Vol. 3(3), 96-103

Journal of Energy & Environmental Policy Options

Environmental and Health Hazards of Pakistan's Leather Industry

Atta Ur Rehman[a]
Shahzad Malik[b]

Abstract
Since gaining independence, Pakistan has developed a robust leather and leather-based industry, evolving from its traditional roots. As an agriculture-dominated country with a substantial livestock population, Pakistan has leveraged this resource to build a significant leather industry. However, the leather industry is among the most polluting industries due to its water-intensive processes and extensive use of chemicals, leading to a high pollution load in the form of effluents. These effluents typically contain hazardous substances such as sulfides, chromium, synthetic tannins, biocides, detergents, dyes, and protein materials. The primary aim of this project is to highlight the environmental and health hazards associated with leather manufacturing and to examine the processes involved in the purification and management of leather waste. The study aims to provide a comprehensive understanding of the negative impacts of leather production and to suggest strategies for mitigating these effects. The research concludes that workers in the tanning industry are exposed to numerous health risks. These include serious conditions such as anthrax, respiratory and skin irritations, chronic bronchitis, contact dermatitis, chrome ulceration, tetanus, Q fever, allergies, eczema, kidney stones, irritation of the mucous membranes of the throat and nose, genetic mutations, and various forms of cancer, including lung, sino-nasal, pancreatic, bladder, and testicular cancer. Additionally, the industry poses risks of acute injuries due to slippery conditions within the workplaces. To address these issues, the project underscores the importance of implementing effective waste management and purification processes. The study explores various treatment methods to reduce the environmental footprint of the leather industry. These methods include physical, chemical, and biological treatments to detoxify and manage waste products effectively. By adopting such measures, the leather industry can mitigate its negative impact on the environment and improve the health and safety conditions for workers. The project advocates for stringent regulations and the adoption of sustainable practices within the leather industry. This includes the use of less harmful chemicals, recycling and reusing water, and investing in modern waste treatment technologies. Furthermore, it emphasizes the need for comprehensive health and safety programs for workers, including regular medical check-ups, proper protective gear, and training on handling hazardous materials.
Keyword: Leather Industry, Environmental Impact, Health Hazards
JEL Codes: Q53, L67, I15

1. INTRODUCTION

Economic development and occupational health services are integral components of state welfare and community healthcare structures. Their synergy contributes substantially to establishing robust practices in health, environment, and safety management across various industries. By prioritizing occupational health services alongside economic development initiatives, governments and organizations can ensure safer working conditions, healthier workforce outcomes, and enhanced environmental stewardship. Menckel and Westerholm (1999) emphasize that effective occupational health services not only mitigate workplace hazards but also foster a culture of safety and well-being. This approach not only protects workers from occupational risks but also boosts productivity and organizational resilience. Moreover, integrating occupational health into economic development strategies helps in creating sustainable practices that support long-term growth while safeguarding public health and the environment. In practical terms, this integration involves policies and programs that prioritize workplace safety, promote health education, and ensure compliance with environmental standards. By investing in occupational health services, countries can enhance their competitiveness by improving workforce productivity, reducing healthcare costs associated with occupational illnesses, and attracting investments that prioritize sustainable development goals. Thus, economic development and occupational health services are not merely complementary but essential for fostering a healthy and productive workforce, promoting sustainable industry practices, and advancing overall societal well-being.

[a] Agriculture University Faisalabad, Pakistan
[b] Agriculture University Faisalabad, Pakistan

