MEDITERRANEAN

Pollution prevention opportunities in the Tanning sector industry within the mediterranean region

CLEANER production

Regional Activity Centre for Cleaner Production (RAC/CP)
Mediterranean Action Plan

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If you consider that some part of this study could be improved or there is any lack of precision, we would appreciate if you could notify it to us.

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PROJECT CONTEXT

Introduction

The Mediterranean Action Plan (MAP), Regional Activity Centre for Cleaner Production (RAC/CP) has carried out the Study on Pollution Prevention Opportunities in the Tanning Sector Industry within the Mediterranean Region focusing on the following MAP countries: Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Morocco, Slovenia, Spain, Syria, Tunisia and Turkey. The RAC/CP National Focal Points have collaborated in the realization of the study by providing all necessary information related to the tanning sector in their countries.

The tanning sector, which plays a very important role in the economy of several Mediterranean countries, supplies the raw material necessary for all related leather industries (i.e. bag manufacturing, shoe manufacturing, belt manufacturing, etc.), and in addition takes in the by-products resulting from the meat industry.

Nowadays, this key sector has a new challenge to deal with**:** to minimize its environmental impacts by evaluating the production process under a new point of view, that is, detecting inefficiencies and discovering that an additional economic benefit can also be achieved by reducing pollution generation**.** Expensive end-of-pipe treatment and retrospective clean up should be overcome and complemented with pollution prevention measures in order to reduce costs and risks, and gain competitiveness.

Objective

In order to help companies deal with this challenge, the main aim of this study has been to promote and facilitate the adoption of environmental criteria leading towards pollution prevention and eco-efficiency among experts, industrialists and operators that manage tanning facilities in the Mediterranean.

Therefore, this study mainly focuses on the pollution prevention opportunities that can be implemented in the tanning sector. These pollution prevention opportunities

consider reduction at source and internal recycling as priorities, leading to product and process redesign, and consequently to changes in raw materials, new technologies and good housekeeping. In addition, the study suggests a set of recommendations to help the concerned countries in implementing initiatives promoting environmentally friendly measures to be adopted by the tanning sector.

Methodology

The following study was divided in five chapters, covering the following issues:

- A general economic questionnaire concerning the tanning sector that was sent to the National Focal Points in the concerned countries, as well as parallel literature research, helped develop the first chapter of the study. The latter (i.e. Chapter I), represents a brief introduction relative to the MAP countries' economic situation and environmental concerns, showing in addition the importance of the tanning sector as well as the environmental efforts related to its leather production activities.
- Based on field visits to tanneries, and on an extensive literature review and studies conducted regionally or internationally, Chapter II represents a description of the leather production process. The description of the process focuses mainly on the preservation, beamhouse and tanyard operations.
- Through research and review of various literature sources, Chapter III provides a general environmental overview of the impacts related to the tanning activities.
- Meetings with specialized experts, as well as other field audits and literature reviews helped develop the main pollution prevention options listed in Chapter IV, as well as the financial cases related to the application of such alternatives.
- Finally, and based on all the above findings and research, Chapter V is to suggest a set of measures and recommendations to be adopted in order to develop strategies to promote, encourage and enforce the adoption of pollution prevention options.

In conjunction to this report, a guide directed to the tanning facilities has also been developed in an effort to be used as a user-friendly kit which would help the tanners in understanding and adopting any of the different pollution prevention options.

List of Acronyms

Acronym	Definition
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
GDP	Gross Domestic Product
R&D	Research and Development
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
VOC	Volatile Organic Compounds

CHAPTER I: OVERVIEW OF THE TANNING SECTOR IN THE MAP COUNTRIES

A general economic and environmental overview of the concerned MAP countries will be covered in this first chapter. A special attention will be given relative to the activities of the tanning sector in the different Mediterranean states.

The information detailing the case of every country will be divided into four main categories: general country background[1]; main environmental concerns; general economic background related to the tanning sector; and general efforts towards environmental issues related to the tanning activities.

This overview of the tanning sector in MAP countries, will provide the reader with a better understanding of the industry's framework and actual situation, especially relative to environmental and cleaner technologies if they are applied or to be implemented.

1.1 Albania

General Country Background

Albania is an East European country located in the Mediterranean region. It has a surface area of 28,750 sq. km, with an approximate population of 3,500,000 and an annual GDP close to 4,410 E million.

General Environmental Concerns

Concerning the current environmental issues, Albania is presently facing some challenges related to the following issues:

- Deforestation;
- Soil erosion;
- Water pollution from industrial and domestic effluents.

General Economic Information Related to the Tanning Sector

N.A

General Efforts Towards Environmental Issues Related to Tanning Activities

N.A

1.2 Algeria

General Country Background

Algeria is an Arab country located in North Africa on the Mediterranean border. It has a surface area of 2,381,740 sq.. km, with an approximate population of 31,000,000 and an annual GDP close to 123.656,4 E million.

General Environmental Concerns

Concerning the current environmental issues, Algeria is presently facing some challenges related to the following issues:

- Desertification;
- Soil erosion from overgrazing and other poor farming practices
- Dumping of raw sewage, petroleum refining wastes, and other industrial effluents into rivers and coastal waters leading to their pollution
- Mediterranean Sea, in particular, becoming polluted from oil wastes, soil erosion, and fertilizer runoff
- Inadequate supplies of potable water

General Economic Information Related to the Tanning Sector

Algeria's tanning industry is limited to 9 tanneries of which only three belong to the private sector. The various tanneries employ between 40 and 200 persons except for the case of one tannery in Jijel City, which employs about 500 workers. However, the tanning sector is still facing a series of difficulties due to an inefficient infrastructure and a low rate of cattle breeding.

[1] In this chapter the main reference for the countries' general economic and environmental information was found at: CIA, *The World Factbook 1999*, http://www.odci.gov/cia/publications/factbook/country.html

General Efforts Towards Environmental Issues Related to Tanning Activities

Algeria has in place a series of environmental regulations concerning the discharge levels allowed. The regulations, which are not specifically directed towards the tanning sector, do affect their process activities, as this sector is considered as a polluting industry.

Thus, the leather tanneries in Jijel and Rouiba have installed recently new wastewater treatment devices discharging acceptable pollution levels in the water recipient medium. In addition, new tanneries are re-using and recycling chrome and liming baths.

Nevertheless, the efficiency of the above mentioned efforts in the tanning sector remain very limited due to various difficulties that the industry is facing (i.e. financial, logistical, etc.).

Furthermore, some extra investments and research remain necessary to treat more efficiently the solid waste generated.

1.3 Bosnia-Herzegovina

General Country Background

Bosnia-Herzegovina is an east European country with an opening to the Adriatic Sea. It has a surface area of 51,233 sq.. km, with an approximate population of 3,500,000 and an annual GDP close to 5.115,6 E million.

General Environmental Concerns

Concerning the current environmental issues, Bosnia and Herzegovina is presently facing some challenges related to:

- Air pollution from metallurgical plants;
- Limited sites for disposing of urban waste are limited;
- Water shortages and destruction of infrastructure, result of the 1992-95 civil strife.

General Economic Information Related to the Tanning Sector

The tanning activity in the country has been very minimal and the sector seems to have suffered considerably from the recent war years. Although the country has a total of 5 facilities located in Bugojno, Visoko, Banja, Kotor Varos, Prnjavor, only one remains operational and continues working at a very low capacity.

General Efforts Towards Environmental Issues Related to Tanning Activities

As the country is still recovering from a long period of war that damaged a large part of its industry, the issues related to environmental pollution are not considered too critical, specially because the industrial activities remain very low. However, the adoption of new environmental standards and regulations is under consideration and is an ongoing process, as the actual legal framework should be further improved. In this sense, the final objective nowadays is to prepare future environmental regulations under the EU Environmental Programme for Bosnia and Herzegovina.

1.4 Croatia

General Country Background

Croatia is an east European country with an opening to the Adriatic Sea. It has a surface area of 56,538 sq.. km, with an approximate population of 4,500,000 and an annual GDP close to 20.815,2 E million.

General Environmental Concerns

Concerning the current environmental issues, Croatia is presently facing some challenges related to:

- Air pollution (from metallurgical plants) and resulting acid rain damaging the forests;
- Coastal pollution from industrial and domestic waste;
- Destruction of infrastructure in border areas affected by civil strife.

General Economic Information Related to the Tanning Sector

The tanning sector in Croatia has 6 large tanneries processing 30 tons of wet salted hides a day. In addition, a number of medium and smaller sized industries continue to operate in some regions next to the Danube river such as: Osijek, Zagreb Varadzin, Poznanovec, Vinkovci and Karlovac.

General Efforts Towards Environmental Issues Related to Tanning Activities

The Croatian government and other interested institutions, including the tanners themselves are very much aware of the ecological burden related to the tanning activities. Thus, efforts are oriented towards finding a set of ecological solutions and environmentally friendly processes for the tanning industry.

The high level of environmental awareness is also noticed through the activities of some tanning industries, which are producing wet-white instead of the usual chrome-tanned leather (wet-blue).

The fact that soon Croatia is planning to join the EU will enable the country to rely on previous European experiences in the environmental field as well as in the tanning sector. Furthermore this will lead the country to apply some high environmental standards relative to pollution generation.

1.5 Cyprus

General Country Background

Cyprus is a European island located in the northeastern part of the Mediterranean basin. It has a surface area of 9,250sq. Km, with an approximate population of 800,000 and an annual GDP close to 8.820 E million.

General Environmental Concerns

Concerning the current environmental issues, Cyprus is presently facing some challenges related to:

- Water resource problems (no natural reservoir catchments, seasonal disparity in rainfall);
- Sea water intrusion to island's largest aquifer;
- Increased salinity in the north;
- Water pollution from sewage and industrial wastes;
- Coastal degradation;
- Loss of wildlife habitats from urbanization

General Economic Information Related to the Tanning Sector

The tanning industry in Cyprus is limited to close to 6 tanneries with 4 located in Nicosia, one in Larnaca and one in Limassol.

General Efforts Towards Environmental Issues Related to Tanning Activities

At least one study to detect environmental management measures has been conducted relative to a tanning facility in Limassol. The environmental issues seem to be of a relative importance for there are some efforts to treat the wastewater generated from tanning activities. However, as the available wastewater treatment plant was not operational, the wastewater generated from the tannery was transported to lagoons in the area. The treatment was based on evaporation of the polluted water deposited in the lagoons. Since the latter were not properly sealed to prevent leakage. The audited tanning facility has recently received a permit to have its wastewater sent for treatment from the lagoons to a new plant in Vathia Gonia, a Central Wastewater Treatment plant constructed under government decision, treating the waters of about 70 different industries in the region.

The study based on its findings came up with the following recommendations to limit the pollution level of tanning activities:

1. Installation of a chrome recovery plant;
2. Installation of a physico-chemical treatment, where alum is dosed, followed by clarification;
3. Aerobic sludge or extended aeration treatment plant is also to be taken into consideration at a later stage.

1.6 Egypt

General Country Background

Egypt is an Arab country located in North Africa on the Mediterranean border. It has a surface area of 1,001,450 sq. km, with an approximate population of 67,000,000 and an annual GDP close to 165.816 E million.

General Environmental Concerns

Concerning the current environmental issues, Egypt is presently facing some challenges related to:

- Agricultural land being lost to urbanization and windblown sands;
- Increasing soil salinity below Aswan High Dam;
- Desertification;
- Oil pollution threatening coral reefs, beaches, and marine habitats;
- Water pollution from agricultural pesticides, raw sewage, and industrial effluents;
- Very limited natural fresh water resources away from the Nile, which is the only perennial water source;
- Rapid growth in population overstraining natural resources

General Economic Information Related to the Tanning Sector

According to studies conducted recently by the Egyptian government, the leather sector could play a major role in the country's economy. This potential could be easily summarized by the table below.

Commodity	1995	1996	1997	1998	1999	2000	2001
Footwear/Leather	22.05	30.87	39.69	52.92	70.56	88.2	105.84

Table: Potential of Egyptian Exports of Footwear & Leather (million E)[2]

However, the industry has been recently facing some financial difficulties. The sector, which is mainly privately owned, employs about 8000 workers in close to 320 tanneries. These are located in two main cities, about 300 units in Old Cairo and the rest in Alexandria. The largest number of tanneries (at least 200) is classified as small size tanneries.

