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Fatima Khudhur Mohammed

Taghreed Khudhur Mohammed

Salwa Hameed Naser Al-Rubae'i

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Evaluating Chemical Security and Safety Levels in Tanning Factories at the General Company for Textile and Leather Industries/Leather Factory in Iraq

Fatima Khudhur Mohammed [a], Taghreed Khudhur Mohammed [b,*], Salwa Hameed Naser Al-Rubae'i [c]

[a] General Company for Textile and Leather Industries, Baghdad, Iraq
[b] Institute of Medical Technology- Al-Mansour, Middle Technical University, Baghdad, Iraq
[c] Department of Chemistry, College of Science, Mustansiriyah University, Baghdad, Iraq

Abstract

Most of the chemicals produced and used today are beneficial, but some also have the potential to damage human health and the environment. To achieve the goal of allowing the use of chemicals for companies and factories, safety and security tools were used in the laboratories, and workers were trained on the dangers of chemicals. We studied worker exposure to hazardous chemicals and determined the prevalence of occupational skin diseases. As well as examining the availability of personal protective equipment. A questionnaire was used to determine the chemicals used, the ages of the employees, their educational level, and the extent of their infection with acute and chronic diseases that may be the result of their exposure to some, and interviews were conducted with the workers. The number of workers in the tanning factory is 122 and their ages range from 21 to 60 years. The number of males was 101, while females were 21 among the total number of 122 workers. It is noted that the percentage of males is higher than females. It was found that workers who adhered to wearing gloves, cotton masks, aprons, and safety shoes were less likely to suffer from skin and chest allergic diseases compared to those who were less committed. Frequent prolonged exposure to many skin-hazardous agents was observed in tanning businesses even though personal protective equipment was relatively available. The prevalence of skin diseases, chest allergies, and bronchitis were among the most common diseases among workers.

Keywords: Occupational skin diseases, Tannery workers, Skin exposure, Hazardous chemicals, Iraq

1. Introduction

The General Company for Leather Industries is an economic production unit that supports the country's economy by manufacturing natural leather and using it to produce clothing, shoes, and bags. It does this by investing public funds efficiently and effectively to achieve the state's objectives and to improve the performance levels of the country's economy to meet development plan objectives. Leather tanning is considered one of the ancient traditional industries, and despite the development it has witnessed, many countries still use ancient primitive tanning methods due to their quality. The Babylonians, Sumerians, Assyrians, and Egyptians used alum (Aluminum salts), which helped preserve the skin after the death of the animal, and thus it was also used in the field of mummification. Then use table salt and magnesium salts to get rid of water in the skin (Tolga & Gülbaş, 2019). Raw animal skins may be infected with many insects, such as the cypress fly and the beetle, as well as some types of bacteria and fungi, which

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* Corresponding author.
E-mail addresses: fatimakudhur@gmail.com (F. K. Mohammed), taghreidkheder@gmail.com (T. K. Mohammed), drsalwahnaser@uomustansiriyah.edu.iq (S. H. Naser Al-Rubae'i).