Occupational health, as emphasized by Abbas et al. (2014), plays a crucial role in safeguarding the well-being of workers across different professions. It encompasses a broad spectrum of activities and interventions designed to protect workers from occupational hazards, ensure their safety in the workplace, and promote their overall health. This field addresses not only physical risks but also considers mental and social factors that can impact workers' health and productivity. Efforts in occupational health range from implementing safety protocols and ergonomic practices to conducting health screenings and providing wellness programs. These initiatives aim not only to prevent injuries and illnesses but also to enhance the quality of work life for employees. By fostering a healthy and safe work environment, occupational health services contribute significantly to employee morale, job satisfaction, and overall organizational productivity. Furthermore, occupational health is integral to broader public health and community well-being strategies. It intersects with environmental health, public policy, and social equity issues, aiming to mitigate workplace risks and ensure equitable access to health protections for all workers. As workplaces evolve and new challenges emerge, the role of occupational health professionals becomes increasingly vital in adapting to these changes and promoting sustainable, safe working environments. The leather industry is recognized as one of the most environmentally hazardous industries primarily because of its intensive water usage and the discharge of chemical-laden effluents. These effluents contain a variety of pollutants such as sulphides, chromium, synthetic tannins, biocides, detergents, dyes, and protein materials. The disposal of these effluents without proper treatment can lead to significant pollution of water bodies and pose serious threats to both aquatic ecosystems and human health. The chemicals present in leather industry effluents are known to be toxic and persistent in the environment. Chromium, for example, is a heavy metal used in the tanning process to stabilize leather and is particularly harmful if released into water sources without adequate treatment. It can cause severe ecological damage and pose risks to human health through bioaccumulation in the food chain. Efforts to mitigate the environmental impact of the leather industry include the implementation of stringent regulatory measures and the adoption of cleaner production technologies. These efforts aim to minimize water usage, improve chemical management practices, and ensure the proper treatment of effluents before discharge. Sustainable practices in leather production, coupled with effective environmental management strategies, are crucial to reducing the industry's ecological footprint and safeguarding both aquatic ecosystems and public health.

The leather industry and its associated sectors play a significant role in the Pakistani economy, with approximately 600 tanneries located mainly in Kasur, Karachi, and Sialkot. However, the industry's operations have significant environmental consequences, particularly due to the discharge of waste that pollutes the air, soil, and water in these areas. This pollution poses serious health risks to both workers and nearby communities. Exposure to the contaminated environmental conditions around tanneries has been linked to various health problems among residents and workers. Studies, such as those by Syed et al. (2010), have documented increased incidences of respiratory issues like asthma, skin ailments such as dermatitis, and more severe health conditions including liver and neurological disorders, as well as certain types of cancers. The pollutants discharged from tanneries include a range of hazardous substances such as chromium, sulphides, and various chemicals used in the tanning process. These substances not only degrade the environment but also pose direct health risks through exposure via air inhalation, skin contact, and contaminated water consumption. Efforts to mitigate these health and environmental risks include stricter regulations on waste disposal and treatment, adoption of cleaner technologies in tanning processes, and improved occupational health and safety measures for workers. These initiatives are crucial to safeguarding public health, reducing environmental pollution, and promoting sustainable practices within the leather industry in Pakistan.

2. METHODOLOGY

The study design employed is explanatory, focusing on investigating the challenges faced by workers in industries, particularly within the context of leather tanneries. Research conducted at institutions like the Kasur Wastewater Management Agency and other relevant bodies aimed to address safety, health, and environmental issues prevalent in these workplaces. Data collection methods utilized in the study included monitoring and observation of industrial practices, as well as conducting structured interviews with employees working in these tanneries. These approaches were chosen to gather comprehensive insights into the working conditions, occupational health hazards, and environmental impacts associated with leather tanning processes. By employing a combination of monitoring, observation, and direct interviews, researchers sought to document firsthand accounts and empirical data regarding the challenges faced by industrial workers. This approach allows for a nuanced understanding of the factors influencing worker safety, health outcomes, and environmental sustainability within the leather industry context in Kasur and other relevant areas.