[2] Ministry of Economy and Foreign Trade, Stanford Research Institute, Achieving Egyptian Export Growth, 1995

Leather Production in Egypt						
Year	**Employment**	**Companies**	**Turnover (Meuros)**	**Export (MEuros)**	**Production Hides (1.000 m2)**	**Production Skins (1.000 m2)**
1998	8.000	322	N.A	6 to 7.5	12.000	N.A

General Efforts Towards Environmental Issues Related to Tanning Activities

Given the environmental impacts generated by the tanning activities in Egypt, the Egyptian government has decided to relocate the whole industry into an area where the environmental impact would be controlled as well as new technologies easily introduced. A 264.6 E million project will be relocating the facilities to the El-Robakey region in which close to 2,200,000 sq. are meters are especially dedicated to the re-installation of the leather facilities. The project takes also into consideration the environmental concerns related to three main aspects:

- The recovery and reuse of residual chrome
- The evaporation of high salt-concentration effluent as dispersion or irrigation is the only possible types of disposal, considering present local norms.
- The chemical-physical treatment of other waste with the possible sludge collection site, potential of using the sludge as a fertilizer after suitable treatment, and construction of suitable sanitary landfills for garbage and non-hazardous industrial wastes.

1.7 France

General Country Background

France is an industrialized European country with its southern part partially bordering the Mediterranean Sea. It has a surface area of 547,030 sq. km, with an approximate population of 59,000,000 and an annual GDP close to 1,16424 E billion.

General Environmental Concerns

Concerning the current environmental issues, France is presently facing some challenges related to:

- Some forest damage from acid rain;
- Air pollution from industrial and vehicle emissions;
- Water pollution from urban wastes,
- Agricultural runoff

General Economic Information Related to the Tanning Sector

Due to a number of strict environmental regulations and to foreign competition (especially from other developing countries), the tanning industry in France has been facing a series of financial difficulties through the past decade. These challenges led a number of French tanneries to halt their activities for good or to conduct additional budget cuts. The comparative table[3] below with figures for the years 1990 and 1998, shows this fact. In addition, the table provides some general information regarding the production level of the sector. The tanning industry in France however continues to play an important role in providing raw material for the local leather industry, which is considered as one of the most important in Europe.

Leather Production in France

Year	Employment	Companies	Turnover (1.000 Euros)	Export (1.000 Euros)	Production Hides (1000 m^2)	Production Skins (1000 m^2)
1990	5.247	181	575.849	32,28	8.321	14.403
1998	2.547	96	495.000	37	16.000	500

General Efforts Towards Environmental Issues Related to Tanning Activities

France, as any other EU country, has to comply with strict environmental standards. This makes out of the French tanning activities one of the most advanced and environmentally friendly in Europe.

Although the French tanning industry continues to encounter a number of obstacles, the present challenges the industry is facing did not hinder its efforts towards finding newer and better technologies, that would limit its environmental impact and improve

[3] COTANCE, *Sector Data*, http://www.euroleather.com/cotance/sector.htm

its product quality. Associations continue to be invested in this field aiming at reducing the entire environmental burden and limiting the possible pollution fines that could result due to tanning activities.

1.8 Greece

General Country Background

Greece is an industrialized European country located in the southern part of Europe and bordering the Mediterranean Sea. It has a total surface area of 131,940 sq. km, with an approximate population of 10,707,135 and an annual GDP close to 126.126 E million.

General Environmental Concerns

Concerning the current environmental issues, Greece is presently facing some challenges related to:

- Air pollution and water pollution.

General Economic Information Related to the Tanning Sector

The tanning industry in Greece, as most of the other European tanning industries, has been losing ground due to a high level of foreign competition and sometimes-strict environmental regulations.

General Efforts Towards Environmental Issues Related to Tanning Activities

Greece being part of the EU has to comply with some EU environmental regulations as well as other National regulations.

The importance of the economic challenges the tanning industry is facing in Greece could be summed up in the comparative table[4] below with figures for the years 1990 and 1997. Greek tanners continue to invest efforts in newer and better technologies, which will limit their environmental impact as well as improve their product quality.

[4] Ibid

Leather Production in Greece						
Year	**Employment**	**Companies**	**Turnover (1.000 Euro)**	**Export (1.000 Euro)**	**Production Hides (1.000 m^2)**	**Production Skins (1.000 m^2)**
1990	1.450	158	110.000	18,22	2.300	1.900
1997	1.000	120	85.000	20	1300	2.500

1.9 Israel

General Country Background

Israel is a country with an annual GDP close to 17.640 E million.

General Environmental Concerns

n.a.

General Economic Information Related to the Tanning Sector

The tannery branch in Israel is one of the oldest industries in this country. This industry has existed for more than 75 years. Up until the seventies, thousands of workers were employed in the tannery industry and at its peak the industry counted 75 factories. Yet, the industry is shrinking since then, and counts now with only 8 plants. These plants are mainly distributed in the centre of Israel, in the city of Petah-Tiqwa (in the greater Tel-Aviv area), and they have an average size of 1000-5000 sq.m. Some other economic and environmental data concerning the tanning industry in Israel can be summarised by the table below.

Leather Production in Israel					
Employment	**Companies**	**Yearly production (of 5 tanneries)**	**% export from total exports**	**Total chrome's salt consumption**	**Total water use**
300	8	8,820,000 E	0.00028%	100 tones	100,000 m^3

General Efforts Towards Environmental Issues Related to Tanning Activities

Some pollution prevention initiatives undertaken in Israel are related to the following issues:

- New water regulations of 1998 prohibit the flow of brines to sewers and streams. Brines must be treated and transported to the sea or elsewhere safely, without causing environmental damage and according to the Barcelona Convention.
- Auxiliary municipal law determines that content of chlorides in sewage should not exceed 200 mg/l above the level found in incoming tap water. Another requirement, set through terms to business licenses, determines that the content of sodium in sewage should not exceed 200 mg/l above the level found in incoming tap water.
- Since sodium is much more destructive than potassium, particularly to soil fertility, the exchange of sodium salts with potassium salts is being promoted.
- Since wastewater from the tanning industry is being treated insufficiently, separation of the sewage into 3 streams is being promoted:
  - Brine water is concentrated in a particular container and then is removed by contractor into a sewage tank. The brine water is supposed to be further treated, desiccated and disposed (not to the main sewage system).
  - Chromic water is neutralized with lime in another container. After several days the sludge is pumped off and removed to the toxic waste site.
  - The general wastewater (produced through the other stages of the process) is sent to one of the 3 precipitation pools in a batch manner, with an automatic pH control (adding NaOH or HCl). From there, the wastewater is discharged to the municipal sewage system.
- Modern tanning processes are almost odourless as opposed to the past, and since most of the air pollution deriving from tanning activities occurs during the dying and painting of the leather using spray methods at the finishing stage, one factory has a scrubber which collects the polluted air and passes it through a water body that collects the harmful aerosol and drains it to the sewage.

1.10 Italy

General Country Background

Italy is an industrialized European country located in the Mediterranean region and bordering the Mediterranean Sea. It has a surface area of 301,230 sq. km, with an approximate population of 56,500,000 and an annual GDP close to 1,041642 E billion.

General Environmental Concerns

Concerning the current environmental issues, Italy is presently facing some challenges related to:

- Air pollution from industrial emissions such as sulfur dioxide;
- Coastal and inland river pollution from industrial and agricultural effluents;
- Damage of lakes by acid rain;
- Inadequate industrial waste treatment and disposal facilities

General Economic Information Related to the Tanning Sector

One of the few European countries that did not suffer seriously from the foreign level of tanned leather competition is Italy. Italian tanners on their own represent about 60% of the total European leather production and close to 15% of the total world leather production. This is linked to the fact that Italian leather remains of a very high quality, as well as to the Italian ability to interpret fashion trends and technological innovations.

The table[5] below reflects the importance of leather tanning industry in Italy.

Leather Production in Italy

Year	Employment	Companies	Turnover (1.000 Euro)	Export (1.000 Euro)	Production Hides (1000 m^2)	Production Skins (1000 m^2)
1990	29.000	2.700	4.651.919	36,71	106.340	43.695
1997	25.000	2.400	5.507.692	50	147.500	40.200

General Efforts Towards Environmental Issues Related to Tanning Activities

As any other EU country, and due to strict environmental regulations, the Italian tanning industry is always pursuing new developments and conducting R&D, in an effort to limit the pollution generated and improves its product quality. The strict standards available make out of the tanning sector an environmentally conscious industry. To decrease the environmental burden resulting from the Italian tanneries, these have been generally regrouped together in specific areas offering all the required

[5] Ibid

services as well as treatment measures to facilitate the leather production and to limit the pollution levels.

1.11 Lebanon

General Country Background

Lebanon is an Arab country located in the Middle East region bordering the Mediterranean Sea. It has a surface area of 10,400 sq. km, with an approximate population of 3,500,000 and an annual GDP close to 13935,6 E million.

General Environmental Concerns

Concerning the current environmental issues, Lebanon is presently facing some challenges related to:

- Deforestation;
- Soil erosion;
- Desertification;
- Air pollution in Beirut from vehicular traffic and the burning of industrial wastes;
- Pollution of coastal waters from raw sewage and industrial effluents

General Economic Information Related to the Tanning Sector

The tanning sector in Lebanon has been lately facing a series of financial difficulties, forcing a number of facilities to halt their operations or to continue running on a minimum level.

In general, there are close to 25 (small to medium sized) privately owned tanneries, with an important level of know how. Most of the Lebanese tanners conduct the leather production process from beginning to end (i.e. from soaking to re-tanning and finishing). These facilities are concentrated in 5 different areas in Lebanon and except for one facility conducting vegetable tanning, they all rely on the chrome process.

The Lebanese tanning sector plays an important role in the economy of the country as it supplies the raw material necessary for the local leather industry, in addition to exporting a certain quantity of its own production.

The table below briefly summarizes the present situation of the Lebanese tanning sector with some information related to its production capacity.

Leather Production in Lebanon						
Year	**Employment**	**Companies**	**Turnover (1.000 Euro)**	**Export (1.000 Euro)**	**Production Hides (1.000 m^2)**	**Production Skins (1.000 m^2)**
1998	500	25	30.000	4.000	1.111	1.111

General Efforts Towards Environmental Issues Related to Tanning Activities

However, the activity of this sector is the cause of some problems such as complaints from neighboring population as well as an additional pollution source for the country. The environmental problems are mainly due to a lack of sound environmental regulations and financial means to and incentives for the implementation of the necessary cleaner production initiatives. The Lebanese Ministry of Environment being conscious of the problems related to the tanning activities has conducted a preliminary study to try and tackle the main issues of this problem and to promote some cleaner technologies. In addition to the study, a capacity building session was also held at the ministry to increase the low awareness level of the tanners relative to the environmental impact of the tanning activity, as well as to the promotion of environmentally friendly processes. Nevertheless, the study also suggested that one of the main solutions to this problem, the relocation of the whole sector. This latter alternative is presently under consideration, and a financial feasibility study for the relocation of the sector is in the “pipeline”.

In the meantime, Lebanese tanners can hardly implement large-scale projects on their own as they continue to face financial difficulties. In addition, they are still waiting for the exact set of environmental regulations if they are to build the required treatment facilities

1.12 Libya

General Country Background

Libya is an Arab country located in North Africa on the Mediterranean border. It has a surface area of 1,759,540 sq. km, with an approximate population of 5,000,000 and an annual GDP close to 33.516 E million.

General Environmental Concerns

Concerning the current environmental issues, Libya is presently facing some challenges related to:

- Desertification;
- Very limited natural fresh water resources;

General Economic Information Related to the Tanning Sector

N.A

General Efforts Towards Environmental Issues Related to Tanning Activities

There are seven leather tanneries in Libya scattered in different areas of the country. Only four of them are located in the coastal area. All these tanneries were constructed with wastewater treatment plants. Yet, environmental audits and control reveal the need for maintenance from time to time. Although regulations do exist, these are not always efficiently applied.

1.13 Malta

General Country Background

Malta is a European island located in the middle of the Mediterranean Sea. It has a surface area of 320 sq. km, with an approximate population of 381,603 and an annual GDP close to 4.410 E million.

General Environmental Concerns

Concerning the current environmental issues, Malta is presently facing some challenges related to:

- Very limited natural fresh water resources;
- Increased reliance on desalination.

General Economic Information Related to the Tanning Sector

The importance of the tanning industry in Malta occupies a secondary role as it has only one facility which conducts only a part of the tanning process, as it imports and processes mainly chrome tanned goat skins.

