LEATHER INDUSTRY

INDUSTRIAL EFFLUENT TREATMENT AND CONTROL

(MES-302)

SUBMITTED BY:

Afreen Fatma

Fazle Ahmad

Jatin Kumar Malhotra

SUBMITTED TO:

Dr. Sirajuddin Ahmad

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ENVIRONMENTAL SCIENCE

JAMIA MILLIA ISLAMIA

JAMIA NAGAR, NEW DELHI-110025, INDIA

INDEX

1. INTRODUCTION

The leather industry is a centuries-old manufacturing sector that produces a wide range of goods including footwear, bags, apparel, and other items. Leather products are used almost every day by humans and are consumed regularly. It is estimated that leather and its derivatives make up the majority of global trade. These products are made from renewable and easily accessible resources. Currently, the leather trade is worth billions of dollars a year, and this figure is expected to rise as countries increase their populations and urbanize.

Leather processing industries rely primarily on slaughterhouses and meat industry waste for raw materials. These raw materials are processed and converted into the leather in tanneries. Due to its importance in the leather industry, tanning plays a crucial role.

IMPORTANCE:

As a significant proportion of the leather industry's output is obtained from food and agriculture waste, it provides a variety of beneficial, sustainable, and desirable products. It is extremely crucial to the global economy that waste byproducts from the meat, dairy, and wool industries are processed and recycled for leather. India is the source of some of the most valuable raw materials and leather. Tanneries in India are typically family-owned, small to medium-sized businesses. The industry is often a significant contributor to the local economy, acting as the primary source of wealth and employment.

GROWTH OF LEATHER INDUSTRY:

On the industrial map of the country, the leather industry occupies a prominent position. As a manufacturer and exporter of leather garments, and as a producer of saddlery and harness items, India is the world's second-largest country. The states of Uttar Pradesh and Maharashtra are the most significant production and export centers for leather, leather products, and footwear. Based on membership records from the Council for Leather Exports (CLE), Uttar Pradesh contributes 31.35 percent of total leather exports, leather products, and footwear from India, while Maharashtra contributes 2.28%.In 2022, the global leather goods sector is projected to reach $424 billion, and by 2030, it is expected to reach USD 744 billion. There is a huge potential in the leather industry worldwide.

LOCATION OF MAJOR LEATHER INDUSTRIES IN INDIA:

The major leather and leather product manufacturing centers in India are in the:

1. Tamil Nadu - Chennai ,Ambur, Ranipet, Vaniyambadi, Vellore, Pernambut, Trichy, Dindigul,Erode
2. West Bengal - Kolkata
3. Uttar Pradesh - Kanpur, Agra, Noida, Saharanpur
4. Maharashtra - Mumbai
5. Punjab - Jallandhar
6. Karnataka - Bangalore
7. Andhra Pradesh - Hyderabad
8. Haryana - Ambala, Gurgaon, Panchkula, Karnal, Faridabad
9. Delhi
10. Madhya Pradesh - Dewas
11. Kerala – Calicut, Cochin

2. MANUFACTURING PROCESS

RAW MATERIALS:

1: Skin/Hides: derived from cows, pigs, goats, and sheep exotic animals like alligators, ostriches, and kangaroos

2: Tanning Materials: vegetable extract derived from the bark and wood of oak, wattle, and Trivalent chromium sulfate is a mineral.

PROCESS:

Hides are generally soaked in a salt solution after being received from slaughterhouses to protect them from microbial attack. When the salt-soaked hides are exposed to the air before being transported to the tanneries, they become very stiff. The first step is to soak the hides in water to eliminate the preservative salt and the stiffness of the hide. Soaking can last from 5 to l0 days. Because the salt-laden water is discharged only occasionally, it generates a strong but intermittent wastewater stream. This stream is dark olive green in color and contains salt, dirt, dung, and blood. The next step is fleshing, which involves removing the fatty tissue from the hides. This can be accomplished manually or mechanically. In this step, a continuous flow of water is used to remove the fleshing. This results in the production of a constant stream of malodorous wastewater. The next step is liming, which involves treating the hides with lime and an alkaline reducing agent such as sodium sulfide ($Na2S$). This chemical promotes the swelling of the hide. The hair on the hides has loosened too though.

The loosened hair is removed mechanically or manually during the unhairing process. They are separated from the wash water using screens. Washing the hides also removes any excess lime that was used previously. Bating is an important step in preparing the hides for tanning. It is done to lower the pH, reduce swelling, peptize the fibers, and remove protein-degrading products. Bating is usually done with ammonium salts and a combination of commercially prepared enzymes, primarily trypsin, and chymotrypsin. Bating the grain makes it silky, slippery, smoother, and more porous, as well as reducing wrinkles on the hides.

The steps outlined above are applicable to both vegetable tanning and chrome tanning.