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cause damage, especially during storage. To reduce cases of damage, many chemical materials are used like Bromomethane (CH_3Br), which later requires disposal before tanning, which exposes workers to the danger of these materials if proper personal protective measures are not taken (Technical *et al.*, 2009). As for piles of waste and leftover leather, they must be removed from the ground so as not to attract insects and damage the leather. This also requires the use of other chemicals that may expose workers' lives to the risk of asthma, bronchial allergies, skin allergies, and suffocation (Black *et al.*, 2013). It is also treated with acetic acid (CH_3COOH) to remove the basicity of the water to reduce damage to the leather to be tanned (Cocheo, 1990). In the liming stage, sodium sulfide Na_2S or lime $Ca(OH)_2$ is used to remove animal hair or wool (Song *et al.*, 2021). To remove the lime deposited during the de-liming or bating stage, ammonia sulfate salt ($(NH4)_2SO_4$) is used (Wingfield, 2017). While in the grease removal stage, chromium is used as a tanning material, in addition to the use of different chemical materials during the tanning stages such as sodium carbonate, borax, calcium, and sodium formats (Annamalai *et al.*, 2022). The safety procedures within the tanning factories and their chemical laboratories are global rules and principles that must be followed by everyone who works in this field to protect themselves, those working with them, and the external environment. The chemical laboratory has become the center for obtaining knowledge and developing new materials for use in the future, as well as observing and controlling these materials, which are used in thousands of commercial processes. Many of these compounds are beneficial, but many of them may also cause harm to human health as well as the environment, hence the need for how to deal with them safely (Fernandes *et al.*, 2013). Process safety and occupational health (PSOH) are critical areas in process industries that require attention while manufacturing and processing development take precedence. The leather industry uses a variety of chemicals, some of which are dangerous. When such chemicals-both liquid and solid—come into contact with skin or are inhaled as gases, health risks arise. As this paper explains, certain unit operations also result in the in-situ release of harmful gases. In PSOH, improved protocols and safety measures are required for the benefit of industry workers as well as the environment in general as a whole. The situation is important anywhere there are risks or toxic chemicals connected to the industry. One of the main concerns is the level of toxicity or hazard and the exposure limit connected to these chemicals in industrial settings. Aside from the chemicals, other factors to think about include dust, noise levels, lighting, ventilation, ergonomics, personal safety, and hygiene. The leather industry as a whole need to increase its capacity in this area even though other industrial sectors have more developed safety and occupational health concern systems. While there are some previous reports available regarding tanneries in this area, they have not addressed every facet of PSOH in the leather industry (Djatioetomo & Marhana, 2022). De-liming is a unit operation in the leather processing industry that is used to extract the bound lime from the limed fur. Traditionally, toxic ammonia gas is released during de-liming, a process that neutralizes lime with ammonium salts (Venkatasubramanian, 2021). In the leather processing industry, PSOH is crucial for both environmental protection and worker health issues. It is important to take a comprehensive approach to these issues. In developing nations, where process industries are dispersed across multiple locations in sizable clusters, these factors demand even more urgent attention. This study examines and evaluates the number of tannery-related risks, including mechanical hazards, particulate matter, noise levels, toxic gases, and others. Potential remedies or corrective actions are also suggested. The current analysis would offer a clean, hygienic, and safe environment for process safety in and around the leather industry, including tanneries, effluent treatment plants, and storage facilities (Shan *et al.*, 2021; Athavale *et al.*, 2007). Compared to developed countries, developing countries typically have fewer occupational health programs that are sufficiently effective and fewer laws and regulations that are appropriately developed and enforced. This could be the cause of the tannery industry's exclusion from occupational dermatoses data for high-risk jobs. The high level of automation used in this sector for the duration that it existed in developed nations could also be a factor in the lack of data on occupational skin diseases in tanneries (Febriana *et al.*, 2012; Taghreed Khudhur *et al.*, 2019). Workers in tanning factories may become infected as a result of skin necrosis with dangerous pathogenic microorganisms such as Candida albicans fungi and some bacterial species such as Staphylococcus aureus and Pseudomonas aeruginosa (Mustafa Riyadh Salman *et al.*, 2020; Mahdi, 2023). Tannery's work is offshored to newly industrialized nations (NICs), where there is little focus on the risks to occupational health. The purpose of this study was to ascertain the prevalence of diseases and occupational skin diseases (OSDs) at tanneries in an NIC by investigating skin exposure to hazardous chemicals in tannery workers and examining the safety equipment found in tanning factories as well.

2. Materials and methods

A cross-sectional study including an inventory and risk assessment of the chemicals used, as well as process observation. Chemicals are categorized as possible sensitizers or irritants, and their exposure to these chemicals is qualitatively evaluated. With the use of the Occupational Skin Questionnaire-2024/Baghdad, workers were assessed and interviewed. The number of workers in the tanning factory is 122, 101 males and 21 females, with ages ranging from 21 to 60 years. Years of service from 21 to 38 years. Most of the workers were from the Al-Rusafa area in Baghdad- Iraq, with several 112 workers, and 10 workers from the Karkh side in Baghdad at different educational levels.

The type of work practiced by the workers is distributed as follows: tanner, dye preparer, operator and transporter of barrels of chemicals and dyes, leather insulation, leather ironing machine operator, measuring machine operator, and leather tester. The diseases they suffer from are blood pressure and diabetes, asthma, and tuberculosis, severe spondylolisthesis, heart catheterization, bronchial sensitivity, skin diseases such as vitiligo, eczema and allergies, osteoporosis and necrosis of the bones, and kidney surgery. The workers were at different educational levels.

Workers are exposed to many chemicals and dyes in tanning factories, the most important of which is ammonium sulfate, formic acid, sulfuric acid, sodium bicarbonate, Butane oil, Vesoil C, Rockacryl AE- 105 (ON), Icacril 597 (OHN), Micro-binder (AN), Arsenic, Lime mortar (Calcium hydroxide), Carbon dioxide and Hydrogen peroxide (De-liming), Parmetol A26 (Preservative), Soda Sanayii A.S., Synthol DA 112 (leather fat remover), Syntan RS-3, Butane color 21005 (black JC), Butane color 21100 (brown DA), Chromium(III) sulfate [$Cr_2(SO_4)_3$], and Mettam sodium. The soaking and softening stage takes place in special tanks with an area of 5–8.5 square feet, and the weight of the sheep's leather is between 3–3.5 kg.