3. RESULTS AND DISCUSSIONS

The tanning process in leather production is indeed a complex operation that spans several stages, each contributing significantly to both the production of leather and the generation of hazardous waste. Starting with the beam house, which is integral to the initial cleaning and preparation of hides, this stage is notorious for its heavy organic pollution load. Here, hides are soaked to remove dirt and hair, resulting in wastewater that contains degraded hide and skin matter. Solid wastes like fleshings and trimmings further add to the environmental impact, necessitating careful management to prevent contamination of soil and water sources. Moving to the tanning process itself, which follows the initial preparation, substantial amounts of chemicals are employed. Lime and salt are fundamental additives, with about 300 kilograms used per ton of hides processed. Throughout tanning, which aims to convert raw hides into durable leather, wastewater is generated at nearly every step except for final finishing operations. On average, 35 cubic meters of wastewater are produced per ton of raw hide, underscoring the scale of environmental impact from this industrial process. Post-tanning stages include essential procedures like shaving, neutralization, retanning, dyeing, and fat liquoring. These steps not only enhance the quality and appearance of the leather but also contribute significantly to wastewater pollution. Effluent from these processes contains residues of chromium salts (common in chrome tanning), dyestuffs, fat liquoring agents, syntans, vegetable tannins, and other organic particles, all of which contribute to the Chemical Oxygen Demand (COD) of the wastewater.

Specifically, soaking generates water solutions laden with dirt, while processes like unhairing and reliming produce alkaline wastewater containing lime and sodium sulfate. Deliming introduces ammonium sulfate or ammonium hydroxide into the wastewater, and bating involves the use of proteolytic enzymes, adding further organic matter. Pickling results in wastewater containing salt and sulfuric acid, and chrome tanning generates wastewater with chromium compounds, a significant environmental concern due to their toxicity. The leather tanning process exemplifies the challenges faced by industries in managing hazardous waste and wastewater. Efforts to implement stringent environmental regulations, adopt cleaner production technologies, and enhance wastewater treatment capabilities are essential to mitigate the environmental and health impacts associated with leather production.

Table 1 summarizes the waste characterization data for conventional pollutants associated with the hair pulp/chrome tan/retan-wet finish subcategory. The table provides concentration ranges in milligrams per liter (mg/l) across various parameters critical for assessing environmental impact: The Biochemical Oxygen Demand (BOD) ranges from 210 mg/l to 4300 mg/l, indicating the amount of oxygen required by microorganisms to decompose organic matter in water. The Chemical Oxygen Demand (COD) ranges from 180 mg/l to 27000 mg/l, reflecting the amount of oxygen needed for chemical oxidation of pollutants in water. Total Suspended Solids (TSS) vary between 925 mg/l and 36000 mg/l, representing the amount of solid particles suspended in water that can be captured by a filter. Total Kjeldahl Nitrogen (TKN) ranges from 90 mg/l to 630 mg/l, encompassing both organic and ammonia nitrogen forms in water. Total Phenol levels range from 0.14 mg/l to 100 mg/l, indicating the presence of phenolic compounds which can have significant environmental implications even at low concentrations. Sulphides range from 0.8 mg/l to 100 mg/l, representing the concentration of hydrogen sulfide and other sulfide compounds in water. Oil and Grease concentrations range widely from 15 mg/l to 10000 mg/l, reflecting the presence of hydrocarbons and other organic compounds from industrial processes. Total Chromium ranges from 3 mg/l to 350 mg/l, indicating the presence of chromium compounds which can be toxic and persistent in the environment. Ammonia concentrations vary between 17 mg/l and 380 mg/l, reflecting the presence of ammonia nitrogen, often originating from organic decomposition and industrial processes. These ranges highlight the diverse nature and potential environmental impact of pollutants discharged from the specified industrial processes, underscoring the importance of effective wastewater management and treatment strategies to minimize environmental harm.