General Efforts Towards Environmental Issues Related to Tanning Activities

Relative to environmental issues, the solid waste from the tannery is sent to landfill sites. However, there is no monitoring for the composition of the wastewater generated as the water used for the re-tanning process is mainly obtained from a sewage treatment plant.

1.14 Monaco

General Country Background

Monaco is a European country bordering the Mediterranean Sea. It has a surface area of 1,95 sq. km, with an approximate population of 32,149 and an annual GDP close to 705,600,000 million.

General Environmental Concerns

Although active at the environmental level, the country is too small to have a large series of different environmental concerns.

General Economic Information Related to the Tanning Sector

There is no tanning industry in Monaco.

General Efforts Towards Environmental Issues Related to Tanning Activities

At the environment level, Monaco could be considered as being very active as it is part of the EU and has to comply with strict European environmental regulations. However, the reader should keep in mind that the industrial activity remains very limited in this country which shifts the environmental efforts towards issues in other sectors.

1.15 Morocco

General Country Background

Morocco is an Arab country located in North Africa and on the Mediterranean border. It has a surface area of 446,550 sq. km, with an approximate population of 29,500,000 and an annual GDP close to 94.374 E million.

General Environmental Concerns

Concerning the current environmental issues, Morocco is presently facing some challenges related to:

- Land degradation/desertification (soil erosion resulting from farming of marginal Areas, overgrazing, and destruction of vegetation);
- Water supplies contaminated by raw sewage;
- Siltation of reservoirs;
- Oil pollution of coastal waters.

General Economic Information Related to the Tanning Sector

The tanning industry in Morocco is one of the most active sectors in the country playing a non-negligible role in the overall economy.

The sector has known some major developments concerning product transformation and total exports and the beginning of the nineties has seen the Moroccan tanners diversifying their products and substantially improving the product quality.

The tanneries are mainly located in the following cities: Casablanca, Mohammedia, Essaouira, Meknes, Fes and Marrakech.

The table below provides an idea of their production level as well as the importance of the sector.

Leather Production in Morocco						
Year	**Employment**	**Companies**	**Turnover (1.000 Euro)**	**Export (1.000 Euro)**	**Production Hides (1000 m^2)**	**Production Skins (1000 m^2)**
1997	2.900	55	81.000	46.200	N.A	N.A.

General Efforts Towards Environmental Issues Related to Tanning Activities

Relative to environment issues, the tanneries in Morocco conduct both vegetable tanning and chrome tanning. The government is aware of the serious impact resulting from chrome tanning activities and has started with the support of USAID a project of chrome recycling. Thus, in Fes, a government-operated facility is allowing tanneries in the city's neighborhood to save money and prevent pollution by helping them remove and reuse chromium from their effluent. Through the implementation of this project, the level of chromium in the water effluent has been reduced to as low as 1%. The resulting sludge is resold at a cost just covering the operational costs of the treatment facility, which at the end becomes cheaper than buying new chromium[6].

The Moroccan government is hoping through this pilot project to promote similar initiatives, which would at the end limit, the environmental level of degradation resulting from tanning activities.

1.16 Slovenia

General Country Background

Slovenia is an east European country with an opening to the Adriatic Sea. It has a surface area of 20,256 sq. km, with a total population of 2,000,000 almost and an annual GDP close to 17.992,8 E million.

[6] Chemonics International Inc., *Water Management in Morocco*, http://www.chemonics.com/watmana.htm

General Environmental Concerns

Concerning the current environmental issues, Slovenia is presently facing some challenges related to:

- Pollution of Sava River with domestic and industrial waste;
- Pollution of coastal waters with heavy metals and toxic chemicals;
- Damage of the forest near Koper from air pollution (originating at metallurgical and chemical plants) and resulting acid rain.

General Economic Information Related to the Tanning Sector

There are seven tanning facilities in Slovenia with two large ones covering about 85% of the total country leather production. The leather industry represents about 1% out the total country exports.

The main tanning facilities are located in the following areas: Vrhnika, Smartno pri Litiji and Ljutomer.

The major production is based on pigskin leather with close to 30,000 pigskins processed daily. However, there is also a small production of hides and sheepskin, which remains very negligible. The table[7] below gives some information about the local leather production in Slovenia.

Leather Production in Slovenia

Year	Employment	Companies	Turnover (1.000 Euro)	Export (1.000 Euro)	Production Hides (1.000 m^2)	Production Pig Skin (1.000 m^2)
1998	1.200	7	80.000	N.A	Negligible	8.000

[7] Dr. Anton Gantar, environmental consultant at the Slovenian Ministry of Environment

General Efforts Towards Environmental Issues Related to Tanning Activities

Slovenia, which is considering being part of the EU, will have in the future to comply with European environmental regulations. Slovenian tanneries are not located in specifically designated industrial areas. However, the tanners seem to be interested in conducting efforts related to economic and environmental issues affecting their activities through their participation in COTANCE (see Annex R6).

1.17 Spain

General Country Background

Spain is an industrialized European country located on the western part of the Mediterranean basin. It has a surface area of 504,750 sq. km, with an approximate population of 39,167,744 and an annual GDP close to 569.419,2 E million.

General Environmental Concerns

Concerning the current environmental issues, Spain is presently facing some challenges related to:

- Pollution of the Mediterranean Sea from raw sewage and effluents from the offshore production of oil and gas;
- Water quality and quantity nationwide;
- Air pollution;
- Deforestation;
- Desertification

General Economic Information Related to the Tanning Sector

The Spanish tanning sector is considered as being the second largest in Europe after the Italian tanning industry. The industry, which has faced a series of difficulties, continues to play an important role relative to the country's economy and to the Spanish leather industries as a whole. The table[8] below provides an idea about the present situation of the Spanish tanning industry.

[8] COTANCE, *Sector Data*, http://www.euroleather.com/cotance/sector.htm

Leather Production in Spain						
Year	**Employment**	**Companies**	**Turnover (1.000 Euro)**	**Export (1.000 Euro)**	**Production Hides ($1000\ m^2$)**	**Production Skins ($1000\ m^2$)**
1990	10.800	296	1.265.678	23,24	25.908	26.662
1997	8.000	255	1.250.000	39	27.720	20.930

General Efforts Towards Environmental Issues Related to Tanning Activities

Spain as any other EU country has to comply with strict environmental standards. This channeled the Spanish tanning activities to be among the most advanced and environmentally friendly ones in Europe. However, one of the main problems that the industry is facing comes from the method of preservation of hides and skins, which relies on salts as a way of conservation. Thus, high levels of salinity end up being found in the wastewaters generated from the tanning activities, which causes additional environmental burdens especially in dry regions.

1.18 Syria

General Country Background

Syria is an Arab country located in the Middle East region and bordering the Mediterranean Sea. It has a surface area of 185,180 sq. km, with an approximate population of 17,000,000 and an annual GDP close to 36.779,4 E million.

General Environmental Concerns

Concerning the current environmental issues, Syria is presently facing some challenges related to:

- Overgrazing;
- Soil erosion;
- Desertification;
- Water pollution from dumping of raw sewage and wastes from petroleum refining; inadequate supplies of potable water

General Economic Information Related to the Tanning Sector

The tanning sector in Syria plays an important economic role as it supplies the local leather industry with all its necessary raw material. There is around 280 tanning industries in Syria divided among the following regions: Zablatini, Aleppo, Ramoussa and Chaykh Said.

Tanneries in Syria belong mainly to the private sector, however, a few large ones are publicly owned. The main characteristics of the Syrian tanning industry could be summed up through the following points[9]:

1. The production of the public sector is not organized;
2. More than 80% of the production comes from the private sector;
3. The leather production covers the local needs;
4. Chemicals and some kind of leathers are imported;
5. Any excess in the production level is usually exported to European markets.

Leather Production in Syria

Year	Employment	Companies	Turnover (1.000 Euro)	Export (1.000 Euro)	Production Hides	Production Skins
1997	N.A	280	N.A	N.A	78 tons/day	63 tons/day

General Efforts Towards Environmental Issues Related to Tanning Activities

Conscious about the environmental damages that the tanning industry might cause, especially as it is located in a highly dense area, the Syrian government conducted some studies in 1988-1989 to relocate the tanning sector, but finally the study was not implemented. However, in an effort to limit the environmental burden and until the implementation of the relocation project, the Syrian government imposes on the tanning facilities in the Damascus region to[10]:

[9] Soha Nassar, Reduction of the Environmental Impact of the Tanning Sector, Damascus University, Syria, 1999, p 20
[10] Ibid, p 28

1. Install water monitors that would measure the level of water consumption for each facility;
2. Construct some canals and water collection basins in each tannery;
3. Install metal screens to limit the amount of solid waste;
4. Construct walls that would separate tanneries that are located close to the river;
5. Collect all the solid wastes and package them in specific bags instead of dumping them outside;

Environmental issues related to the tanning activities continue to represent some concern for the Syrian government, which in addition to the above, is conducting additional studies to build a possible leather board facility. The latter would treat some of the tanneries solid wastes generated following the chrome tanning process.

1.19 Tunisia

General Country Background

Tunisia is an Arab country located in North Africa on the Mediterranean border. It has a surface area of 163,610 sq. km, with an approximate population of 9,513,603 and an annual GDP close to 43.218 E million.

General Environmental Concerns

Concerning the current environmental issues, Tunisia is presently facing some challenges related to:

- Ineffective disposal of toxic and hazardous waste, which presents human health, risks;
- Water pollution from raw sewage;
- Limited natural fresh water resources;
- Deforestation;
- Overgrazing;
- Soil erosion;
- Desertification

General Economic Information Related to the Tanning Sector

The leather tanning activity in Tunisia has been a flourishing one lately, and most of the tanneries have been doing very well financially. In addition to providing the raw material for the local leather industry, some tanning facilities export their products abroad. The following table provides a general idea of the total production and the number of industries in the tanning field. Most of the tanning facilities are medium sized ones, and some of them are quite modern

Leather Production in Tunisia

Year	Employment	Companies	Turnover (1.000 Euro)	Export (1.000 Euro)	Production in 1.000 m^2 Hides / Skins
1995	1.450	25	N.A	N.A	3.890

General Efforts Towards Environmental Issues Related to Tanning Activities

Tunisia has been very concerned with the overall impact of the tanning industry on the environment and has conducted a series of studies and audits to determine new cleaner production options to be introduced to the tanning sector.

A large number of tanneries are equipped with their own wastewater treatment facilities and the majority of the industry is situated in industrial zones with wastewater treatment plants available.

The Tunisian government has been trying to promote the introduction of pollution prevention options that would focus mainly on the following issues:

1. Collection of Chrome;
2. Collection of hair
3. Improving the operational and technical processes to reach a better product quality.
4. Limiting the wet-blue production to a specific number of facilities, to be able to have a better control over the chrome containing wastewater and the solid waste generated. Such a solution will permit the government to construct the required treatment installations in one specific area (i.e. next to the chrome tanning

facilities). On the other hand, the remaining tanneries would be more specialized, thus provide better-finished products.

Tunisia has been very active relative to different environmental issues, and is one of the Arab countries to be applying advanced measures to limit the overall pollution resulting from tanning activities.

1.20 Turkey

General Country Background

Turkey is located both on the European and Asian continents bordering mainly the Mediterranean Sea. It has a surface area of 780,580 sq. km, with an approximate population of 65,500,000 and an annual GDP close to 375.202,8 E million.

General Environmental Concerns

Concerning the current environmental issues, Turkey is presently facing some challenges related to:

- Water pollution from dumping of chemicals and detergents;
- Air pollution, particularly in urban areas;
- Deforestation;
- Concern for oil spills from increasing Bosporus ship traffic.

General Economic Information Related to the Tanning Sector

The tanning industry in Turkey could be considered as one of the most important sectors in the country representing close to 14% of total leather production worldwide. The industry occupies a leading role in the European skin leather production.

General Efforts Towards Environmental Issues Related to Tanning Activities

The Turkish government, aware of the pollution generated through the tanning activities, conducted a series of studies that led to the relocation of part of its tanning sector.

The successful relocation that was to move the Kazlicesme leather industrial zone to Tuzla (next to Istanbul) was followed by a series of additional relocations in other regions. The positive experience of Turkey has proven that the establishment of "Organized Leather Specialty Zones" is a sound method that will contribute to the overall prevention of environmental pollution resulting from tanning activities.

Legislative Issues and Potential Trade Barriers Related to the Leather Market

Although this chapter permitted to cover briefly the economic and environmental issues related to the tanning industries in the MAP countries, one can notice that a number of Mediterranean states are facing a series of obstacles regarding the full implementation of sound environmental measures concerning their tanning activities. However, some initiatives to improve this situation, government and privately driven, have been arising.