Vegetable tanning is a natural process that uses tree tannins and water. Chrome tanning, on the other hand, is based on chromium salts and tanning liquors that must be carefully managed and monitored in order to have the least environmental impact.

In terms of durability, both vegetable tanning and chrome tanning have advantages. Chrome-tanned leather is relatively water-resistant, making it ideal for products exposed to heat or humidity, whereas vegetable-tanned leather is thicker and can withstand more rugged or daily use. If properly cared for, vegetable-tanned leather can last for decades.

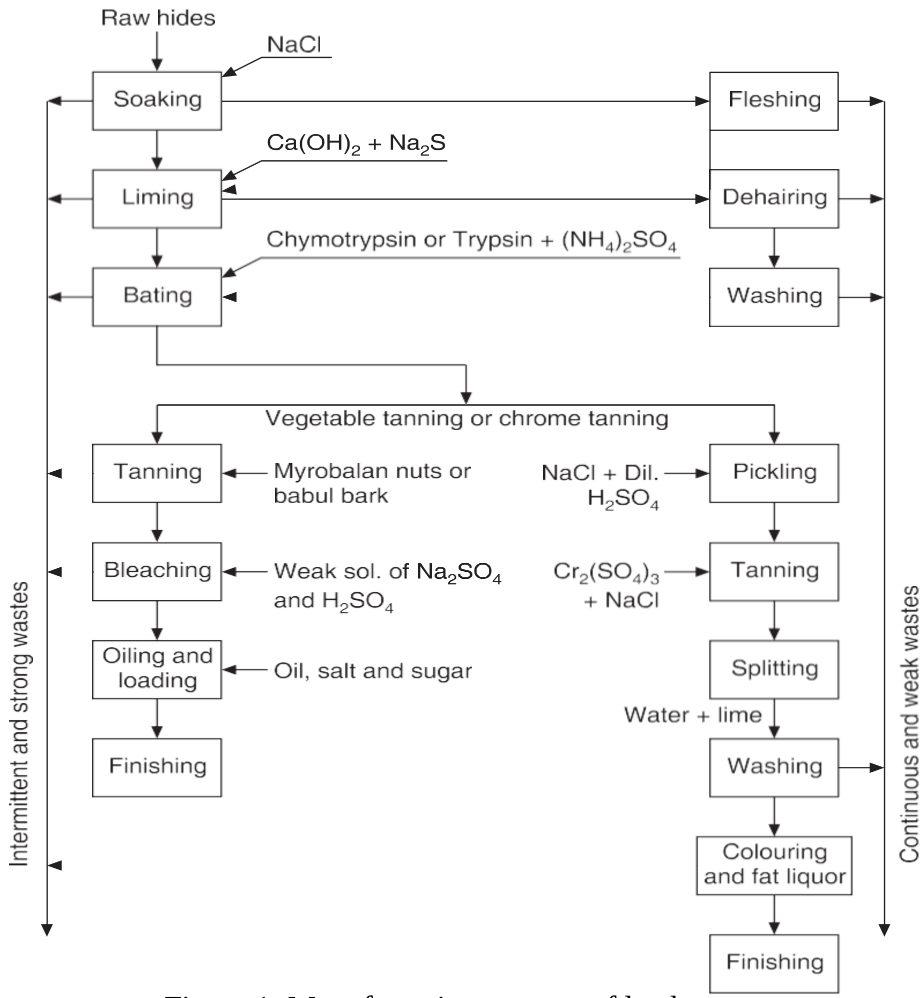

Figure 1: Manufacturing process of leather

Table 1: Chemical consumption in the leather processing industry

Sr. No.	Chemical Name	Per kilogram/ton of hides or skin processed
1.	Soaking Aids	1.0-2.5
2.	Preservatives	2.5-5.0
3.	Lime	80-200
4.	Sodium Sulphide	20-30
5.	Sodium Chloride	80-100
6.	Ammonium Salts	10-15
7.	Sulphuric Acid	12-20
8.	Sodium formate	5-12.5
9.	Basic Chromium Sulphate	60-120
10.	$Al(Al_2O_3)$	1-20
11.	$Zr(ZrO_2)$	0-15
12.	Vegetable Tanning	10-220
13.	Synthetic Tanning Agents	20-60
14.	Fat liquors	25-100

15.	Dyes	2.5-20
16.	Binders	20-45
17.	Pigments	10-25
18.	Top Coats	20-45
19.	Wax Emulsions	2.5-5.0
20.	Feel Modifier	1.0-2.0

3. SOURCE OF POLLUTION AND ITS CHARACTERISTICS

The entire leather manufacturing process involves a large number of chemicals, which is the primary source of waste and pollution.