There are different stages of leather tanning processes beginning with the purchase of raw leather from leather processing shops and ending with dyeing using several chemical materials, then delivered to special warehouses as seen in Scheme 1 and Fig. 1. On the other hand, Scheme 2 represents the chemical materials and their quantities used in each stage of the leather tanning process.

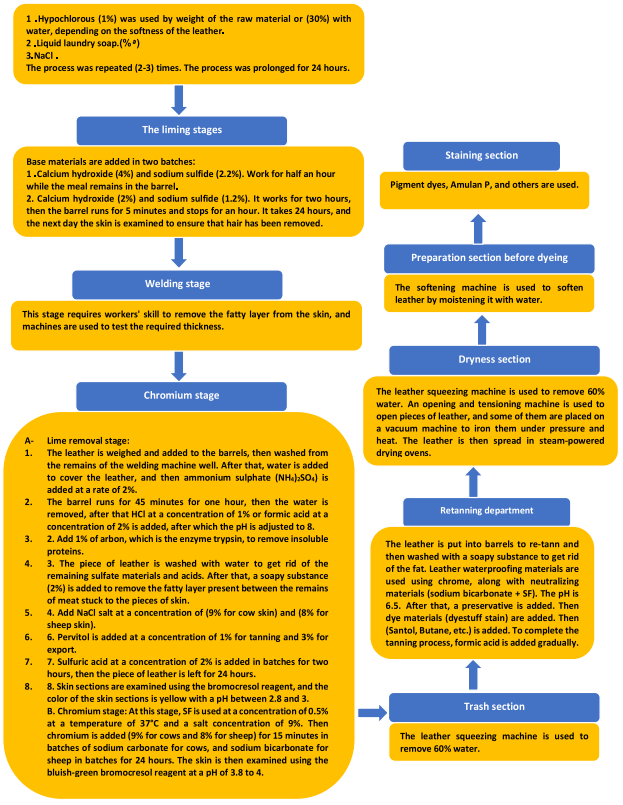
3. Results

The current study shows that the number of males was 101 (82.78%), while females were 21 (17.21%) among the total number of workers, which numbered

Scheme 1. Stages of leather tanning processes.

Fig. 1. A look at the stages (A- I) of leather tanning and the chemicals used in tanning factories.

122 workers. The highest age group for male workers was in the 41–50 years group, with a percentage of 81 (80.19%), while females were in the 51–60 years age group, with a percentage of 9 (42.85%) (Table 1). It is noted that the percentage of males is higher than females because working in tanning factories requires great effort, in addition to the work risks to which they are exposed, which leads to giving birth to deformed children with a high incidence of various cancers in males. The educational level is distributed among both genders as follows: 44 (36.06%) primary school graduates, 25 (20.49%) middle school



Scheme 2. Chemical materials used in each stage of leather tanning processes.

Table 1. Percentage of males and females of different ages who work in tanning factories and their affiliated factories.

Age range (year)	Female (%)	Male (%)	Total (%)
0–10	0 (0)	0 (0)	0 (0)
11–20	0 (0)	0 (0)	0 (0)
21–30	5(23.80)	6(5.94)	11(9.01)
31–40	3(14.28)	7(6.93)	10 (8.19)
41–50	4(19.04)	81(80.19)	85 (69.67)
51–60	9(42.85)	7(6.93)	16 (13.11)
Total (%)	21(100)	101(100)	122 (100)

graduates, 23 (18.85%) high school graduates, 15 (12.29%) from different institutes (technical diploma), and 15(12.29%) from different colleges, most of them from chemical engineering.

The extent of workers' commitment to wearing personal protective equipment in tanning factories and other leather manufacturing factories has been studied. It was found that workers who adhered to wearing gloves, cotton masks, Apron, and safety boots were less susceptible to skin and chest allergic diseases compared to those who were less committed, even though they were monitored, in addition to the fact that there may be a shortage in providing them with masks. It was also noted that there was a sufficient number of extinguishers and a fire early

Table 2. Diseases suffered by workers in tanning factories in Baghdad.