EU countries (i.e. France, Greece, Italy, Spain,) have been led to comply with a stricter legal framework, and therefore remain environmentally active. Furthermore, other European countries planning to join the EU in the future (i.e. Croatia, Turkey, Slovenia) are influenced by this fact, and therefore also take into consideration improvements in their environmental situation in relation to the tanning activities.

The research and interviews conducted for the means of the study, showed that there were almost no environmental regulations as such aimed specifically towards the tanning industry. However, tanners had to comply with a set of general pollution standards aimed at a general industrial sector.

Thus, even in the countries with a stricter legal framework, regulations remain basically general ones, relative to the pollution levels to be respected by any polluting facility. The EU Integrated Pollution Prevention and Control (IPPC) directive, encouraging the usage of Best Available Techniques in the European industries as well as other environmentally friendly initiatives, is an example in this sense. These general regulations stating the maximum allowed pollution thresholds are meant to be used by the different EU partners. However, the table in annex R1 shows clearly the differences among the standards of different EU countries as each one will usually have its own set of standards, specific to its country needs.

It should be noted however, that the strict environmental regulations to which EU tanners are subjected and the high leather qualities that are increasingly required, imply the application of control and pollution prevention measures. Therefore, parallel to the general efforts conducted towards a greater environmental awareness and pollution reduction, the EU tanners have also a series of programs and associations to promote and develop economically but also environmentally their tanning industry.

Other MAP countries are increasingly aware of these efforts towards environmental issues, which on the long run could represent potential trade barriers or threats to their overall leather exports, which lead them to consider also the national environmental issues on both levels:

- To limit pollution levels resulting from the national tanning activities;
- To introduce advanced and environmentally friendly techniques when there is an economic and technical feasibility, which would improve the leather quality, permitting to their industries to remain attractive to other foreign markets.

CHAPTER II: THE TANNING PROCESS

Tanning is the process through which rawhides and skins are converted into leather as a final usable and sellable product. The latter is used afterwards, as the basic raw material for the production of various leather commodities (i.e. shoes, bags, etc.).

As there is no single or general procedure for leather production; the techniques available vary considerably according to the original raw material (hides, skins…) and the final product needed. Tanning is usually performed through a series of batch processes that could last from as short as a few minutes or hours to as long as several months for some kinds of vegetable tanning techniques. Hide and skin tanning, is a process divided into a series of stages, in which the pelts are treated with different chemical and non-chemical agents, as well as passing through different mechanical operations.

The tanning process is usually divided into the following phases:

- Beamhouse (Preparation Phase);
- Tanyard (Tanning Phase);
- Re tanning - and finishing activities


Raw hides / skins
Preservation
Trimming
Rinsing
Soaking
Limming
Rinsing
Lime Fleshing
Deliming & Batting
Rinsing
Degreasing
Pickling
Tanning
Sammying
Spliting
Shaving
Re-tanning
Finishing
leather

This chapter will be covering the main parts of the tanning processes in application in most tanneries, with a main focus on the beamhouse and tanyard operations. However an overview of the re-tanning and finishing activities will also be presented.

The most common type of process in application for pelts' treatment could be summarized according to the following phases necessary for leather production.

The different steps listed in the figure above will be explained thoroughly in the following pages, where every process will be described according to the following criteria:

Process definition

A definition for every step in the tanning process will be presented to provide a better idea of the object of every stage. If there are more than one available method practiced, the main processes in application will be presented (i.e. tanning process could be either done using minerals or vegetable tannins).

Main equipment used

The equipment necessary at each stage will be listed; the main object of this part being to provide the reader with an additional idea of what is usually needed to conduct a particular process. Equipment usage could vary from one tannery to another, since there is a wide range of traditional and newer techniques applied.

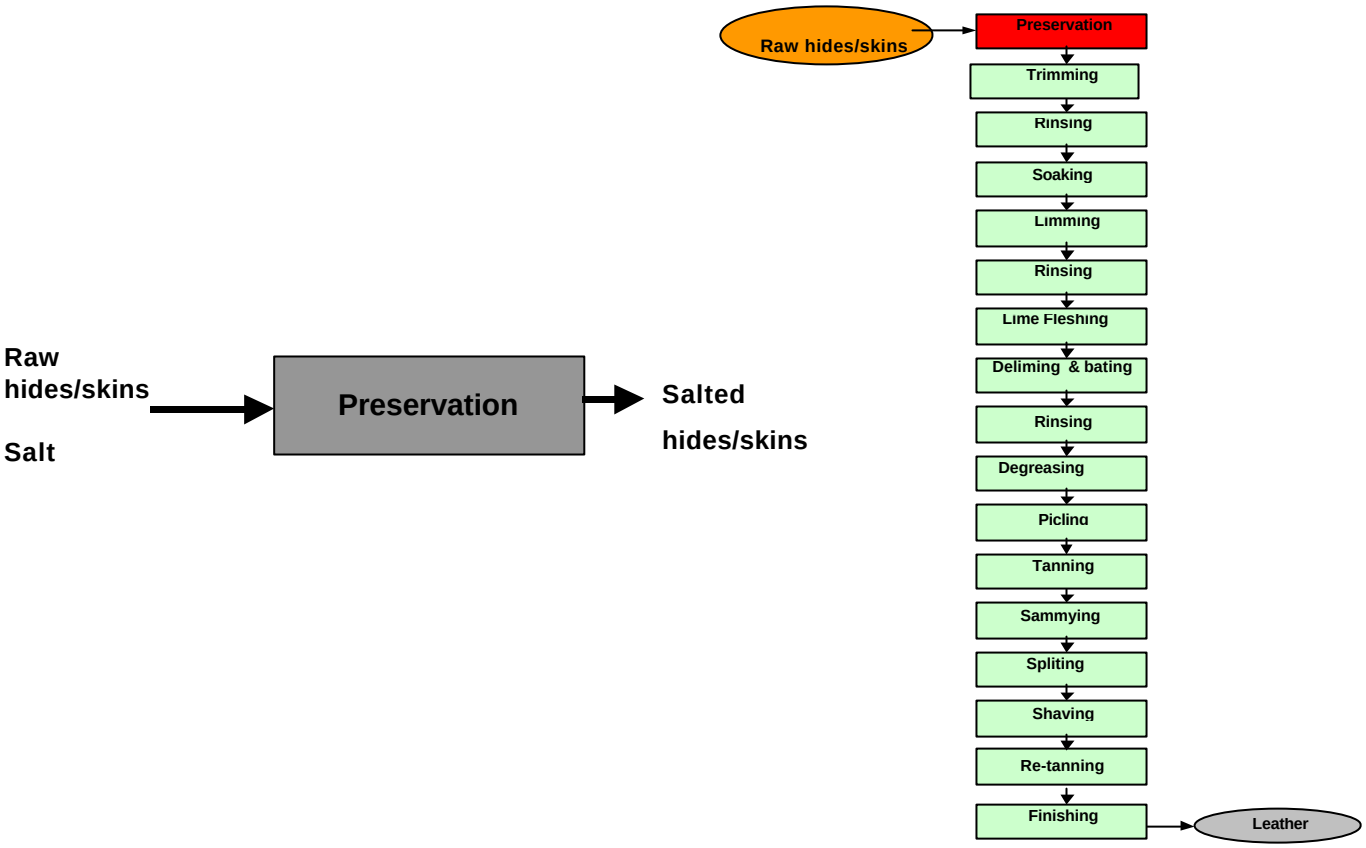
Materials in /Materials out

This section will be describing the different chemicals, non-chemical agents and other additives that are added to the pelts during the tanning process. In addition to the description of the materials in, a listing of all the materials out at the end of every process is also given.

Environmental considerations

The environmental considerations originating from each stage of the tanning process will be listed according to the following three categories;

- Water Pollution
- Solid Wastes
- Air Pollution.



Preservation	
This is a necessary step to prevent the deterioration of the skins or hides until the tanner is ready to process them and to convert them into leather as a final product. Usually preservation techniques to allow pelts conservation and prevent any bacterial growth rely on one or a combination of the following methods[11]: 1-Chilling 2-Drying 3-Brining 4-Wet salting 5-Dry Salting 6-Pickling 7- Chemicals	
Main Equipment Used	
Protective gloves (for salting)/Refrigeration equipment /Large Containers (for Brining)	
Material In	**Material Out**
Freshly flayed hides or skins	Cured hides or skins Wastewater (containing; high levels of salinity, blood, dirt, hair)

[11] Lanning David, *SD1-Leather Manufacture*, http://www.hewit.com/sd1-leat.htm

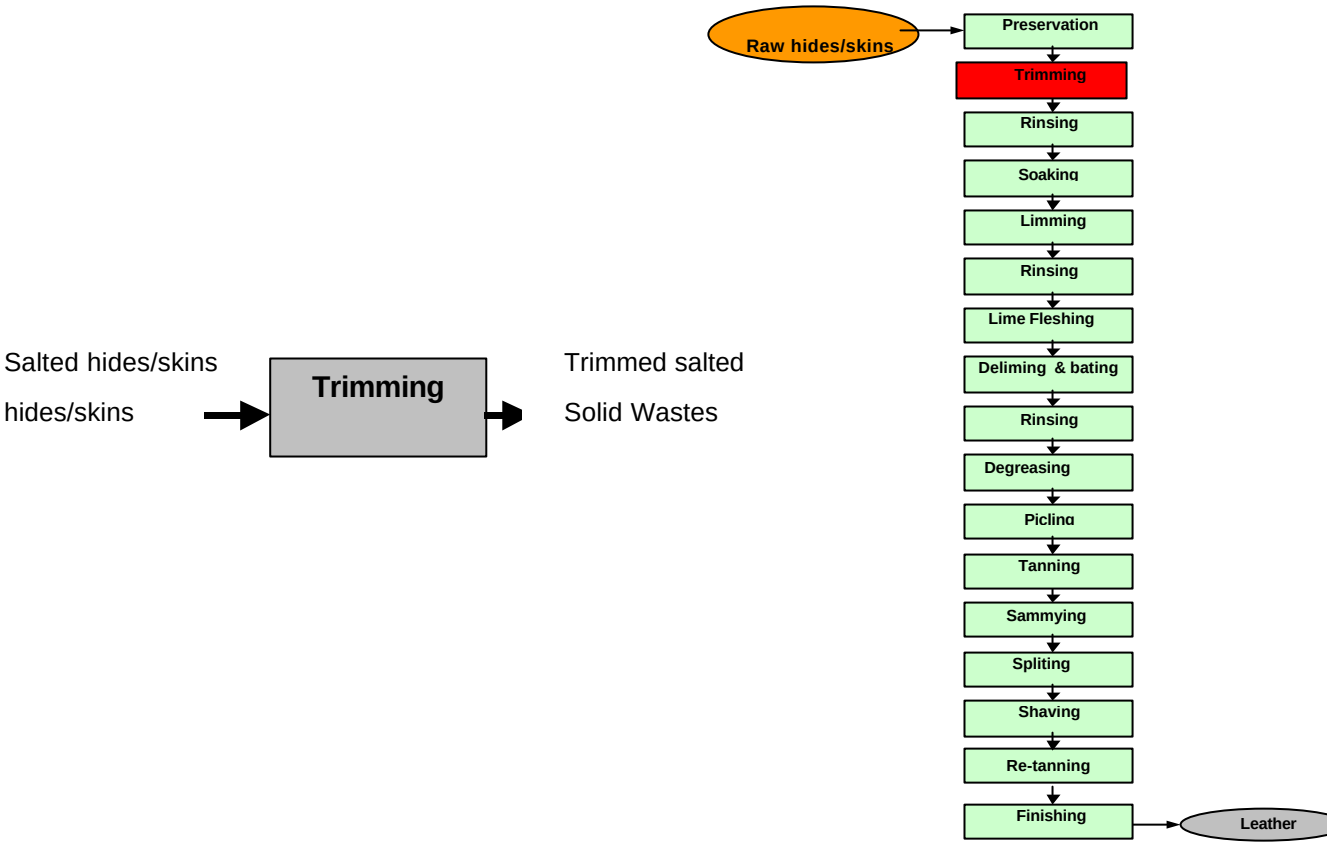
Environmental Consideration
Water Pollution: BOD, COD
Solid Wastes: ----
Air Pollution: Noxious odors

Note: Depending on curing methods, the usage of salts could lead to high levels of salinity in wastewater. Furthermore, The curing method used determines greatly the level of moisture content in the hides or skins to be processed; thus affecting the final needs in water for pelts' re-hydration. Low moisture content could result in a greater need for re-hydration (i.e. higher water consumption). However, the figures for the water percentage would vary considerably depending on the curing method and the time hides or skins have been stored. The table below represents the composition of a freshly flayed hide with its percentage level in water, protein, fats, mineral, etc.