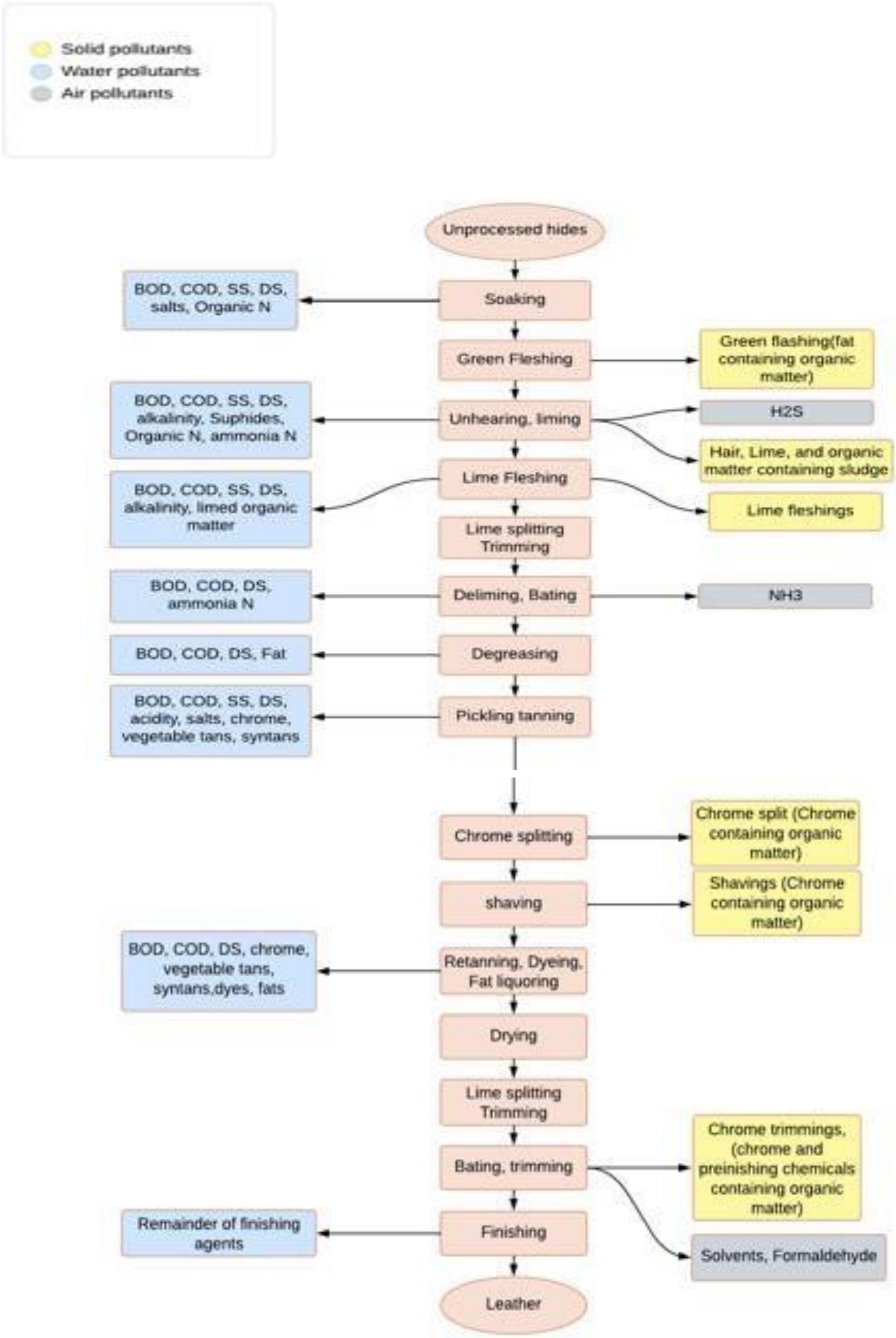

Figure 2: Flow Chart of pollutants produced

As a result, the sources of waste are primarily generated by the use of chemicals during leather processing, as the chemicals react with the leather and emit waste materials and pollution. The flow chart in figure 2 shows how various types of pollutants are released during the manufacturing of leather.

Table 2: shows the average chemical composition of leather manufacturing process.

Solid waste	Generation kg
Salt from shaking of raw hides	75-90
Salt from solar evaporation pans	200-225
Hair	100-125
Raw trimmings	50-60
Lime sludge	50-70
Fleshings	100-125
Wet blue trimmings	25-40
Chrome splitting	55-75
Chrome shavings	80-100
Buffing dust	50-75
Dyed trimmings	30-60
Sludge (35% dry solid basis)	300-400

Table 3: shows the solid waste kg per tonne of raw hides generated in beamhouse operations.

Wastes	kg/ton
Raw Trimmings	80-120
Wet limed Fleshing’s	250-300
Hair / Wool	40-50

At least 300 kg of chemicals (lime, salt, etc.) are added per tonne of hides during the tanning process. There is an excess of non-used salts in the wastewater. This wastewater contains salts (Cl), fat, protein, preservatives (soaking), lime and ammonium salts, ammonia, protein (hair), sulfides (fleshing, trimming, and bating), chromium (salts) and polyphenolic compounds (tanning), dye and solvent chemicals (wet-finishing).