Name of the disease	Number
severe spondylolisthesis	23
eczema and skin allergies	22
diabetic mellitus	20
osteoporosis and necrosis of the bones	18
blood pressure	10
Asthma	10
bronchial sensitivity	10
heart catheterization	3
Vitiligo	3
Tuberculosis	2
kidney surgery	1

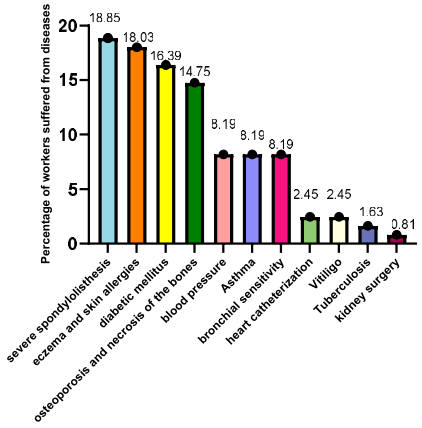


Fig. 2. Percentage of workers who suffered from several diseases in tanning Factories in Baghdad.

warning system in the main laboratories. In addition, there are fire engines inside the tanning factories, fully prepared in the event of an emergency or fire.

The diseases they suffer from are 23 (18.85 %) severe spondylolisthesis, 23 (18.85%) eczema and skin allergies, 20 (16.39%) diabetic mellitus, 18 (14.75%) osteoporosis and necrosis of the bones, 10 (8.19 %) blood pressure, 10 (8.19%) asthma, 10 (8.19%) bronchial sensitivity, 3 (2.45%) heart catheterization, 3 (2.45%) vitiligo, 2 (1.63%) tuberculosis, and 1 (0.81%) kidney surgery. It was also noted that all workers 122 (100%) suffer from recurring headaches that range from mild to severe and chronic, as seen in Table 2 and Fig. 2.

It has been observed that when following up on a number of those referred for retirement, they were suffering from an increase in the severity of the diseases mentioned above. It was also noted that they were suffering from types of cancer, such as intestinal and breast cancer, as well as a deficiency in immunity and loss of appetite. Also, it observed a health center available in the General Company for Leather Industries to treat some cases that could be treated. On the other hand, critical cases require review by specialized doctors. The salaries that workers receive

are low compared to the effort and time they expend, therefore, most workers are late in diagnosing their diseases, such as cancers, allergies, and bone diseases, due to the high cost of treatment, which may require them to travel outside Iraq.

4. Discussion

In addition to solvents (dichloromethane, benzene, ethanol, tetrachloroethane, trichloroethylene), tanning chemicals include calcium hydroxide, sodium sulfide, sulfuric acid, formic acid, hydrogen sulfide, and aniline-based dyes. Nitrile, formaldehyde, nitrocellulose, and resins are examples of finishing chemicals. Mineral salts like chromium sulfate, vegetable tannin, and fish or animal oil are the three most commonly used tanning agents. Dihydroxyacetone is the only chemical that is permitted (DHA). The DHA reacts with the amino acids in your skin to produce a browning effect, much like when you toast bread or grill meat. The theory that breathing in spray-on tanning chemicals could increase your risk of developing cancer, asthma, or chronic obstructive pulmonary disease (COPD) was validated by further studies. Chromium salts, especially chromium alum and chromium (III) sulfate, are used in chromium tanning of leather. Chromium stabilizes the skin by binding collagen fibers (Athavale *et al*., 2007; Febriana *et al*., 2012).

In Indonesia, in the tanneries under investigation, the primary cause of occupational skin diseases (OSDs) was chemical exposure to workers' skin in hot, muggy conditions. 9% of the 472 workers reported having had OSD in the past, and 12% reported having it now. Dermatologists confirmed occupational contact dermatitis (OCD) in 7.4% of cases, and OSD in 10% of cases. They found that personal protective equipment (PPE) was primarily worn as a result of previous skin issues rather than as the main line of defense against open-source disease (OSD) (Taghreed Khudhur *et al*., 2019).

Within the vicinity of the tanning factories in Baghdad, Iraq, the researchers examined the degree of pollution and the potential health risks associated with heavy metal (Cr) exposure. Calculations were made to determine the concentration, mean, and median of chromium. It is thought that there is a high level of contamination in the soil to the north of the factory down to a depth of 50 cm (Foroutan *et al*., 2020). Hides are de-limed, batted, and pickled in the pre-tanning phase. Using carbon dioxide and hydrogen peroxide, de-liming is the process of removing too much lime. The next step involves baking to eliminate extra hair with a protease enzyme and natural fat with a lipase enzyme. Using formic acid, H_2SO_4, sodium formate, NaCl, and sodium metabisulphite, the hide is put into an acidic condition (pickling). In this step, sodium formate, sodium chloride, and sodium metabisulphite are exposed to the worker's skin. The employee's skin could become dehydrated from NaCl. Skin sensitizers include sodium metabisulphite. The skin can become irritated by substances such as sulfuric acid, caustic soda, sodium sulfide, soda ash, acetic acid, and formic acid. Metam sodium irritates the skin and causes contact sensitization (Kaaman *et al*., 2010, Sasseville & El-Helou, 2009, Dickel *et al*., 2002). Workers in tanneries are often reported to have chromate allergy. There have also been reports of contact allergies to urea formaldehyde resin and mimosa tree flower and leaf extract (Athavale *et al*., 2007, Hu *et al*., 2020).