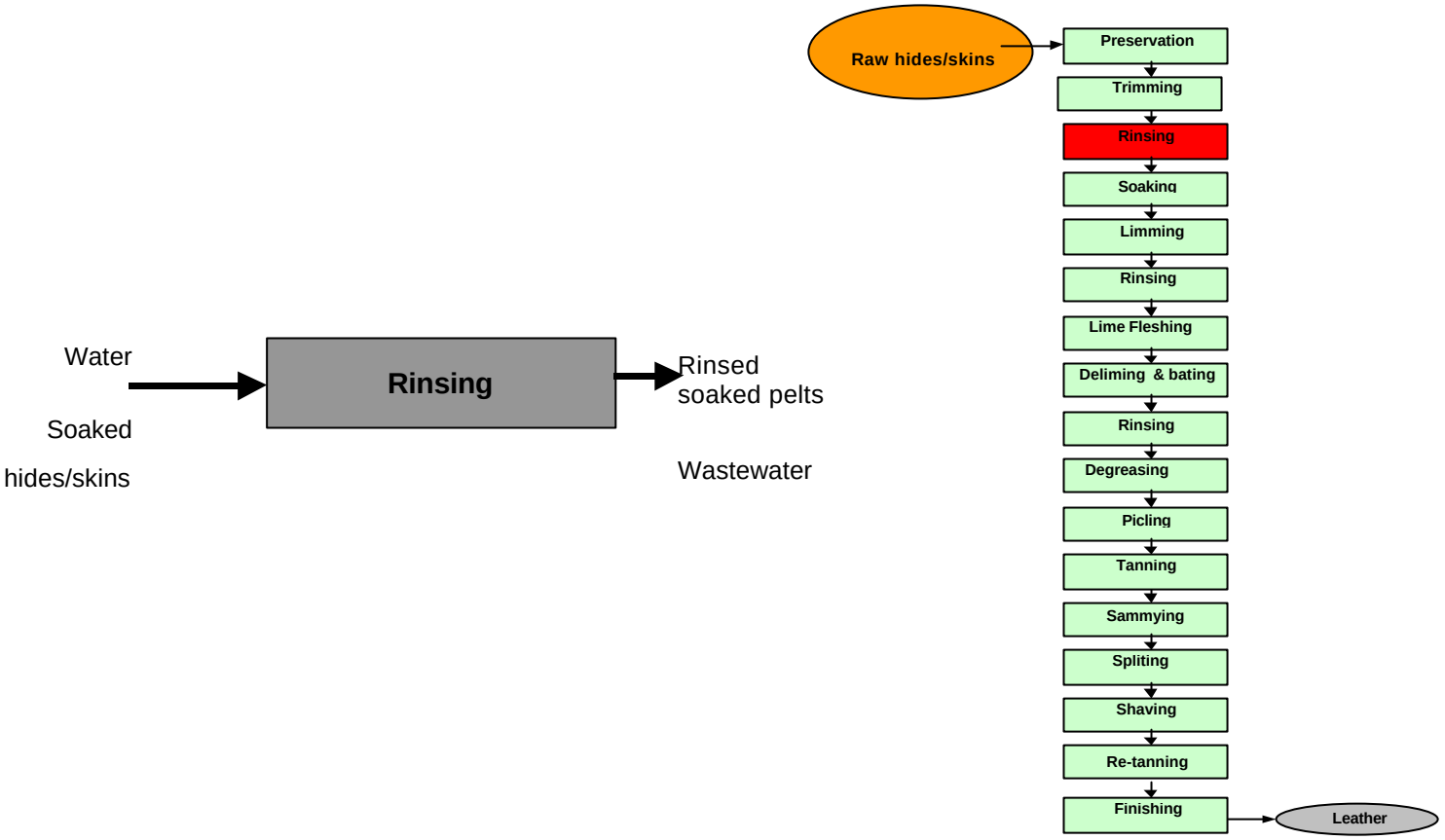
Before the tanning process, the approximate composition of a freshly flayed hide/skin is:

Composition	Hide composition[12]	Goat Skin composition	Sheep Skin composition
Water	64%	64%	64%
Protein	33%	33%	33%
Fats	2% to 6%	2% to 10%	5% to 30%
Mineral Salts	0.5%	0.5%	0.5%
Other substances (pigments, etc.)	0.5%	0.5%	0.5%

[12] Etherington & Roberts Dictionary, *Leather*, http://palimpset.stanford.edu/don/dt/dt2021.html



Preliminary Trimming	
A pre-step to soaking is a preliminary trimming to remove the remaining tails and legs of the hides and skins to be processed. Skins and hides are often received in a cured form, however without always the basic trimming.	
Main Equipment Used	
Hand held tools, mainly knives	
Material In	**Material Out**
Untrimmed preserved hides or skins	Trimmed Pelts Solid Organic Waste Sodium Chloride *(if hides were previously salted for curing purposes)*
Environmental Consideration	
Water Pollution: ---- *Solid Wastes:* Organic solid waste *Air Pollution:* ----	



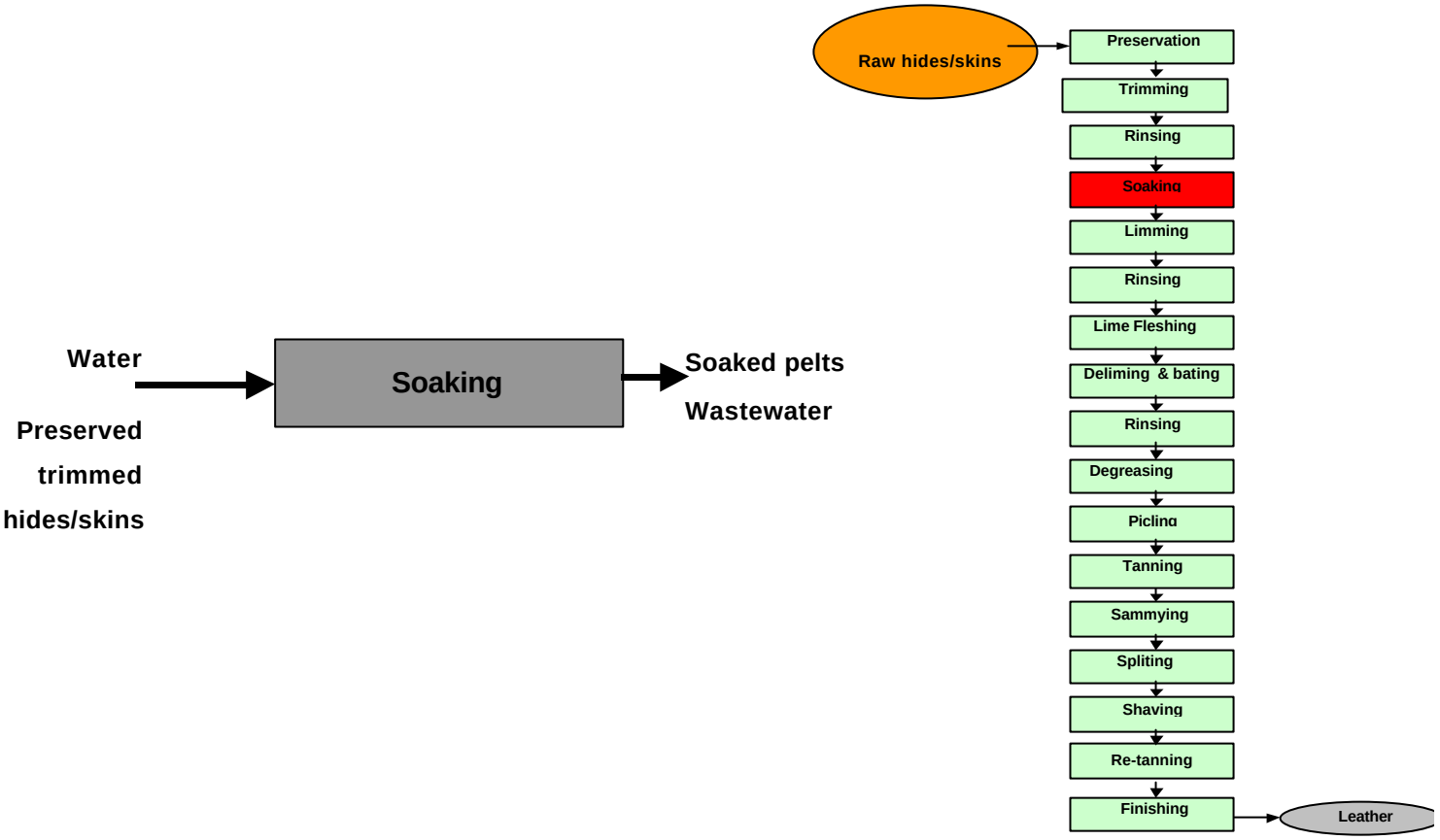
Rinsing

Prior to the soaking stage, rinsing ensures that the stocks of hides or skins have been cleaned of all dirt, blood and dung, etc. and begins to dilute the curing salts.

The rinsing operation takes place in a container full of water, necessary for the cleaning operation. Depending on the equipment used (drum, pit, or paddle) and on the conditions of the pelts the water could be changed and several rinses could be required.

Main Equipment Used	
Drum or Pit or Paddle	
Materials In	**Materials Out**
Water	Cleaned pelts
Soaked or freshly flayed hides or skins	Wastewater

Main Environmental Consideration
Water Pollution: BOD, COD, Suspended Solids, Dissolved Solids, Total Solids, Salts, and Organic Nitrogen *Solid Wastes:* ---- *Air Pollution:* ----



Soaking

The main objective of the soaking step is to reverse the curing process, by re-hydrating, cleaning and preparing the pelts to accept the different chemical and non-chemical agents added at subsequent stages.

Having counted and weighed the hides, the whole operation would usually take place either in a drum or a pit filled with water. Because of many different conditions, the time and temperature necessary for this process depends mainly on the previous method of curing of the stock (i.e. longer time for dry cured skins–approximately 72 hours–and shorter for wet salted hides–24 hours– if using drums).

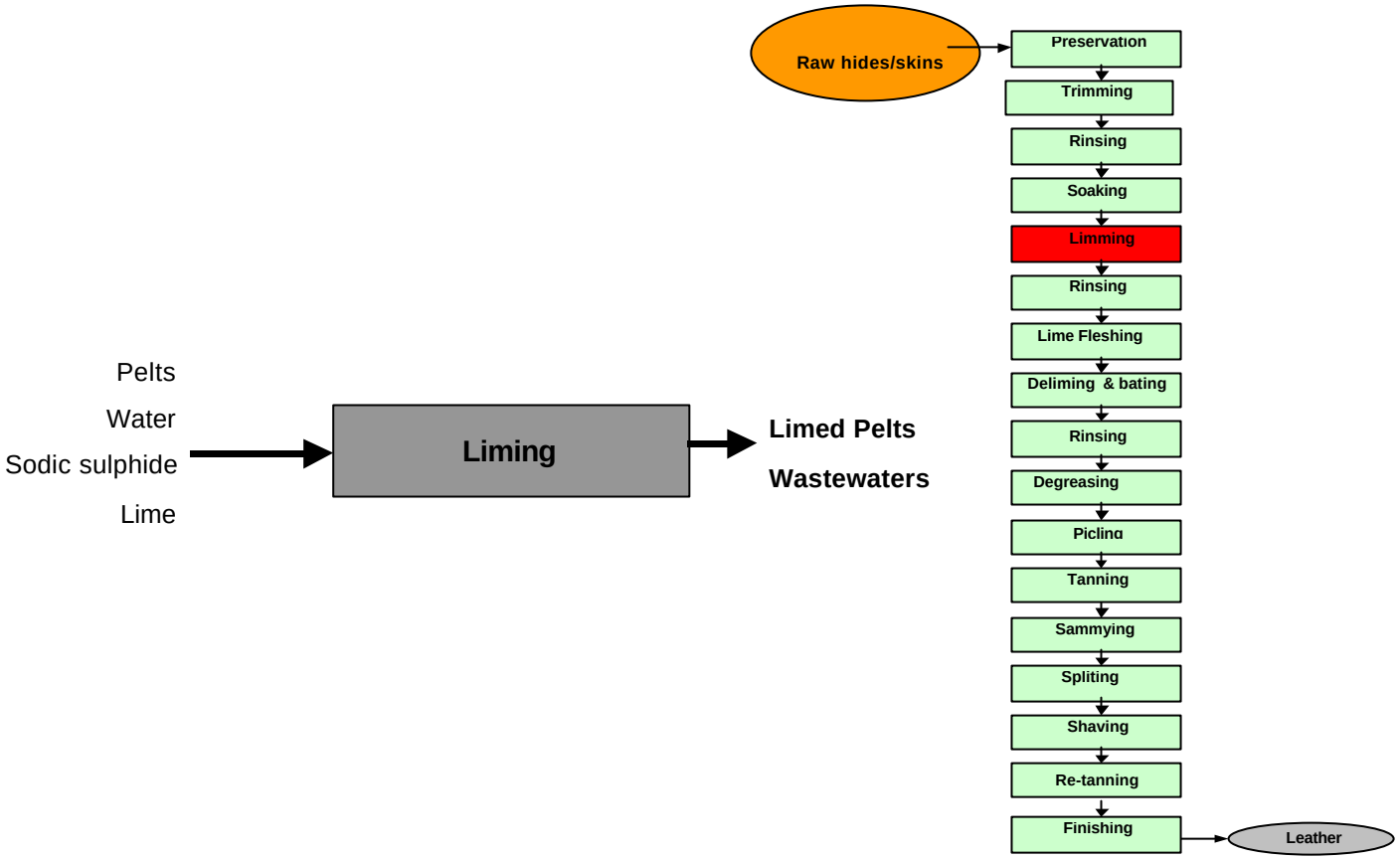
Pelts have to be re-hydrated and cleaned from all sorts of dirt, blood, or non-structural proteins. Soaking has to be done correctly, for the pelts to relax properly. In the case of an incorrect soaking the penetration of chemicals in all the next stages might be patchy and would affect the final quality of the leather[13].