Table 4 Polluting gases released into the atmosphere during beam house operations

Process-step	Air pollutants
Unhairing/liming	H_2S
Deliming/Bating	NH_3

4. GENERAL CHARACTERISTICS

Different types of waste with saline properties

Table 5 Saline characteristics of soaking waste

Parameter	mg/L	Kg
TS	40,000-50,000	200-250
TSS	5,000-10 ,000	25-50
TDS	30,000-40,000	50-200
BOD	1,200-2,000	6-10
COD	3,000-5,000	15-20
Oil and Grease	200-400	1-2
Alkalinity	1,000-1,500	5-7.5
Chromium	None	None
Sulphide	None	None
pH	7.5-9.0	-

Table 6 Saline characteristics of Liming waste , Deliming waste and Pickling waste

	Liming waste saline characteristics	**Deliming waste saline characteristics**	**Pickling waste saline characteristics**
Parameter	mg/L	mg/L	Mg/L
PH	10.0-12.8	7.0-9	2.0-3.0
BOD5 at 20'C	5,000-10,000	1,000-3,000	400-700
COD	10,000-25,000	2,500-7,000	1,000-3,000
Sulphides	200-500	30-60	-
TS	24,000-48,000	5,000-12,000	35,000-70,000
TDS	18,000-30,000	3,000-8,000	34,000-67,000
SS	6,000-18,000	2,000-4,000	1,000-3,000
Chlorides	4,000-8,000	1,000-2,000	20,000-30000
Sulphate	600-1,200	2,000-4,000	12,000-18,000

Table 7: Saline characteristics of Chrome tanning waste, vegetable tanning waste and Beamhouse waste

Parameters	**Chrome tanning waste saline characteristics**		**Features of vegetable tanning waste saline**		**Beamhouse waste saline characteristics**	
	Mg/L	Kg	Mg/L	Kg	Mg/L	Kg
TS	30,000-60,000	150-300	25,000-60,000	125-300	30,000-50,000	300-500

TSS	1,000-2,500	5-12.5	5,000-10,000	25-50	6,000-20,000	60-200
TDS	9,000-57,500	145-287	20,000-50,000	100-250	24,000-30,000	240-300
BOD	400-800	2-4	6,000-18,000	30-90	5,000-10,000	50-100
COD	1,000-2,000	5-10	15,000-40,000	75-200	10,000-25,000	100-250
Oil and Grease	600-1,200	3-6	200-400	1-2	400-500	4-5
Acidity	2,000-5,000	10-25	2,000-4,000	10-20	Alkalinity 12,000-20,000	120-200
Chromium	2,000-5,000	10-25	None	None	None	None
Sulphide	None	None	None	None	300-500	3-5
pH	2.5-4.5	-	3.5-5.0	-	10.0-13.0	-
Ammonia	-	-	--	-	500-1,000	5-10

Table 8 Water consumption and wastewater emissions from pickling and chrome tanning

Parameter	kg/ton of Raw Hide
Salts (Cl^-)	30-100
BOD	~3
COD	~14
SS	~5
TDS	~175
NH_4-H	~0.5
TKN	~1
Cr^{+3} salts in spent liquors	5-10

Table 9 Waste water emissions from post-tanning operations

Parameter	Kg/ Ton
TS	~65
COD	20-30
Chromium	2-5
BOD	~14
SS	7
NH_4 +	0.6-0.8
Cr	1
Cl	2-5

5. DISPOSAL STANDARDS

Treatment of Wastewater

To reduce pollution load, waste water treatment involving an effective on-site and/or off-site combination of the following techniques shall be used-

1. Mechanical Treatment involving removal of solids, skimming of fats, oils, and greases.
2. Physicochemical Treatment-Oxidation of Sulphur, COD and suspended solids removal via coagulation and flocculation. Chromium precipitation is achieved by raising the pH to 8.0 or higher.
3. Biological Treatment using aerobic bacteria in presence of oxygen
4. Biological Sulphide oxidation can be done with pre-denitrification and nitrification.
5. Membrane technique and reverse osmosis with evaporation systems in water scarcity or if the waste water needs to be used for irrigation.

Treatment of Solid Waste

Waste should be properly segregated, labelled and transported in well sealed containers.

The reuse recycle disposal cycle must be followed. Hazardous and non-hazardous waste should be identified and disposed accordingly. On-site incineration of wastes having Chromium should be restricted.

Lime Splitting should be practiced, performing the splitting process earlier in the procedure to generate an untanned by-product. Chromium sludge can be used as a raw material.