Workers were exposed to paint spray, organic vapours, leather dust, dust, and mist during the finishing process. Cotton and leather gloves were worn by some employees in the shaving and buffing department. In the spraying and dyeing area, workers wore synthetic rubber gloves with cotton gloves inside. Dust masks were worn by employees who handled vacuum dryers as well as staking, spraying, sorting, and measuring. Synthetic leather is commonly produced using dimethylformamide (DMF) as a solvent. Prior research has concentrated on workers in leather factories who were exposed to DMF. The exposure group consisted of 962 subjects over 60 who lived close to the factories, while the control group consisted of 1924 long-term residents who lived further away from the factories. Exposure to DMF has been associated with a higher risk of cardiac injury as well as liver and kidney dysfunction (Palomba *et al*., 2008).

The most frequent histopathological finding about the surface epithelium was squamous metaplasia (64.7%), which was linked to mild to moderate dysplasia in 37 cases (41.1%). Extended occupational exposure to tanning leather was substantially linked to the presence of goblet cell hyperplasia. The type and duration of occupational exposure did not appear to be correlated with either dysplasia or squamous metaplasia (Maniscalco *et al*., 2004). Nitric oxide (NO) in exhaled air can be measured non-invasively to measure airway or pulmonary inflammation and to measure the environmental irritant effects of air pollution. This study set out to assess the levels of NO exhaled by workers who produced synthetic leather after being exposed to organic xylene solvents, toluene, and methyl ethyl ketone. The concentrations of environmental solvents were high but still within acceptable exposure limits. When compared to the controls, the leather workers exhaled NO concentrations rose by 40% at the end of the workday (Jiménez-Garza *et al*., 2017).

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Although it is not a significant issue in the manufacture of leather, poor hygiene habits (such as not washing your hands) may allow the *Streptococcus mutans* bacteria to spread among employees, particularly in settings where oral hygiene is disregarded (Hassan *et al*., 2023). Leather factories often involve handling raw animal hides, which can be contaminated with *Staphylococcus aureus*. Skin infections can occur in workers who have cuts, abrasions, or inadequate skin protection (Jawad & Taghreed Khudhur, 2020). Contaminated water used in the tanning process could also be a source of *Escherichia coli*. The bacteria and fungi can also thrive in warm, moist environments, such as improperly cleaned machinery or work surfaces, leading to cross-contamination (Hussein *et al*., 2024).

5. Conclusion

National laws or regulations or the competent authority should specify the measures to be taken to ensure orderly cooperation between employers and workers to promote safety and health in textile, clothing, leather, and footwear manufacturing establishments. These measures should include the formation of safety and health committees

representing employers and workers with the stipulated powers and duties; Elect or appointing empowered worker safety and health representatives and supporting them with appropriate training and definition of their duties; The employer appoints suitably qualified and experienced persons and provides appropriate training to promote safety and health; Training of safety and health representatives and members of the safety and health committee. Dealing with accidents, illnesses, and hazardous events that may involve risks or risks to safety and health in the textile, clothing, leather, and footwear industries; Use of self-contained respirators and other personal protective equipment; In addition to providing fire extinguishers and a fire alarm system.

Conflict of interest

The authors declare that they have no conflict of interest.

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References

Tolga KarakuzuHulya Elmali, & GülbaşHulya Elmali Gülbaş. (2019) Determination of chemical and physical risk factors in leather industry in terms of occupational health and safety. *e-Journal of New World Sciences Academy*, 14(3):154–168. DOI: 10.12739/NWSA.2019.14.3.1A0438

Technical Eia Guidance Manual for Leather/Skin/Hide Processing Industry–Ministry of Environment and Forests Government of India, by IL&FS Ecosmart Limited Hyderabad September (2009) https://dste.py.gov.in/SEIAA/pdf/Sector/Leather_Industry.pdf

Black Michael, Michele Canova, Stefan Rydin, Bianca Maria Scalet, Serge Roudier, & Luis Delgado Sancho. (2013) Best Available Techniques (BAT) Reference Document for the Tanning of Hides and Skins Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and control, European Union; https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/TAN_Published_def.pdf

Cocheo V. (1990) Impatto ambientale delle lavorazioni conciarie [Environmental impact of tanning industry]. *Med Lav*, 81(3):230–41. Italian. PMID: 2277598.

