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SUSTAINABLE ENVIRONMENTAL TECHNOLOGIES INCLUDING WATER RECOVERY FOR REUSE FROM TANNERY AND INDUSTRIAL WASTEWATER – INDIAN AND ASIAN SCENARIO

Dr. S. RAJAMANI

Chairman-Asian International Union of Environment (Ajue) Comission, Old No. 18, New No. 45, First Street, South Beach Avenue, MRC Nagar, Chennai-600028, India, E-mail: dr.s.rajamani@gmail.com

Abstract: *World leather sector generates 600million m3 of wastewater per annum. The Asian tanneries contributes more than 350 million m3 of wastewater from the process of 8 to 10 millions tons of hides and skins. Environmental challenges due to depletion of quality water resources and increase in salinity, it has become necessary to control Total Dissolved Solids (TDS) in the treated effluent with water recovery wherever feasible. Adoption of special membrane system has been engineered in many individual and Common Effluent Treatment Plants (CETPs) in India, China and other leather producing countries. The sustainability of saline reject management is one of the major challenges.*

Conventional tannery wastewater treatment systems include physiochemical and biological treatment to reduce Chromium, BOD, COD and Suspended Solids. To tackle treated effluent with TDS in the rage of 10000 to 30000mg/l, multiple stage high pressure membrane units have been designed and implemented for recovery of water. To reduce the chemical usage and sludge generation in the tertiary treatment, Membrane Bio-Reactor (MBR) has been adopted which replace secondary clarifier and sophisticated tertiary treatment units such as Reactive Clarifier, Ultra-filtration (UF), etc. Commercial scale high-tech membrane systems have been implemented in many locations for the capacities ranging from 500 to 10000m^3/day. Recent applied R&D on the environmental protection techniques with focus on water-recovery for reuse, salt recovery, marine disposal of saline reject with proper bio-control system, etc. are dealt in this novel technical paper.

Key words*: Effluent Treatment System, Environment, Sustainability, Water Recovery.*

1. INTRODUCTION

Annual leather process in Asian Countries is estimated at 8 to 10 million tons of hides and skins which is more than 50% of the estimated World leather production of about 16 million tons per year. The tanneries in Asian countries including India, China, Vietnam, etc. discharge more than 350 million m^3 of wastewater per annum [1].

Conventional physiochemical and biological treatment systems are designed and implemented only to reduce Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), Heavy metals etc. and not TDS and salinity which are mainly contributed by chlorides, hardness and sulphates [2]. Due to inherent quality of wastewater from tanning industry, the treatment plants are unable to meet the prescribed standards in terms of TDS, chlorides in salinity in the treated effluent. The TDS limit is being enforced in India and other parts of the World depending upon the final mode of disposal. In addition to the removal of TDS in the treated effluent, it is necessary to recover water for reuse to meet the challenge of water shortage. In many states in India, the pollution control authorities insist on water recovery integrated with Zero

Liquid Discharge (ZLD) system [3]. However, the achievement of Zero Liquid Discharge concept has got many technical challenges in addition to the application of various types of membrane systems.

Recent applied R & D activities including case studies of major environmental projects implemented in India, Spain, China, etc. are covered in the novel technical paper.

2. ADVANCED TREATMENT SYSTEM FOR SLUDGE REDUCTION & TDS MANAGEMENT WITH WATER RECOVERY

Due to inherent quality of industrial wastewater such as textile dyeing units, tanneries etc., the conventional treatment plants are unable to meet the prescribed TDS level of 2100 mg/l in the treated effluent. In addition to TDS management the control of volatile solids in hazardous category sludge is also becoming a necessity.

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For control of sludge and recovery of quality water from wastewater, the required treatment steps are (i) Chrome recovery and other in process control including cleaner production (ii) Conventional physiochemical and biological effluent treatment systems to reduce BOD, COD, SS etc. and (iii) Tertiary treatment systems including, micro-filter, low pressure membrane units such as ultra-filtration etc., before the application of single or multiple stage Reverse Osmosis (RO) system[4]. A special treatment process for recovery of water from waste water is given in Figure 1.

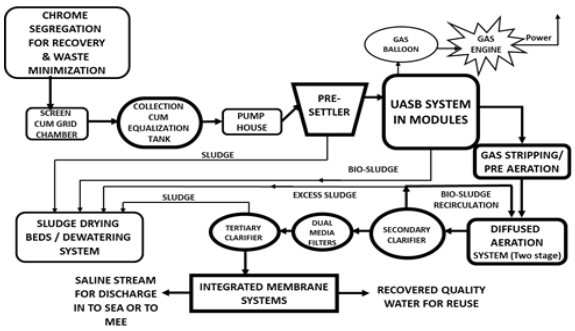

Fig. 1: *Tannery Waste Treatment & Integrated Saline Management*

After primary and secondary treatment units, Reactive Clarifier, Dual Media Filter, Micro Filter, Ultra-Filter (UF) are installed prior to RO system for recovery of water. Quality water with TDS less than 500mg/l could be achieved with rate of recovery of 70 to 90% depending upon the feed water TDS level, type and stages of membrane system etc. In addition to recovery and reuse of quality water by the industry, the additional benefits are savings in chemical usage in the tanning process and reduction in pollution load in the effluent.

3. MEMBRANE BIO-REACTOR (MBR) INTEGRATED WITH RO SYSTEM

Membrane Bio Reactor (MBR) system is adopted as tertiary treatment to remove the residual BOD, suspended solids / coliform, etc. from the effluent. A Common Effluent Treatment

Plant (CETP) in Spain with MBR and RO system for water recovery was established in 2005. After MBR / UF treatment, the suspended solids and BOD values in the effluent are below detectable level and taken for treatment with RO system for recovery of water after the removal of TDS and salinity.