The whole process can be speeded up by adding products such as enzymes, alkalis, weak acids, etc. or slightly warm water –20-25º–to the batch if necessary.

[13] Lanning David, *SD2-Leather Manufacture*, http://www.hewit.com/sd2-leat.htm

Main Equipment Used	
Drum or Pit or Paddle	
Materials In	**Materials Out**
Water	Soaked pelts
Preserved hides or skins	
	Wastewater with impurities, dirt
Main Environmental Consideration	
Water Pollution: BOD, COD, Suspended Solids, Dissolved Solids, Total Solids, Salts, and Organic Nitrogen	
Solid Wastes: Organic and inorganic wastes coming from the hides' or skins' impurities and from the mechanical action of the process	
Air Pollution: Noxious odors, ammonia, H_2S (According to the agents used)	

Note: Frozen and freshly flayed hides or skins that are directly sent to the tanneries do not need to be re-hydrated. Thus the soaking and rinsing steps could be combined together and conducted in one stage.



Liming

Another step in the beamhouse operations performed in leather tanning is liming. At this stage pelts would have been completely cleaned. Nevertheless, hair (or wool depending on the animal) would still need to be fully removed before proceeding to the tanning operation. The liming process is thus necessary for the removal of the hair roots, epidermis and the hair, in order to clean the grain layer for the subsequent stages.

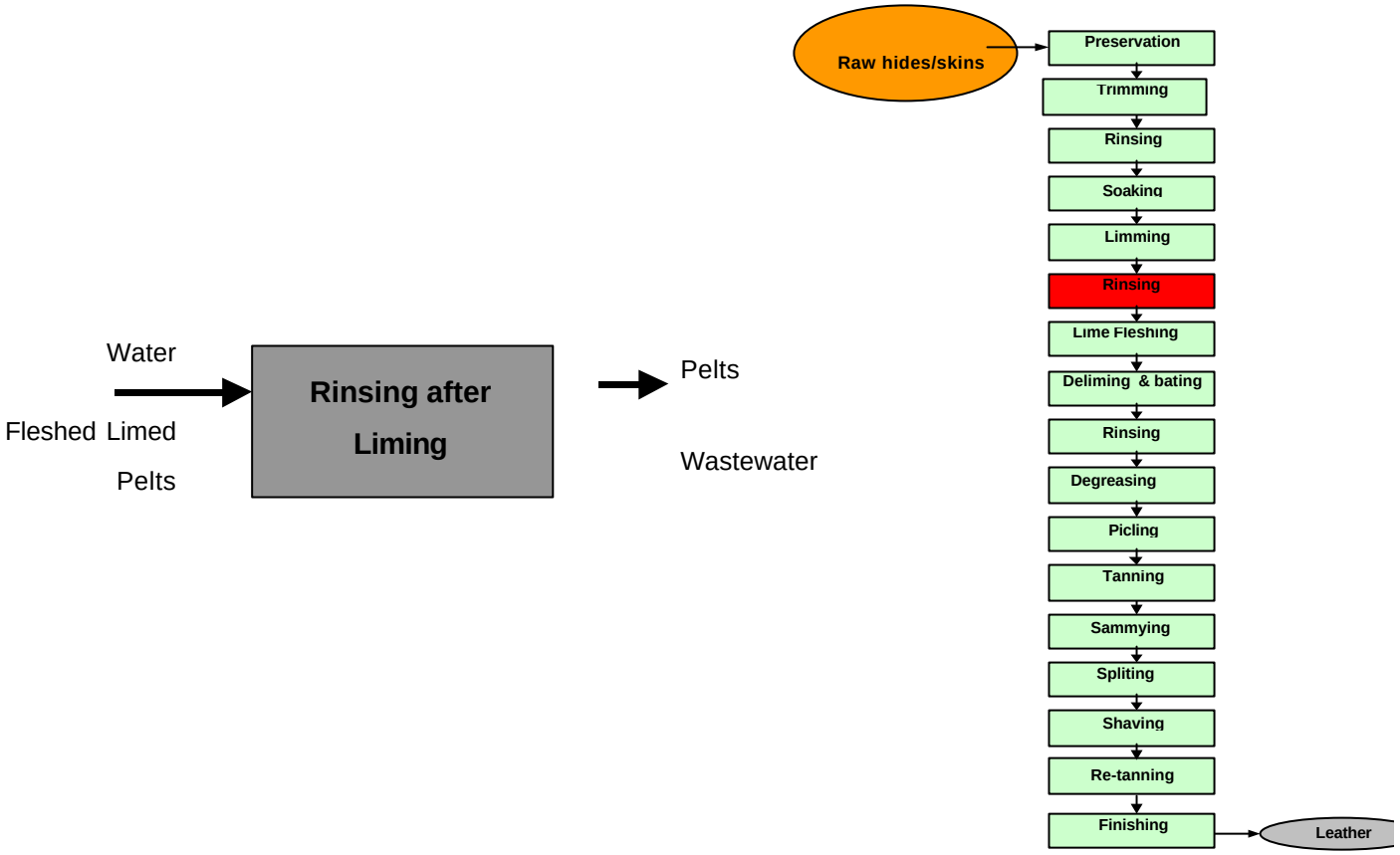
The liming operation requires the mixture of the pelts with various alkaline chemicals, which attack the queratine and by causing the pelts to swell allow the hair to fall freely or to be dissolved.

Lime causes mainly two important physical effects: Osmotic Swelling and Lyotropic Plumping. The result of this operation is that the skin becomes swollen and engorged with water, causing the fiber bundles to open up allowing for thorough penetration of the tanning agents[14].

[14] Ibid

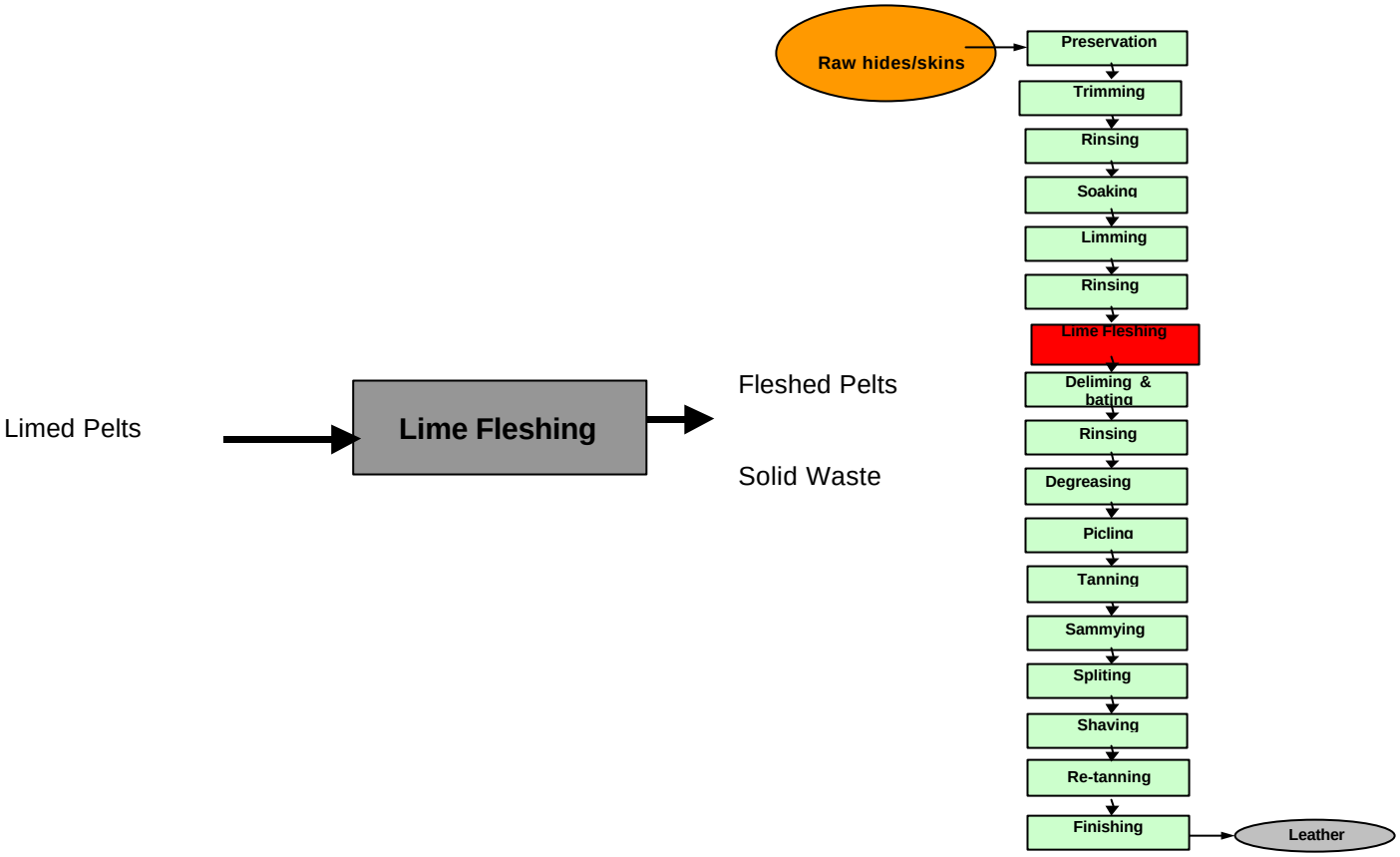
Main Equipment Used	
Drum or Pit or Paddle	
Materials In	**Materials Out**
Soaked Trimmed Hides	
Water	Pelts (Limed Hides)
Sodium Sulfide	Wastewater
Sodium sulfhydrate	
Lime	
Main Environmental Considerations	
Water Pollution: BOD, COD, Suspended Solids, Dissolved Solids, Total Solids, Sulfides, Alkalinity, and Total Nitrogen	
Solid Wastes: Fibers	
Air Pollution: Potential emission of H_2S, Noxious Odors	

Note: Sometimes the hair is partially removed through a mechanical operation halfway through the liming stage.



Rinsing after Liming	
Following the liming stage, excess lime and other material loosened during the de-hairing process are washed away through one or several a rinsing stage.	
Main Equipment Used	
Drums or Paddles	
Materials In	**Materials Out**
Limed pelts	Washed pelts
Water	Wastewater
Main Environmental Consideration	
Water Pollution: BOD, COD, Total Suspended Solids, Sulfides, and Alkalinity *Solid Wastes:* ---- *Air Pollution:* ----	

Note: Depending on the pelts' condition and on the tanners' techniques additional rinsing could be conducted.