Song L.J., Xu Y.H., & Yang J.Y. (2023) Assessing the impact of lime on chromium migration in soil caused by basic chromium sulfate in tannery. *Environ Technol*, 44(10), 1367–1378. doi: 10.1080/09593330.2021.2003436. Epub 2021 Dec 2. PMID: 34739353.–

Wingfield Paul T. (2017) Protein Precipitation Using Ammonium Sulfate. *Current Protocols in Protein Science*, 13(1), A.3F.1–8. DOI: 10.1002/0471140864.psa03fs13. ISBN 978-0471140863. ISSN 1934-3655. PMC 4817497. PMID 18429073.

Annamalai S., Chandrasekaran K., Shin W.S., Sundaram M., & Khaleel T.M. (2022) Beyond dumping: New strategies in the separation of preservative salt from tannery waste mixed salt and its reuse for tannery industrial application. *Environ Res*, 214(Pt 2), 113885. doi: 10.1016/j.envres.2022.113885. Epub 2022 Jul 14. PMID: 35843275.

Fernandes I.P., Amaral J.S., Pinto V., Ferreira M.J., & Barreiro M.F. (2013) Development of chitosan-based antimicrobial leather coatings. *Carbohydr Polym*, 15 98(1), 1229–35. doi: 10.1016/j.carbpol.2013.07.030. Epub 2013 Jul 21. PMID: 23987468.

Djatioetomo Y.C.E.D., & Marhana I.A. (2022) Deadly dust: Silico tuberculosis as a downplayed and overlooked fatal disease in Indonesia. *Ann Med Surg (Lond)*, 17(78), 103794. doi: 10.1016/j.amsu.2022.103794. PMID: 35734735; PMCID: PMC9207042.

Sivakumar Venkatasubramanian. (2021) Analysis of Process Safety and Occupational Health in Leather Process Industry: A Holistic Approach. *JALCA*, 116, 428.

Shan B., Hao R., Xu H., Li J., Li Y., Xu X., & Zhang J. (2021) A review on mechanism of biomineralization using microbial-induced precipitation for immobilizing lead ions. *Environ Sci Pollut Res Int*, 28(24), 30486–30498. doi: 10.1007/s11356-021-14045-8. Epub 2021 Apr 26. PMID: 33900555.

Athavale P., Shum K.W., Chen Y., Agius R., Cherry N., & Gawkrodger D.J. (2007) EPIDERM Occupational dermatitis related to chromium and cobalt: experience of dermatologists (EPIDERM) and occupational physicians (OPRA) in the UK over an 11-year period (1993–2004), Br J *Dermatol*., 157(3), 518–522. doi: 10.1111/j.1365-2133.2007.08030.x.

Febriana S.A., Jungbauer F., Soebono H., & Coenraads P.J. (2012) Inventory of the chemicals and the exposure of the workers' skin to these at two leather factories in Indonesia. *Int Arch Occup Environ Health*, 85(5), 517–26. doi: 10.1007/s00420-011-0700-1. Epub Sep 22. PMID: 21938525; PMCID: PMC3371324.

Mohammed Taghreed Khudhur, Khalil Molod Wahab, Mohammed Abed Jawad. (2019) Isolation and Identification of *Candida albicans* in different clinical samples. *Al-Nisour Journal for Medical Sciences*, 1(1), 85–97.

AL-Rubaye Mustafa Riyadh Salman, Taghreed Khudhur Mohammed, & Hanaa N. Abdullah. (2020) Isolation and diagnosis of multi-drug resistance pseudomonas aeruginosa from wound and burn patients in baghdad city. *Indian Journal of Forensic Medicine & Toxicology*, 14(3), 2431–2437.

Rawnaq S. Mahdi. (2023) Assessment of the environmental and health risks of chromium in the soil of tanning factories (Baghdad City - Iraq). *Engineering and Technology Journal*. 41(5), [Civil Engineering]: 673–686.