Air Emission Treatment

Emission of Hydrogen sulphide, Sodium sulphide, NaHS needs to be strictly monitored. To reduce the odour issue in leather industry, a chemical air scrubber can be utilised. Chemicals that disguise odours can be added. Solid and water wastes should be disposed quickly to eliminate stench.

6. IMPACT OF INDUSTRIAL POLLUTION

On Environment-

Leather manufacturing cause deforestation, biodiversity loss, environmental pollution and greenhouse gas emissions. The pre-tanning procedure generates pH changes and cause increased COD, total dissolved solids (TDS), chlorides, and sulphates in industrial effluents. Highly contaminated sediments caused by chemical discharge including Chromium and heavy metals have a negative impact on river ecology. Leather itself is slow degrading and further treatment renders it more resistant to degradation, impacting ground water reserves and agricultural activities. This pose further threats to the ecosystem. A high proportion of VOCs are produced by various procedures in tannery, that might constitute a harm to the environment if not effectively managed. Leather industry also produce significant amount of carbon dioxide and monoxide, contributing to green house effect and also many chemicals are released into the air, posing heat to environment.

On Health-

Leather industry causes severe environmental pollution. Contact with polluted environment is linked to a wide range of diseases, including asthma, dermatitis, hepatic and neurological problems, and different cancers. Premature, discoloured, itchy skin with rashes, pain, nausea and vomting and damaged limbs presented by tannery employees. Chemical substance, like sulfuric acid and sodium sulphide, can be harmful to health as they can damage tissue, ocular membranes, epidermis, and the upper airways. Chances of cancer are also increased in such workers. The contaminated water reaching agricultural fields affects population far from the leather industries. Effluents released in air further add to health hazards. According to IARC over exposure to leather dust is carcinogenic for humans.

7. EFFLUENT TREATMENT SCHEME

Before wastewater is reused, allowed to enter natural waterbodies, or used for irrigation it must first undergo a treatment procedure involving various stages. The objective is to minimise or eliminate organic compounds, sediments, nutrients, Cr, and other contaminants. The waste water treatment is carried out in the following stages-

1- Physical-chemical treatment (primary)
2- Biological treatment (secondary)
3- Advanced (tertiary) treatment
4- Sludge handling and disposal

Zero Liquid Discharge system-

The Zero Liquid Discharge (ZLD) technology guarantees a waste treatment system with no water emission. Using modern cleanup technologies, the cleaned effluent is recycled, recovered, and reused. The worldwide scenario depicts the deployment of ZLD as a result of regulatory agency pressure. The ZLD system includes a pre-treatment system that includes traditional physical, chemical and tertiary treatments, the water of treated effluent is softened, reverse osmosis (RO) technique is used for desalination, and the salts are separated by evaporation of rejected saline from R.O. Water usage is decreased by using this technique. Additionally, in regions where the tannery sector is a significant economic player, ZLD has also been successful at managing disasters. In tannery industry, consumption of water is a significant problem, and substantial progress has been done to minimise and recycle water. Using cleaner technologies may cut water usage by 55–58%, while reusing the effluent from the pre– and post–tanning procedures can cut consumption of water by 67%. No water is released from the leather processing owing to the closed water cycle method used by the ZLD system. This minimises the chance of brine discharge contaminating the water and increases water use.

Thermal-Based ZLD Systems-

System based on thermal processes in the early stages of ZLD development, evaporated the wastewater produced by the conventional treatment plant in a saline concentrator followed by a crystallizer or evaporation pond.

MVC- Mechanical Vapor Compression or MVC is utilised in the ZLD system, where water is combined with brine slurry by heat tubes and the brine slurry is evaporated by heat exchange.

Brine Concentrators- with solid concentrations up to 250 g/L, brine concentrators may recover 98% of the water they are fed.

The concentrated brine is then pumped via a submerged heat exchanger and supplied to a crystallizer for further recovery of water. The treated water is gathered and cycled back to the tannery industry. As a byproduct of the ZLD system, salts are created. They can be recycled into useful salt products or disposed away in landfills.