Table 1: Waste characterization

No.	Parameters	Concentration mg/l Range of individual data points
1.	BOD	210-4300
2.	COD	180-27000
3.	TSS	925-36000
4.	TKN	90-630
5.	Total Phenol	0.14-100
6.	Sulphides	0.8-00
7.	Oil and Grease	15-10000
8.	Total Chromium	3-350
9.	Ammonia	17-380

Table 2 presents the wastewater characterization data for conventional pollutants specific to the hair shave/chrome tan/retan-wet finish subcategory. The concentrations are reported in milligrams per liter (mg/l), detailing the range of individual data points for each parameter: Biochemical Oxygen Demand (BOD) ranges from 140 mg/l to 2800 mg/l, indicating the amount of oxygen required by microorganisms to decompose organic matter in water. Chemical Oxygen Demand (COD) varies significantly from 700 mg/l to 57000 mg/l, reflecting the amount of oxygen needed for chemical oxidation of pollutants in water. Total Suspended Solids (TSS) range between 94 mg/l and 86000 mg/l, representing the concentration of solid particles suspended in water that can be captured by a filter. Total Kjeldahl Nitrogen (TKN) ranges from 63 mg/l to 3600 mg/l, encompassing both organic and ammonia nitrogen forms in water. Total Phenol levels vary between 0.44 mg/l and 6.8 mg/l, indicating the presence of phenolic compounds which can have environmental implications. Sulphides range from 0.03 mg/l to 300 mg/l, representing the concentration of hydrogen sulfide and other sulfide compounds in water. Oil and Grease concentrations range from 49 mg/l to 620 mg/l, reflecting the presence of hydrocarbons and other organic compounds typically originating from industrial processes. Total Chromium varies widely from 0.006 mg/l to 390 mg/l, indicating the presence of chromium compounds which can be toxic and persistent in the environment. Ammonia concentrations range between 0.4 mg/l and 600 mg/l, reflecting the presence of ammonia nitrogen, originating from organic decomposition and industrial processes. These data points underscore the variability and potential environmental impact of pollutants associated with the specified industrial processes, emphasizing the importance of robust wastewater management practices to mitigate environmental harm.

Table 2: Wastewater characterizations

No.	Parameters	Concentration mg/l Range of individual data points
1.	BOD	140-2800
2.	COD	700-57000
3.	TSS	94-86000
4.	TKN	63-3600
5.	Total Phenol	0.44-6.8
6.	Sulphides	0.03-300
7.	Oil and Grease	49-620
8.	Total Chromium	0.006-390
9.	Ammonia	0.4-600

Table 3 details the wastewater characterization of conventional pollutants for the hair shave/chrome tan/retan-wet finish subcategory. The concentrations of various pollutants are measured in milligrams per liter (mg/l) across a range of individual data points: The Biochemical Oxygen Demand (BOD) ranges from 1 mg/l to 7800 mg/l, reflecting the amount of oxygen required by microorganisms to break down organic material. Chemical Oxygen Demand (COD) spans from 1100 mg/l to 75000 mg/l, indicating the oxygen needed for the chemical oxidation of both organic and inorganic substances. Total Suspended Solids (TSS) are measured between 28 mg/l and 8200 mg/l, representing particles suspended in water that can be filtered out. Total Kjeldahl Nitrogen (TKN) varies from 130 mg/l to 1200 mg/l, indicating the presence of organic nitrogen and ammonia. Total Phenol concentrations range from 0.28 mg/l to 100 mg/l, reflecting the presence of phenolic compounds, which are potentially harmful to aquatic life. Sulphides range between 0.1 mg/l and 330 mg/l, indicating the concentration of sulfur compounds, which can lead to odor and corrosion issues. Oil and Grease concentrations vary from 2 mg/l to 1300 mg/l, representing the presence of organic compounds that can cause water pollution. Total Chromium levels are between 0.25 mg/l and 110 mg/l, highlighting the presence of chromium, which can be toxic and pose environmental risks. Ammonia concentrations range from 23 mg/l to 680 mg/l, reflecting the presence of nitrogen in the form of ammonia, which can contribute to nutrient pollution. These data points provide insight into the variability and potential impact of wastewater pollutants from this industrial subcategory, underscoring the need for effective treatment and management strategies to minimize environmental contamination.