Lime Fleshing & Trimmimg

Fat and tissues still remaining on the under side of the skin have to be removed to allow a better penetration of the chemical agents in later stages. This operation promotes the entry of water from the flesh side, especially because it has a higher capacity of absorption than on the epidermal or grain side. In addition, the fleshing operation removes all remaining hair roots that did not fall out during the liming operation.

The process can be done with the help of a fleshing machine.

Following this step an additional trimming is needed to remove, rough edges and undesired pelt sections still pending.

Main Equipment Used

Manual or Machine Fleshing/Manual Trimming

Materials In	**Materials Out**
Pelts	Fleshed Pelts Solid Waste
Main Environmental Considerations	
Water Pollution: Due to the water necessary to operate the fleshing machine, wastewater with some lower chemical contents similar to the ones in the wastewater produced through the liming stage could be generated *Solid Wastes:* Organic matter with high levels of lime content *Air Pollution:* Noxious odors	

Note: The fleshing operation could also be conducted directly after the pickling stage or the soaking and rinsing steps.

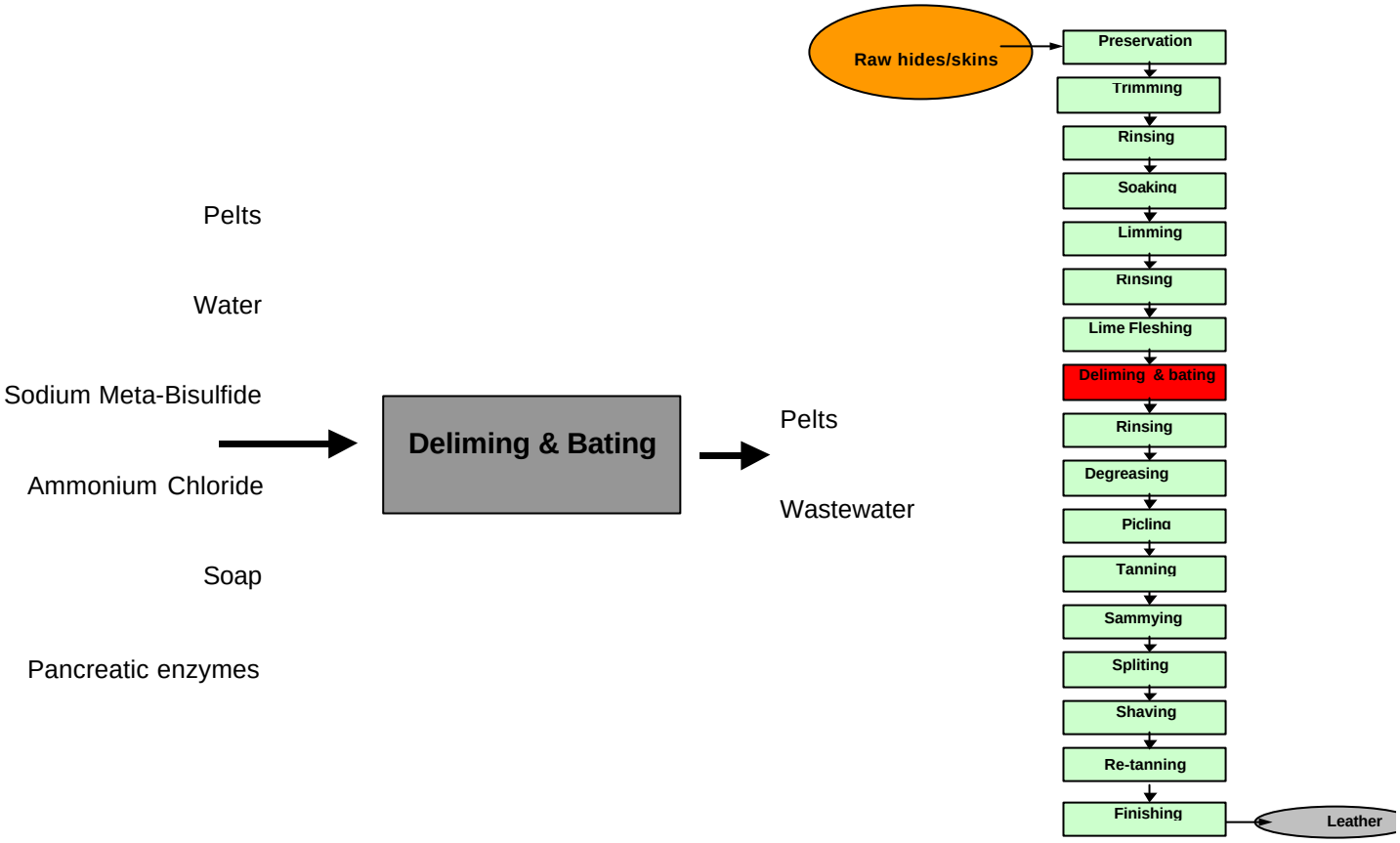
The process called green fleshing is conducted previous to the liming operation and could represent a series of advantages[15]:

It provides a more uniform grain surface and helps the liming products to penetrate

- It prevents from reducing the effect of the liming operation that occurs when thick flesh with important amounts of fat is introduced for liming
- Formation of calcium soaps during liming and oily matter during tanning is held to a minimum because the fat is eliminated.

It should be noted however that green fleshing represents also some disadvantages, as it could in some cases lead to mechanical damage of the pelts, which have not been fully relaxed.

[15] Etherington & Roberts Dictionary, *Green Fleshing*, http://palimpset.stanford.edu/don/dt/dt1638.html



Deliming & Bating

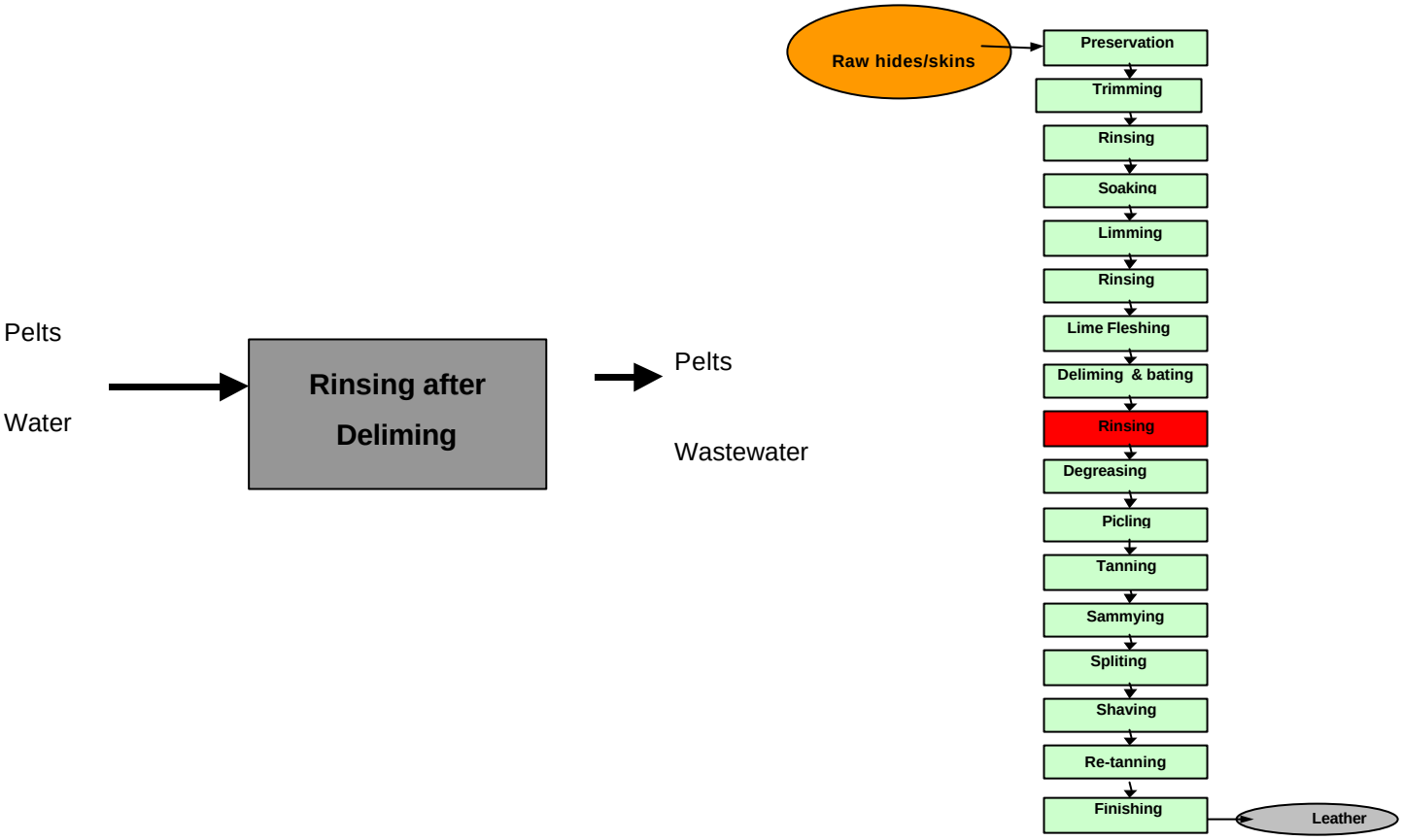
Deliming: To reduce the high alkalinity of the pelts following the liming stage a deliming operation is needed. Thus ammonium salts (chlorides and sulfates) are used to neutralize the lime content resulting in a de-swelling of the pelts. This reduction in the pH level will bring the hides or skins to their original thickness. In conjunction to the deliming operation another process called bating takes place in the drum or paddle used.

Bating: Enzymes are added to digest and dissolve all of the remaining non-structural proteins. This process clears cavities within the leather matrix to allow it to receive fillers and tanning agents and would ultimately improve the finishing characteristics of the finished end product, by giving it a softer texture.

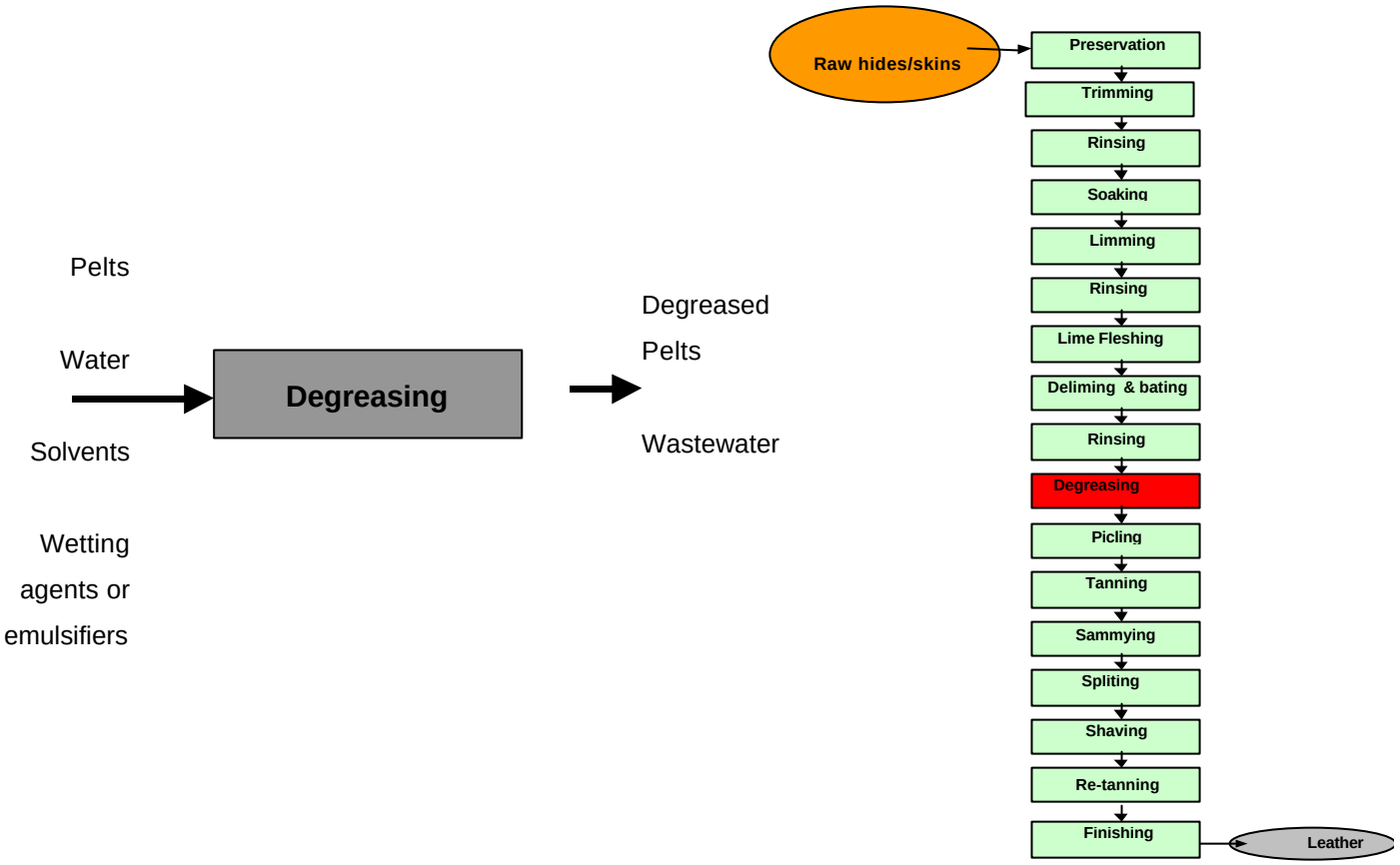
Main Equipment Used

Drums or Paddles

Materials In	**Materials Out**
Pelts	
Water	
Sodium Meta-Bisulfide	De-swelled Pelts
Ammonium Salts	Wastewater
Wetting agent	
Pancreatic Enzyme	
Main Environmental Considerations	
Water Pollution: BOD, COD, Ammonia-Nitrogen, and Sulfur	
Solid Wastes: Fibers	
Air Pollution: $NH_{3,}$ possible H_2S formation (in case of a bad process control)	