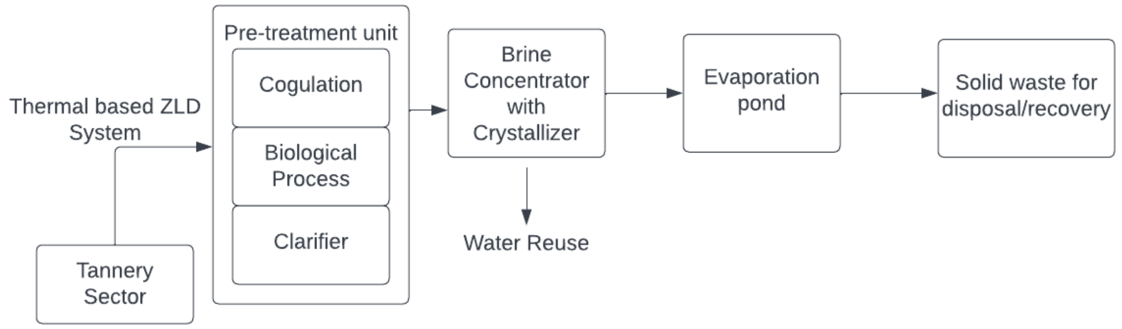

Figure 3: Thermal-based ZLD system

RO-Based ZLD Systems-

When used in conjunction with a traditional thermal-based ZLD system, RO technology can lower the amount of slurry that enters the brine concentrator, which lowers MVC's energy usage. The irreversible losses connected to evaporation and condensation in heat processes are eliminated by RO. R.O. membrane segment is placed in front of the MVC brine concentrator to pre-concentrate the inflowing water and lessen the strain on the concentrator.

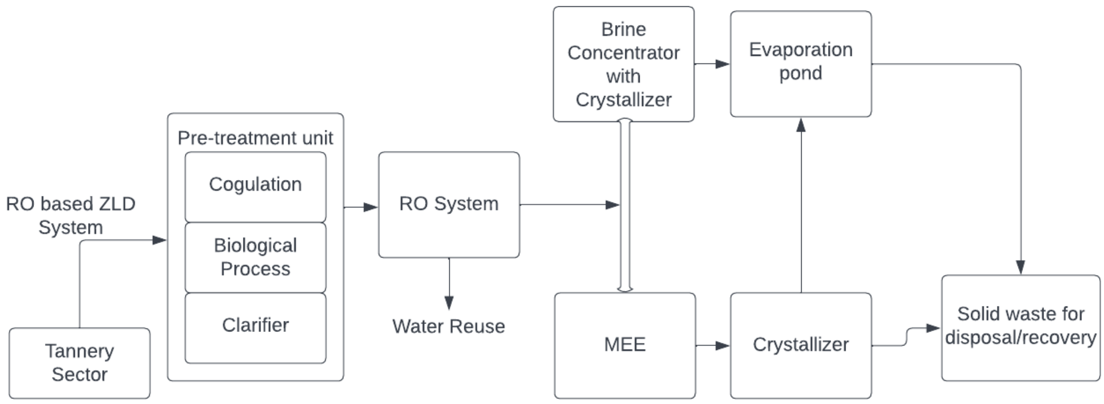

Figure 4: R.O. based ZLD system

8. SOLID WASTE MANAGEMENT SCHEME

a) The practice of reuse – recycling – disposal shall be followed and documented.

b) Guidelines regarding the identification, collection, storage and disposal of hazardous and non- hazardous waste shall be followed.

c) Yearly records of the type and quantity of hazardous, non-hazardous waste, by-product and part- product for collection and disposal shall be prepared and made available.

d) Manifests/receipts of the collection, transport, disposal of waste shall be kept for record.

e) Cr-containing waste should not be incinerated on site.

f) On-site storage arrangements for waste shall be: correctly marked,

- Adequately segregated,
- Bounded and soil-protected locations of storage areas, and
-Good condition sealed containers, with no spillage (e.g. in jacketed tanks).

g) Use of residues as by-product: To limit the quantities of wastes sent for disposal, take necessary actions to dispose the process residues as by-products.
h) Waste re-use, recycle and recovery: To limit the quantities of wastes sent for disposal, organize operations on the site to facilitate waste reuse, or failing that, waste recycling, or failing that, 'other recovery'.
i) Lime splitting: To reduce the chemical consumption and reduce the amount of leather waste containing chromium-tanning agents sent for disposal, use lime splitting.
    - Description: Carrying out the splitting operation at an earlier stage of processing, to produce an untanned by-product.
    - Applicability: Applies only to plants using chromium tanning.
    - Not applicable:
      -When hides or skins are being processed for full substance (i.e. unsplit) products,
      -When a firmer leather must be produced (e.g. shoe leather),
      -When a more unifom1 thickness is needed in the final product, and – where tanned splits are produced as product or co-product.

j) Chrome recovery: To reduce the amount of chromium in sludge sent for disposal.
k) ln order to reduce energy, chemical and handling capacity requirements of sludge for its subsequent treatment, reduce the water content of sludge by using sludge dewatering.
    - Applicability: Applies to all plants carrying out wet processing.
l) Proven processes for utilization of process solid wastes and waste generated during treatment of tannery wastewater.