Table 3: Wastewater characterization subcategory

No.	Parameters	Concentration mg/l Range of individual data points
1.	BOD	1-7800
2.	COD	1100-75000
3.	TSS	28-8200
4.	TKN	130-1200
5.	Total Phenol	0.28-100
6.	Sulphides	0.1-330
7.	Oil and Grease	2-1300
8.	Total Chromium	0.25-110
9.	Ammonia	23-680

Table 4 lists common chemicals used in leather finishing. These include a variety of solvents and compounds, each with specific roles in the finishing process. Examples include Butanol and Ethyl acetate, which are solvents often used for their quick evaporation rates. Butyl acetate and Isobutyl acetate serve similar purposes, aiding in the application of finishes and coatings. Formic acid is frequently used for pH adjustment and as a preservative. Monochlorobenzene and Cyclohexane are utilized for their solvent properties, assisting in the dissolution of other compounds. Di-isobutylketone is another solvent that provides specific evaporation characteristics. Ethylmercaptan and Ethyl glycol are included for their unique chemical properties, which can enhance various aspects of the finishing process. Methylethylketone and Methyl butyl ketone are effective solvents used for their fast-drying capabilities. Perchloroethylene and Trichloroethylene are used in degreasing and cleaning applications, although their use is increasingly regulated due to environmental concerns. Toluene and Ethyl benzene are aromatic hydrocarbons used for their solvent power and ability to dissolve a wide range of resins and waxes. Each of these chemicals plays a crucial role in achieving the desired qualities in leather products, such as durability, finish, and appearance. However, careful handling and adherence to safety guidelines are essential due to the potential health and environmental impacts associated with many of these substances.

Table 4: Common Chemicals used in leather finishing

No.	Chemicals	No.	Chemicals
1.	Butanol	9.	Ethylmercaptan
2.	Ethyl acetate	10.	Ethyl glycol
3.	Butyl acetate	11.	Methylethylketone
4.	Isobutyl acetate	12.	Methyl butyl ketone
5.	Formic acid	13.	Perchloroethylene
6.	Monochlorobenzene	14.	Toluene
7.	Cyclohexane	15.	trichloroethylene
8.	di-isobutylketone	16.	Ethyl benzene

Table 5 outlines the desired levels for various solid wastes in the leather processing industry. Trimmings are set at a standard of 120 kg. Fleshing ranges from 70 to 230 kg, reflecting the variability in processing techniques. Chrome shaving waste is aimed at 99 kg, while chrome split waste targets 115 kg. Buffing dust is kept minimal at 2 kg. Solids in treatment sludge are aimed at 120 kg, which corresponds to the handling of 250 to 1800 kg of wet sludge, considering a 75% removal efficiency in treatment processes. The total desired level for all these solid wastes falls between 680 and 848 kg, indicating an overall target for waste minimization and efficient waste management in the industry.

Table 5: Desired Level for Solid Wastes

Trimmings	120
Fleshing	70-230
Chrome shaving	99
Chrome split waste	115
Buffing dust	2
Solid in treatment sludge	120 (corresponding to 250-1800kg wet sludge resulting from 75% removal efficiency)
Total	680-848kg

Table 6 details the quantities of solid waste generated from conventional and low-waste leather production processes, measured in kilograms per ton of raw hide. In conventional production, various waste types include raw trimmings at 17 kg with 45% humidity, and fleshing and trimming after the liming process at 229 kg with 75.5% humidity. Chrome (Cr) shavings and splits and trimmings are both at 48% humidity, generating 71 kg and 200 kg respectively. Finished waste and buffing dust are minimal at 11 kg each with 15% humidity. Screening from the effluent treatment plant (ETP) accounts for 100 kg at 77% humidity, while dewatered sludge from the ETP reaches 442 kg with 80% humidity. The total waste for conventional production sums up to 1081.5 kg. For low-waste production, the list includes salt and other impurities trashed off from raw hide at 49.5 kg with 33% humidity, and green fleshing and trimmings at 92.9 kg with 87% humidity. Post-liming fleshing and trimming generate 136.6 kg with 76% humidity. Hair shaved contributes 76.5 kg at 67% humidity. The same levels of Cr shavings and splits and trimmings are maintained as in conventional methods, along with finished waste and buffing dust at 11 kg each. Screening from the ETP drops to 25 kg at 74% humidity, and dewatered sludge reduces to 212 kg at the same humidity level. The total solid waste for low-waste production is 902.5 kg.

