implemented to remove ammonia by introducing anoxic treatment. This increases the efficiency of treatment of aerobic system and makes the operation of membrane system smoother, which also reduces the ammonia concentration in the evaporator condensate. Hence, the condensate can be reused in the process of tanning.

iii. Improvements in aeration system of

biological treatment

Currently, in aeration tanks diffusers are used have lesser life span and also requires high maintenance regularly. The oxygen transfer efficiency is also low. The Original Hydrodynamic Reaction (OHR) Aerators have been implemented which has long life, less maintenance and nonclogging. It also ensures high oxygen transfer efficiency and complete mixing which increases the performance of biological treatment.

iv. Membrane Bio Reactor (MBR) and

Ultrafiltration (UF) system

Membrane bioreactors are used in tannery CETP to improve the performance of aerobic treatment process by increasing the biomass concentration in the aeration tank. In addition, MBR ensures the complete removal of Suspended Solids (SS) from aerobic system before tertiary treatment. In the absence of MBR system, ultrafiltration (UF) is implemented to ensure complete removal of SS and reduce Silt Density Index (SDI) before subsequent reverse osmosis membrane system. Also, ceramic based UF system is also implemented for the first time in leather sector in Pallavaram CETP, Chennai.

v. Advanced Oxidation Process

The advanced oxidation processes such as ozone, chlorination, hydrogen peroxide etc., are generally studied in the laboratory to remove the residual organics with colour after secondary treatment. The bio-fouling could be significantly controlled in the RO system. Based on the laboratory and pilot plant studies, the full-scale ozonation system has been implemented for first time in leather sector to remove the color effectively in Pallavaram CETP, Chennai and in RANITEC CETP, Ranipet. Implementation of ozonation also ensures that the salt generated from MEE is white in colour.

vi. Nano Filtration (NF)

One of the major challenges in disposal of reject salt is due to present of monovalent chlorides and divalent sulphates. NF membrane system has been developed and has been implemented for separation of monovalent chlorides and divalent sulphates in the wastewater at RANITEC CETP, Ranipet.

vii. High Pressure RO System (HPRO)

In two stage RO system only 65% to 70% of water is recovered leaving 30% to 35% of saline water as reject. The HPRO system can increase the water recovery further by which about 85% of water can be recovered in the

whole system. Due to reduction in the volume of evaporation of reject in Multiple Effect Evaporator (MEE) – Agitated Thin Film Dryer (ATFD), the operation and maintenance cost is significantly reduced.

viii.Multiple Effect Evaporator (MEE) and

Agitated Thin Film Dryer (ATFD)

This reject from the Reverse Osmosis is being evaporated in the multiple effect evaporator. The evaporator with improved material of construction i.e., SS316L and titanium tubes have been implemented to increase the life span of the evaporator. During evaporation the concentrated saline liquor is crystallized leaving the mother liquor which contains high COD saturated stream. Agitated Thin Film Dryer specially designed film type dryer for evaporation of mother liquor has also been implemented to ensure the dry salt is obtained from the evaporation system.

ix. Introduction of renewable energy and

Energy saving Measures in CETPs

a) Solar Photovoltaic Energy System for

power generation

About 35% to 40% of the operation and

maintenance cost of a CETP is towards the electrical power cost. Increase in effluent treatment costs affects the cost of leather and consequently the export competitiveness of the cluster. Hence, the solar photo voltaic system has been implemented in 9 CETPs in the country with 1 MW per MLD based

on the requirements. In total, 18.5 MW capacity solar plants have been implemented to generate about 5000 units/day/MW which reduces the O&M cost. Also, it resulted in significant reduction in carbon print from CETP and leather sector. In addition, solar thermal system has been implemented in RANITEC CETP to meet the thermal energy requirement of CETP.

b) Energy saving measures

The major O&M cost in primary and

secondary treatment system is towards the blowers for equalization and aeration tank and other pumps. To save energy, energy efficient pumps, blowers, compressors, etc. have been implemented in all CETPs to reduce the energy demand in CETPs.

c) Solar based Sludge Drying system

Mechanical sludge dewatering ensures only

30 to 35% moisture is removed from both primary and secondary sludge and hence the industry to bear the disposal cost of moisture as well (70% by weight basis) while disposing the hazardous wastes. Thermomechanical based sludge drying systems have been implemented in tannery CETPs to reduce the remaining moisture content in the sludge after dewatering using filter press. The capital and operating cost of the Thermo-mechanical based sludge drying systems is slightly high but the space requirement is less. Few CETPs are implementing solar based sludge drying system which requires less energy but requires more land area. This solar based sludge drying process could be used where sufficient land is available as it is economical and reduces the carbon footprint.

4. Management of mixed salt from ZLD based CETPs

Treatment technology developed by Central Salt and Marine Chemicals Research Institute for purification of mixed salt to pure NaCl (~98%) would also address the long-standing challenge of disposal of stored mixed salt from ZLD plants in leather CETPs. Also, the energy requirement of this salt purification will also be met by solar energy ensuring that the operation and maintenance of this plant is reduced and also ensuring that there is not addition carbon print.

5. Policy framework for leather sector

The regulatory requirements are becoming more and more stringent as the environment is an essential component of the ecosystem for the wellbeing of all the living organisms in the earth. However, development of industries, employment and export are also essential for economic development of the nation. Hence, to balance these aspects, Govt. of India has come out with various schemes for development of leather sector including upgradation of CETPs in the country to meet the regulatory requirements and utilize CETP at its full capacity under sustainable approach.

6. Conclusions

The upgradation of CETPs in India in CETPs targeted preventing discharge of wastewater from the industry to the environment and at the same time prevents the consumption of fresh water to be reused in the process of leather tanning. Moreover, the upgradation scheme by using the above technological development can also ensures the better treatment of tannery wastewater and reduces the cost of operation and maintenance for about 30 – 40%. With these advanced treatment technologies, the tanneries can also enhance their production and employment generation in the country. This ensures the sustainability of the industry and development in Indian economy by increasing the leather and leather goods export values. Implemented solar photovoltaic power and solar thermal energy generation reduces the O&M cost

and carbon foot print from leather sector. The salt purification system being implemented ensures the salt is also used in chemical industry achieving circular economy concept. Regular upgradation of CETPs with the latest state of art technology ensure that the CETP operates at reduced O&M cost and also meet the regulatory requirements and moving the leather sector towards sustainability.

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