9. APCD

Air Emission Treatment – Preventive Maintenance Programmes for All Air Emission Treatments Need to be Available –

a) Boiler dust emission especially for wood, renewables or coal fired boilers need dust treatment emissions like cyclones or similar.

b) Spray machine need to be equipped with water wash and I or activated carbon treatment or equal. Ensure that protection windows in the spray nozzle cabin are closed to protect the staff from VOC emission.

c) List all liquid finishing chemicals with the percentage of the organic solvent content (VOC) of each chemical and counted per unit of leather produced.

d) Hand spray booth is equipped with water-wash or activated carbon system or equal.

e) Weighing of powder dyestuff on a scale-weight with an exhaust system.

f) Buffing/De-dusting machines with dust exhausting systems, dust bag filters and dust cake pressing.

g) To reduce air-borne emissions of VOCs from finishing, use one or a combination of the techniques given below:
   - The use of water-borne coating in combination with an efficient application system.
   - The use of extractive ventilation and abatement systems.
   - PU coating systems need special air treatment like internal incineration system or activated carbon filter. The activated carbon filters must be maintained and changed in time.

h) H_2S emission in beam house (liming/de-liming) and chemical storage/handling of $NaHS$ and Na_2S need special H_2S monitoring systems (online or moveable metering systems with alarm function).

- Applicability: applies to all plants carrying out raw to finished leather processing.

10. CASE STUDY

CHALLENGES FACED BY LEATHER INDUSTRY IN KANPUR

India's leather industry occupies a prominent role in international trade, generating foreign exchange and providing employment. The industry employs more than 2.5 million people. Much of the economic benefits derived from leather production and trade, however, have typically come at considerable cost to the environment and human health. The case study has presented important findings and analyses, leading to an enhanced understanding and appreciation of the multiplicity of barriers and opportunities for the further development of the Indian leather sector. The problems faced by leather industry in India shows the very nature of the Indian economy. It shows how democratic structure shatters when every individual defends his failures with other‟s shortcomings. As for the common man, this ignorance has led to financial, social and health related problems and they feel desolated on their own land.

However negative these findings may be, there are opportunities to improve this situation. A comprehensive, well synchronized action by respective governments, industry, R&D and establishments, environmental authorities, international organizations, etc. to address the main constraints mentioned earlier is a prerequisite to achieving sustainable development in the tanning industry.

Government Regulations:

First, there is an immediate need to stop the corruption that is making it possible for the tanners to get away with not cleaning their effluents as the regulations abide them to. Second, there should be an increased reciprocity between the tanners and the CETP in Jajmau so that the tanners would feel more responsible for the effluent let out by them to the CETP. The focus on corruption is extremely important because it gives the tanners not only an opportunity to escape from cleaning their effluents as they should, but an actual encouragement to not do so, because non-compliance with regulations is the only way of having only one cost (for corruption) rather than two (for corruption and cleaning). Hence there are not only no incentives to clean, but the corruption is an actual impediment to clean. No matter how well the tanners do in cleaning, they still have to pay bribes. The need to end this corruption is therefore urgent. It is also important to make sure that the PCB officers that are responsible for the control of the tanneries have enough skills to do the control properly, and that they have the knowledge to teach the tanners how to achieve the standards if they are not meeting the norms at the moment of control.

Effective Monitoring:

Charge each tanner for the cleaning on the basis of how much effluent the tannery emits. This would be possible by establishing a measuring unit at the end of each tenner's pipe, measuring the amount of effluent it creates before it goes in to the common conveyance system. This would force the tanners to be more careful about their water consumption, and reduced water use could reduce the quantity of chemicals used. An even better option would be to have measuring equipment that could monitor the quantity of chrome and other chemicals contained in the effluent, and that each tanner would pay according to these measures. This would further encourage the tanners to reduce their use of chemicals as well as it would be another incentive to install recycling options such as chrome recovery plants. One obstacle is that the installment of these measuring equipments could be expensive. Instead, one could invent a system of discounts for tanneries that had for example chrome recovery plants, so that they would pay some percentages less for their effluent treatment at the CETP than other tanneries sending heavier pollution loads to the CETP. The way in which the CETPs function today (based on quantity of hides or water consumption), they are "anti-cleaner technology"

Inter Tannery Monitoring:

A less technical alternative is to improve the environmental performance of the Jajmau tanners by so-called "noisy monitoring". This means that the tanneries should monitor and report on each other. This is possible because already today the tanners in Jajmau are closely related and well informed about each other"s activities. One would have to find a way to ensure reporting and avoid "brotherhood" tendencies between the different tanners.

Eco-Labelling:

For the leather industry, there have already been suggestions to market vegetable tanned leather as environmental friendly or give the leather an eco-label. This is problematic both because it is not so certain that the vegetable tanned leather is any more environmentally sound than the chrome tanned leather and anyway, there is not a demand for such "clean" leather among the customers.

Financial Support:

Changes in the financial and in the insurance markets could be effective tools to improve the environmental performance of the tanning industry. If better interest rates on loans were given to tanneries with a good performance, or maybe a discount in the insurance premium, tanners would strive to achieve environmental standards. Special financial schemes can be floated for small and medium scale enterprises.