Table 7 details the air pollutants generated during various steps of leather processing. In the unhairing and liming stage, hydrogen sulfide (H2S) is released, which is a result of chemical reactions used to remove hair from hides. This gas can be hazardous and requires proper ventilation and safety measures. During the deliming and bating stage, ammonia (NH3) is emitted; this gas results from neutralizing and softening the hides, and it can contribute to air quality issues if not controlled. In the finishing process, a variety of solvents and formaldehyde are used, leading to emissions that can pose health risks and environmental concerns. These substances are integral to achieving the desired leather qualities but necessitate careful management to minimize their impact on workers and the environment. Proper emission controls and safety protocols are essential throughout these stages to ensure compliance with environmental regulations and to protect human health.

Table 8 provides detailed information about the noise levels recorded in various tannery processes and compares them with the required standards for an 8-hour workday. Processes like grading, samming, and wet back generally remain below the 85 dB(A) threshold, ensuring compliance with occupational safety standards. However, several processes, including splitting, wet blue shaving, setting out, toggling, and ironing, exceed the recommended noise level, with some reaching as high as 96 dB(A).

Table 6: Solid waste quantities

Type of waste	Humidity	Generated kg/t of raw hide
From Conventional Production		
Raw trimmings	45	17
Fleshing and trimming after liming process	75.5	229
Cr-shavings	48	71
Cr-splits and trimmings	48	200
Finished waste	15	11
Buffing dust	15	11
Screening from ETP	77	100
Dewatered sludge from ETP	80	442
TOTAL A		1081.5
From low waste production		
Salt and other impurities trashed off from raw hide	33	49.5
Raw trimmings	45	17
Green fleshing and trimmings	87	92.9
Fleshing and trimming after liming process	76	136.6
Hair shaved	67	76.5
Cr-shavings	48	71
Cr-splits and trimmings	48	200
Finished waste	15	11
Buffing dust	15	11
Screening from ETP	74	25
Dewatered sludge from ETP	74	212
TOTAL B		902.5

Table 7: Processes and Gas Emissions

PROCESS-STEP	AIR POLLUTANT
Unhearing/liming	H2S
Declaiming/Bating	NH3
Finishing	Solvents, formaldehyde

These higher noise levels indicate potential risks for hearing damage if proper protective measures are not implemented. It is crucial for tannery operators to ensure that workers in these areas are provided with appropriate personal protective equipment, such as earplugs or earmuffs, to mitigate exposure to harmful noise levels. Additionally, noise reduction strategies, such as installing sound barriers or implementing engineering controls, can help lower the overall noise within the facility. Regular monitoring and assessment of noise levels are essential to maintain compliance with safety regulations and to protect workers' hearing health. By prioritizing noise control and implementing effective safety measures, tanneries can create a safer and more comfortable working environment for their employees, ultimately contributing to improved occupational health outcomes.

Table 9 provides an overview of noise levels in various units at Awan Sports, emphasizing the importance of maintaining safe auditory conditions in the workplace. The molding sections, at 92 dB(A), exceed the recommended limit of 85 dB(A) for an 8-hour workday, highlighting the need for immediate intervention to reduce noise exposure. This can be achieved through engineering controls, such as installing sound barriers or using quieter machinery, and administrative controls, including scheduling shifts to minimize prolonged exposure. The paint shop, with noise levels at 86 dB(A), also slightly exceeds the standard, suggesting that hearing protection should be mandated for workers in this area. Other sections, like the drying ovens and transverse sections, fall within acceptable limits but should still be monitored regularly to ensure compliance. In areas like the printing and packing sections, where noise levels are lower, continued vigilance is necessary to maintain these conditions. Providing regular training on the importance of hearing conservation and the use of personal protective equipment can further safeguard workers’ health. Overall, maintaining a comprehensive noise management program is essential for protecting employees and fostering a safer working environment.