Foroutan R., Peighambardoust S.J., Mohammadi R., Omidvar M., Sorial G.A., & Ramavandi B. (2020) Influence of chitosan and magnetic iron nanoparticles on chromium adsorption behavior of natural clay: Adaptive neuro-fuzzy inference modeling. *Int J Biol Macromol*, May 15, 151, 355–365. doi: 10.1016/j.ijbiomac.2020.02.202. Epub 2020 Feb 19. PMID: 32087228.

Kaaman A.C., Boman A., Wrangsjo K., & Matura M. (2010) Contact allergy to sodium metabisulfite: an occupational problem. *Contact Dermatitis*, 63(2), 110–112. doi: 10.1111/j.1600-0536.2010.01756.x.

Sasseville D., & El-Helou T. (2009) Occupational allergic contact dermatitis from sodium metabisulfite. *Contact Dermatitis*, 61(4), 244–245. doi: 10.1111/j.1600-0536.2009.01618.x.

Dickel H., Kuss O., Schmidt A., & Diepgen T.L. (2002) Occupational relevance of positive standard patch-test results in employed persons with an initial report of an occupational skin disease. *Int Arch Occup Environ Health*, 75(6), 423–434. doi: 10.1007/s00420-002-0328-2.

Athavale P., Shum KW, Chen Y., Agius R., Cherry N., Gawkrodger DJ. (2007) EPIDERM Occupational dermatitis related to chromium and cobalt: experience of dermatologists (EPIDERM) and occupational physicians (OPRA) in the UK over an 11-year period (1993–2004). *Br J Dermatol*, 157(3), 518–522. doi: 10.1111/j.1365-2133.2007.08030.x.

Hu Z.Y., Chang J., Guo F.F., Deng H.Y., Pan G.T., Li B.Y., Zhang Z.L. (2020) The effects of dimethylformamide exposure on liver and kidney function in the elderly population: A cross-sectional

study. *Medicine* (Baltimore), 2; 99(27), e20749. doi: 10.1097/MD.0000000000020749. PMID: 32629651; PMCID: PMC7337450.

Palomba A., Iaia TE, Biancalani M., Conti S., Battista G., Papaleo B., & Franchi A. (2008) A morphologic and immunohistochemical study of nasal mucosa in leatherworkers. *Am J Rhinol*, 22(4), 356–60. doi: 10.2500/ajr.2008.22.3201. PMID: 18702897.

Maniscalco M., Grieco L., Galdi A., Lundberg J.O., & Sofia M. (2004) Increase in exhaled nitric oxide in shoe and leather workers at the end of the work-shift. *Occup Med (Lond)*, Sep;54(6), 404–7. doi: 10.1093/occmed/kqh082. Epub 2004 Sep 3. PMID: 15347779.

Jiménez-Garza O., Guo L., Byun H.M., Carrieri M., Bartolucci G.B., Barrón-Vivanco B.S., & Baccarelli A.A. (2018) Aberrant promoter methylation in genes related to hematopoietic malignancy in workers exposed to a VOC mixture. *Toxicol Appl Pharmacol*, 15, 339:65–72. doi: 10.1016/j.taap.2017.12.002. Epub 2017 Dec 5. PMID: 29217486.

Binazzi A., Mensi C., Miligi L., Di Marzio D., Zajacova J., Galli P., Camagni A., Calisti R., Balestri A., Murano S., Piro S., d'Errico A., Bonzini M., Massacesi S., Sorasio D., & Marinaccio A. (2021) On Behalf of ReNaTuNS Working Group. Exposures to IARC carcinogenic agents in work settings not traditionally associated with sinonasal cancer risk: the experience of the italian national sinonasal cancer registry. *Int J Environ Res Public Health*, 29;18(23), 12593. doi: 10.3390/ijerph182312593. PMID: 34886319; PMCID: PMC8656996.

Jawad Mohammed Abed, & Mohammed Taghreed Khudhur. (2020) Stye, Bacterial Eye infection among the students of the technical medical institute, AL-mansour. *Medico Legal Update*, 20(4), 739–743. https://doi.org/10.37506/mlu.v20i4.1908

Ražić S.E., Kopjar N., Kašuba V., Skenderi Z., Akalović J., & Hrenović J. (2022) Evaluation of DNA-Damaging effects induced by different tanning agents used in the processing of natural leather-pilot study on HepG2 cell line. *Molecules*, 18;27(20), 7030. doi: 10.3390/molecules27207030. PMID: 36296622; PMCID: PMC9611901.

Neiva A.M., Sperança M.A., Costa V.C., Jacinto M.A.C., & Pereira-Filho E.R. (2018) Determination of toxic metals in leather by wavelength dispersive X-ray fluorescence (WDXRF) and inductively coupled plasma optical emission spectrometry (ICP OES) with emphasis on chromium. *Environ Monit Assess*, 28;190(10), 618. doi: 10.1007/s10661-018-6990-y.