Qualitative boost:

Despite the economic importance of the leather industries for the economies of developing countries there is a discriminating attitude towards them because of the high pollution level. The younger generation at colleges and technical institutions do not find the tanning industry very attractive and are likely to select other industrial options. Developing countries should work towards a qualitative up-grading of the tanning industries. New industrial complexes should be designed, on a modern basis, incorporating all possible equipment safeguards and intrinsic safety features, to house new tannery units and relocate those currently beset with serious pollution problems.

Human Resource Development:

Most of the developing countries are facing acute shortage of technically qualified personnel for the operation, monitoring and maintenance of effluent treatment plants for tannery wastes. Appropriate training and education programmers are needed to cater for the needs of technical personnel at various levels (operating, supervisory, managerial and design). There is an urgent need to prepare a working paper which precisely identifies a training curriculum, type of faculty and infrastructural facilities required for this purpose. The existing expertise and facilities available in some of the developing countries should be taken into consideration and if necessary they should be strengthened and made more broadbased to cater for the regional needs.

Development of Commercial Plants:

Pollution control technologies have to be techno-economically viable with attractive financial returns for adoption in the traditional leather sector. The technology packages should consist of in-plant control, end of the pipe treatment and waste management components. There is a great need to set up demonstration plants for common effluent treatment, in-plant process controls and tannery waste utilization in the midst of tanneries in selected developing countries in order to enable them to see the performance of the new systems under field conditions. The demonstration plants should also be utilized for training of technical personnel from the developing countries. Adequate attention should be paid to the management of the demonstration plants. Sharing of managerial responsibilities by the existing tanneries will promote the cause of smooth technology transfer and generate a multiplier effect.

Conclusions:

Even though the Indian environmental regulations for the tanning industry are equally stringent as the international regulations, the pollution load coming from the tanneries is still heavy, and it is a problem both for the people living nearby, and for the river and ground water. There is a wide gap between the environmental regulations for the tanning industry and the environmental performance among the tanneries in the Kanpur area. Though few tanneries have the prescribed equipment to do primary treatment but most still fail to operate them properly or at all. Many of the tanners believe their activity is not harmful to the environment, or they do not see the environment as something that needs to be protected or treated properly. Much of the reason for this is the problem of corruption and the bribery that the PCB officers demand. The poor financial position and the small size of many tanneries are also important factors. Even though the cost of doing primary treatment is very low in India, the organization of the payment for secondary treatment has led to a lot of confusion, mal-information and mistrust between the tanners and the state bureaucracy administrating the CETP in Jajmau. Many tanners have failed to contribute their share of the cost. Also the fact that most of the tanneries in India are supplying the world market with low quality products or intermediaries, limits the opportunities to benefit from technological upgrading towards cleaner technology. Finally, "demanding customers" are too far away to be able to influence the environmental performance of the tanneries. All these factors contribute to explain the tanners" environmental performance. Finally, it is important to acknowledge that the opportunities for technological upgrading that could trigger a better use of resources and hence reduce the production of waste, are few and costly. Implementing costly technology or even cleaning mechanisms is a problem particularly for the many small tanneries (around 80% of the total number) that are in a poor financial position.

REFERENCES

[1] Dixit, Sumita, Ashish Yadav, Premendra D. Dwivedi, and Mukul Das. "Toxic hazards of leather industry and technologies to combat threat: a review." *Journal of Cleaner Production* 87 (2015): 39-49.

[2] Moktadir, Md Abdul, Hadi Badri Ahmadi, Razia Sultana, James JH Liou, and Jafar Rezaei. "Circular economy practices in the leather industry: A practical step towards sustainable development." *Journal of Cleaner Production* 251 (2020): 119737.

[3] Ozgunay, Hasan, S. Colak, M. M. Mutlu, and F. Akyuz. "Characterization of Leather Industry Wastes." *Polish Journal of Environmental Studies* 16, no. 6 (2007).

[4] Tewari, Meenu, and Poonam Pillai. "Global standards and the dynamics of environmental compliance in India's leather industry." *Oxford Development Studies* 33, no. 2 (2005): 245-267.

[5] Patterson, James William. "Industrial wastewater treatment technology." (1985).

[6] Koppiahraj, K., Bathrinath, S., & Saravanasankar, S. (2019). Leather waste management scenario in developed and developing nations. *International Journal of Engineering and Advanced Technology*, *9*(1S4), 852-857.

[7] Ricky, Rajamanickam, Subramanian Shanthakumar, Ganapathy Pattukandan Ganapathy, and Fulvia Chiampo. "Zero Liquid Discharge System for the Tannery Industry—An Overview of Sustainable Approaches." *Recycling* 7, no. 3 (2022): 31.

[8] Buljan, J., I. Kral, and G. Clonfero. "Introduction to treatment of tannery effluents." *UNIDO, Vienna* (2011).