Table 8: Noise levels recorded of various units in tannery

No.	Processes	Noise levels	Required standards for 8 hrs.
01.	Grading	82 dB(A)	85 dB(A)
02.	Samming	83 dB(A)	85dB(A)
03.	Splitting	93 dB(A)	85dB(A)
04.	Wetblue Shaving	93 dB(A)	85dB(A)
05.	Wet Back	77 dB(A)	85dB(A)
06.	Rechroming	78 dB(A)	85dB(A)
07.	Neutralizing	75 dB(A)	85dB(A)
08.	Fat Liquoring	78 dB(A)	85dB(A)
09.	Retanning	79 dB(A)	85dB(A)
10.	Dying	80 dB(A)	85dB(A)
11.	Fixation	77 dB(A)	85dB(A)
12.	Setting Out	96 dB(A)	85dB(A)
13.	Vacuum	83 dB(A)	85dB(A)
14.	Sun Drying / Shed	75 dB(A)	85dB(A)
15.	Vibrating Staking	87 dB(A)	85dB(A)
16.	Toggle	94 dB(A)	85dB(A)
17.	Buffing	81 dB(A)	85dB(A)
18.	De-Dusting	87 dB(A)	85dB(A)
19.	Finishing	86 dB(A)	85dB(A)
20.	Ironing	94 dB(A)	85dB(A)
21.	Pigmentation	84 dB(A)	85dB(A)
22.	Final Inspection And Packing	80 dB(A)	85dB(A)

Table 9: Noise levels recorded of various units in Awan Sports

No.	Processes	Noise levels dB(A)	Required standards for 8 hrs. dB(A)
01.	Molding Sections	92	85
02.	Paint Shop	86	85
03.	Drying Ovens	82	85
04.	Transverse Sections	81	85
05.	Pre Preg Hall	82	85
06.	Laying Hall	80	85
07.	Printing Hall	78	85
08.	Packing Section	79	85
09.	Main Store	78	85

CONCLUSIONS

Economic growth in Pakistan has come at a cost, particularly evident in industries like leather tanning and sports manufacturing, which face increasing scrutiny and pressure from local communities and environmental advocates. The leather tanning industry, in particular, stands out as one of the most polluting sectors, causing significant environmental degradation across various fronts. This includes contamination of soil, groundwater, and the general atmosphere, posing threats to local flora, fauna, and human health due to the salinity and hazardous nature of its wastes. The environmental impacts of leather tanning extend beyond basic pollution concerns. Issues such as oxygen depletion in water bodies, eutrophication (excessive nutrient enrichment leading to algal blooms and subsequent oxygen depletion), and toxicity from chemicals used in the tanning process are also significant. These pollutants can affect aquatic life, disrupt ecosystems, and contribute to corrosion and other environmental hazards in surrounding areas. Communities living near tanneries often bear the brunt of these environmental burdens, experiencing health risks and reduced quality of life due to air and water pollution. The cumulative effect of these challenges underscores the urgent need for sustainable practices, stringent regulations, and effective waste management strategies within the leather tanning industry and similar industrial sectors in Pakistan. Balancing economic growth with environmental stewardship is crucial for fostering long-term prosperity and protecting public health and natural resources.