In China also water is becoming a scarce commodity in many locations. Expansion of high water consuming industries is allowed only if they are provided with water recovery system in the effluent treatment plants. To recover water from the tannery wastewater, submerged MBR linked with activated biological treatment is provided in the first stage. Following MBR system an RO plant in "Christmas Tree" configuration has been installed and operated at 12–16 bars. The RO plant produces about 70% permeate and 30% concentrate. The quality of the recovered water meets the drinking water standards. The saline water concentrate stream is further treated with Fenton process before disposal[5].

A view of the submersible MBR in one of the tannery effluent treatment plants in China is shown in Figure – 2.

Fig. 2: *Submerged Membrane Bioreator*

Multiple stage evaporators using thermal and electrical power have been installed for evaporation of the reject saline stream from RO system. Further techno economical review and modified options are required on the sustainability of the multiple stage evaporator system.

4. TECHNOLOGICAL DEVELOPMENTS IN ASIAN AND MAJOR LEATHER PRODUCING COUNTRIES

The recent developments in cleaner production and waste management in Asian and other major leather producing countries are given in Table 1.

Table 1: *Technological Developments in Environmental Protection*

Country	Research & Technological Development
BANGLADESH	The main tannery cluster in Bangladesh is located in Dhaka city. Tanneries introduced cleaner technologies and chrome recovery system etc. with the support of UNIDO. The tanneries from the Dhaka city are being relocated in a newly developed industrial estate with Common Effluent Treatment Plant (CETP) of 30MLD capacity.
CHINA	There are about 800 tanneries and 13 CETPs in China. R & D activities on reduction of volume of water usage and pollution load at source through cleaner production program have been undertaken by many institutions. The tanneries are permitted to expand the capacity without increase in the water usage. One of the major tanneries has implemented the MBR and RO system for water recovery and reuse.

Country	Research & Technological Development
	As such there is no specific restriction on the Total Dissolved Solids (TDS) or salinity norms for the disposal of treated effluent. However meeting the BOD, COD norms for the saline streams from RO is one of the issues being addressed by new technological development. As a sustainability measure new licenses are given to tanneries with a processing capacity of more than 3000 tons /year of raw hides and skins.
INDIA	 **Fig. 3:** *UASB system with Bio-Energy generation from a CETP in India* Disposal of the saline stream from membrane units in land locked areas is one of the unresolved technical challenges. Treated effluent is mixed with treated domestic sewage and utilized for green development in some of the land locked areas. Decentralized secured landfill system linked with CETPs for leather sector had been implemented in many tannery clusters[6]. (First of its kind in the World). R&D activities on bio processing are under progress.
ITALY	Total aerobic biological oxidation system without the use of chemical is adopted in major CETPs for reduction of COD and sludge generation. Thermal treatment of sludge, energy generation from volatile organic matter and overall sludge management are followed. Central chrome recovery and reuse system are being adopted in many locations.  **Fig. 4** – *Extended Aerobic oxidation for sludge reduction in a CETP, Italy*
ROMANIA	R & D activities in Cleaner Production and Environmental Protection are being carried out in National Research and Development Institute for Textiles and Leather (INCDTP) / ICPI & University of Oradea, Romania. Many co-operation programmes in association with COTANCE and other institutions are under progress. Romania. Media and Conferences are effectively used to promote the importance and image of leather industry and environment protection activities[7].

Country	Research & Technological Development
RUSSIAN FEDERATION	Many institutions such as Department of Leather and Fur Technology. Water Recourses and Commodity Research, East Siberia State University of Technology and Management, Ulan-Ude, Russia and other industrial organizations promote technological development and environmental protection in leather and other industrial sector.
TURKEY	There are about 540 tanneries existing in 14 zones. Eight Common Effluent Treatment Plants (CETPs) have been established and are in operation. The biggest CETP with a capacity of 36,000m^3/day is in Tuzla near Istanbul[8]. The other major tannery cluster is in Izmir with an integrated CETP. The tanneries had resettled in industrial zones. The treated effluent is disclosed in to sea for TDS management with special bio-control.

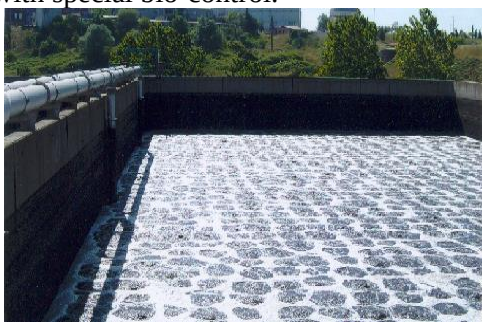

Fig.6 - *CETP in Istanbul, Turkey with Sea discharge for TDS management*

R&D activities on cleaner production and environmental protection are being continued in universities such as Ege University, Izmir etc. Sludge disposal is a major problem similar to other countries.

6. CONCLUSION

The leather production activities especially raw to semi-finishing process are being shifted from the developed nations such as United States, West European countries, etc. to Asian, North African and Latin American countries. The tanneries in major leather producing countries such as China, Italy, India, etc. have to develop and adopt new environmental protection measures such as adoption of membrane system for water recovery & TDS management due to enforcement of stringent environmental regulations. Sustainability of the small-scale units is becoming a serious issue to meet the new environmental requirements. Major investments are being made for environmental protection and resettlement of tanneries from the urban areas to the industrial parks with common effluent treatment plants. New regulations and restrictions such as REACH on the use of certain chemicals, salinity and water recovery under zero discharge concepts, disposal/ management of chrome containing sludge etc. envisage continued Research & Development activity[9]. Innovative tanning processes which will greatly reduce the water and chemical usage and minimize solid waste generation are needed together with overall environmental planning and management**.**

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