Hedberg Y.S., & Lidén C. (2016) Chromium (III) and chromium (VI) release from leather during 8 months of simulated use. *Contact Dermatitis*, 75(2), 82–8. doi:10.1111/cod.12581. Epub 2016 May.

Moretto A. (2015) Hexavalent and trivalent chromium in leather: What should be done? *Regul Toxicol Pharmacol*, 73(2), 681–6. doi: 10.1016/j.yrtph.2015.09.007. Epub 2015 Sep 8.

Shelnutt S.R., Goad P., & Belsito DV. (2007) Dermatological toxicity of hexavalent chromium. *Crit Rev Toxicol*, 37(5), 375–87. doi: 10.1080/10408440701266582. PMID: 17612952.

Mater J. Hazard. (2014) 15; 280: 654–61. doi: 10.1016/j.jhazmat.2014.08.061. Epub 2014 Sep 6.

Were F.H., Moturi M.C., & Wafula G.A. (2014) Chromium exposure and health effects among tannery workers in kenya. *J Health and Pollution*, 4(7), 25–35.

Hedberg Y.S., Erfani B., Matura M., & Lidén C. (2018) Chromium (III) release from chromiumtanned leather elicits allergic contact dermatitis: a use test study. *Contact Dermatitis*, 78(5), 307–314. doi: 10.1111/cod.12946. Epub 2018 Jan 11.

Mago A., Yang Y.S., Shim J.H., & John A.A. (2023) Wearable Device for Cumulative Chlorobenzene Detection and Accessible Mitigation Strategies. *Sensors (Basel)*, 23(18), 7904. doi: 10.3390/s23187904. PMID: 37765961; PMCID: PMC10536231.

Qi C., Gu Y., Sun Q., Gu H., Xu B., Gu Q., Xiao J., & Lian Y. Low-Dose N. (2017) N-Dimethylformamide exposure and liver injuries in a cohort of chinese leather industry workers. *J Occup Environ Med*, 59(5), 434–439. doi: 10.1097/JOM.0000000000000983. PMID: 28368964.

Lee J., Hahm M., Huh DA, & Byeon SH. (2018) Prioritizing type of industry through health risk assessment of occupational exposure to dimethylformamide in the workplace. *Int J Environ Res Public Health*, 13;15(3), pii: E503. doi: 10.3390/ijerph15030503.

Arathanaikotti D., Ramesh R.R., Ponnuvel M., & Rathinam A. (2023) Synthesis and crosslinking of collagen using 4-3,4,5-tris(oxiran-2-ylmethoxy) benzamido)benzenesulfonic acid for the development of robust metal-free leather. *Environ Sci Pollut Res Int*, 30(54), 115310–115321. doi: 10.1007/s11356-023-30505-9. Epub 2023 Oct 26. PMID: 37884713.

Misery L. (2021) Irritated skin is not sensitive skin. *JID Innov*, 11;1(3), 100031. doi: 10.1016/j.xjidi.2021.100031. PMID: 34909728; PMCID: PMC8659814.

Hashim Bassim Mohammed, Esam Abdulraheem, & Haider Sattar Abdali. (2018) Effect of discharged industrial water from tannery plants in nahrawan on groundwater and brick quarries soil. *Iraqi Journal of Science*, 59(3B), 1339–1346. https://ijs.uobaghdad.edu.iq/index.php/eijs/article/view/379

Wassan Lowrance Hassan, Abid Ahmad Erdeni, & Taghreed Khudhur Mohammed. (2023) Effect of methanolic *Cymbopogon citratus* extract on bacteria *Streptococcus mutans* and *Streptococcus sorbinus*. *African Journal of Biological Sciences*, 5(2)48–62 ISSN: 2663-2187. https://doi.org/10.48047/AFJBS.5.2.2023.48-62

AL-Mansour Mohammed Abed Jawad, & Taghreed Khudhur Mohammed. (2020) Stye, bacterial eye infection among the students of the technical medical institute. *Medico-legal Update*, October-December, 20(4), 739.

Seror Ali Abdul Hussein, Sara Salah Qadoori, & Taghreed Khudhur Mohammed. (2024) Biosafety of some eye lenses and artificial eyelashes by measuring pathogenic bacteria and fungi, AIP Conference Proceedings (ISSN: 0094-243X, 1551-7616) Scopus Indexed Proceeding. aureus In vitro and In vivo. Frontiers in Microbiology 7.