The operations of leather tanneries pose a multitude of hazardous consequences due to the discharge of various pollutants into the environment. These include chemical leather dust, odors, and significant water pollution. Groundwater contamination and soil pollution are also prevalent, often stemming from the disposal of sludge generated during the tanning process. These pollutants contribute to a range of environmental issues, including the depletion of oxygen in water bodies and eutrophication—a process where excess nutrients lead to harmful algal blooms and subsequent ecosystem degradation. The presence of toxic substances such as hydrogen sulfide (H2S) gas, sulphides, heavy metals, acids, phenols, and other harmful chemicals further exacerbates the environmental and health risks associated with tanning wastes. These substances not only endanger the lives of microorganisms crucial for ecological balance but also pose threats to plants, animals, and human populations residing near tannery operations. The release of these toxic pollutants into the environment can lead to severe health impacts, including respiratory problems, dermatological issues, and long-term illnesses linked to exposure to heavy metals and other hazardous compounds. Efforts to mitigate these risks require robust regulatory frameworks, effective monitoring systems, and technological advancements in waste treatment and management within the leather tanning industry. Addressing these challenges is essential for safeguarding both environmental quality and public health, ensuring sustainable industrial practices that minimize the adverse impacts of tannery operations on ecosystems and communities.

The adoption of cleaner technologies in the leather tanning industry aims not only to reduce pollution but also to enhance the working environment for employees, making it safer and more comfortable. Solid waste is a significant byproduct generated during various operations within tanneries, typically consisting of raw hides, lime waste, chrome waste, and sludge from effluent treatment processes. These waste materials pose challenges for disposal and management due to their chemical composition and environmental impact. Gaseous emissions from tanneries include odors and solvent vapors released during finishing processes. Some of these gases are highly corrosive to tannery equipment and other waste management infrastructure. They also pose health risks to workers, affecting both human and animal organs due to their toxic nature and potential for long-term health implications. Efforts to mitigate these issues involve implementing advanced waste treatment technologies, such as efficient effluent treatment systems and solid waste management practices. Cleaner technologies aim to minimize emissions of hazardous gases and pollutants, thereby reducing environmental contamination and improving occupational health and safety standards within tannery facilities. By focusing on cleaner technologies, tanneries can not only meet regulatory requirements but also enhance their operational efficiency and sustainability. This approach supports a healthier workplace environment and contributes to overall environmental stewardship by reducing the industry's ecological footprint and mitigating risks associated with hazardous waste and emissions. Workers in the tanning industry face a wide array of health risks and safety hazards, ranging from acute conditions like anthrax and respiratory irritations to chronic illnesses such as bronchitis, dermatitis, and various forms of cancer. Exposure to hazardous substances like chromium compounds, volatile organic compounds (VOCs), and other chemicals can lead to serious health consequences such as lung cancer, skin disorders, and even fatalities. Additionally, workplace injuries are prevalent due to slippery floors, machinery hazards like revolving drums and rollers, and cuts from sharp blades. Despite these risks, many workers in the leather industry in Pakistan are not fully aware of the environmental challenges that threaten the industry's sustainability. The introduction of ISO 14001 standards in some leather manufacturing facilities has helped in maintaining a better environmental balance. These standards focus on implementing effective environmental management systems, which include reducing waste generation and improving health and safety measures for workers. To further improve conditions, there is a critical need for comprehensive training programs aimed at educating workers about the specific hazards associated with tanning processes. This training should cover proper handling of chemicals, use of personal protective equipment (PPE), and awareness of environmental impacts. By enhancing workers' knowledge and awareness, the industry can better protect its workforce and mitigate environmental risks, thereby ensuring long-term sustainability and compliance with health and safety regulations.

REFERENCES

Abbas, Z. Qasim, M. Bashir, A. (2014). Occupational Health, Safety And Environmental Conditions At Faruki Pulp Mills Pvt Ltd. *International Journal Of Science, EnvironmentAnd Technology*, 3(2), 561-570.

JRC, D. G. (2001). Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for the Tanning of Hides and Skins May 2001.

Menckel, E. and Westerholm, P. (1999). Evaluation in occupational health practice. Oxford Press.

Syed, M. Saleem, T. Shuja-ur-Rehman, Iqbal, M. A. Javed, F. Khan, M. B. S. and Sadiq, K. (2010). Effects of Leather Industry on Health and Recommendations for Improving the Situation in Pakistan. *Archives of environmental and occupational health*, *65*(3), 163-172.