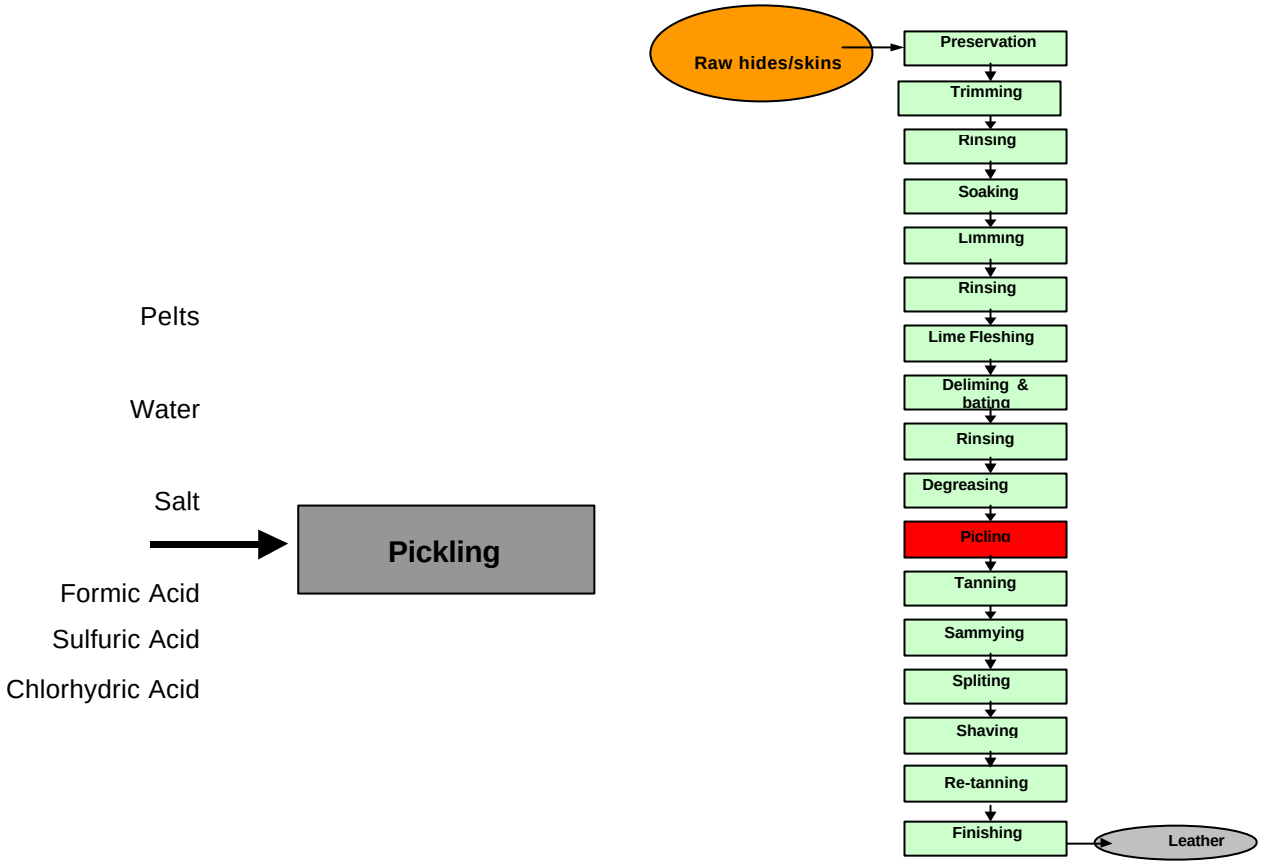


Rinsing after Deliming	
Following the deliming and bating stage an extra rinsing operation is performed to clean the leather from the remaining chemicals.	
Main Equipment Used	
Drum or Pits or Paddle	
Material In	**Material Out**
De-swelled Pelts	Pelts
Water	Wastewater
Main Environmental Considerations	
Water Pollution: BOD, COD, and Ammonia-Nitrogen	
Solid Wastes: ----	
Air Pollution: ----	



Degreasing	
After the deliming and bating stage, a degreasing step could follow. This operation is mainly conducted in the case of sheep or pigskins where the grease contained in such fatty pelts is eliminated to prevent the formation of chrome soaps and fat spues in later processes. The degreasing step is sometimes carried out on bovine hides as it improves the uniformity of the dyes.	
Main Equipment Used	
Drum or Pit or Paddle	
Materials In	**Materials Out**
Pelts	Degreased pelts
Water	Wastewater
Solvents (rarely)	
Wetting Agents or Emulsifiers	

Main Environmental Considerations
Water Pollution: BOD, COD, and Dissolved Solids, Fat *Solid Wastes:* ---- *Air Pollution:* Odors



Pickling

Pickling is the final beamhouse stage conducted before the chrome tanning necessary for the following purposes:

- It is conducted as a pre-step to tanning necessary to adjust the pH level of the skins or hides thereby sterilizing the stock following the bating action. In addition the pickling operation allows a better absorption of the tanning agents that are to be added in the following stages.
- It is also a way of preserving the hides.

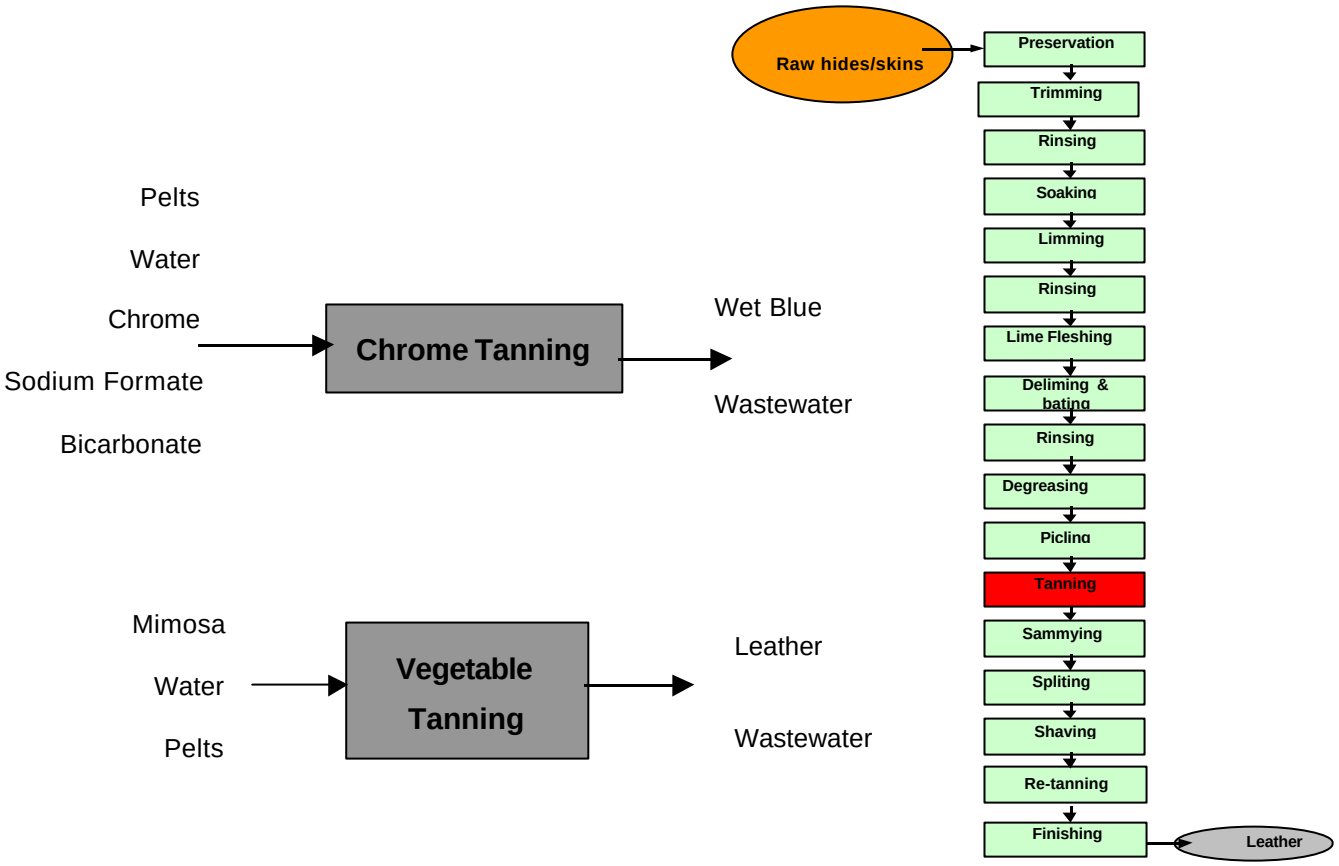
Pickling is mainly a step for use in modern Chrome tannages, and takes place in drums or paddles with a mixture of water, salts and acid (sulfuric, chlorhydric, acetic or formic, or a mixture).

Main Equipment Used

Drum or Pit or Paddle

Materials In	**Materials Out**
Pelts	
Water	Wastewater
Salt	Pickled pelts
Formic Acid	
Sulfuric Acid	
Chlorhydric Acid	
Main Environmental Considerations	
Only if the pelts are meant for export that the wastewater is generated	
Water Pollution: Suspended Solids, Dissolved Solids, and Total Suspended Solids, Low pH, Salts, COD.	
Solid Wastes: Fibers	
Air Pollution: To prevent the emissions of H_2S, some small quantities of Sodium Bisulfate or Hydrogen Peroxide can be added	

Note: The above pickling operation precedes the chrome tanning stage only. Pickling may or may not be carried out prior to vegetable tanning.



Tanning

At this stage the hides or skins are treated with either mineral or vegetable agents, which combine with the collagen, transforming it into leather. Depending on the desired end product, the most commonly used techniques for the transformation of the pelts into leather are either Chrome tanning or vegetable tanning.

Chrome tanning:

Chrome tanned leather is done using soluble chromium salts, primarily chromium sulfate. Chrome tannage represents nowadays one of the most commonly used techniques in leather tanning due to its quality and the speed of the whole process compared to vegetable tanning.

Chrome tanning stabilizes the collagen structure of the hides and skins and imparts them with their basic properties. Thus, trivalent Chrome salts are used to give green/pale blue leather, which is more resistant to heat. The end product called wet blue is mainly used as a raw material for leather goods, clothing, shoe uppers and industrial leathers.

Vegetable tanning:

Vegetable tanned leather is done using vegetable materials derived from tree bark and various other plants. The latter gives brown colored leather used mainly for shoe soles and leather goods

Vegetable tannage, which has been conducted over the past centuries, has been completely replaced by chromium as the major tanning process. However it is still employed for sole and saddles and some specialty leathers. Vegetable tanning necessitates a long operation that could take as little as one day (in drums) to several weeks in (pits)[16].

Nowadays, as it is considered more ecological, vegetable tanning is also used to manufacture upholstery for cars.

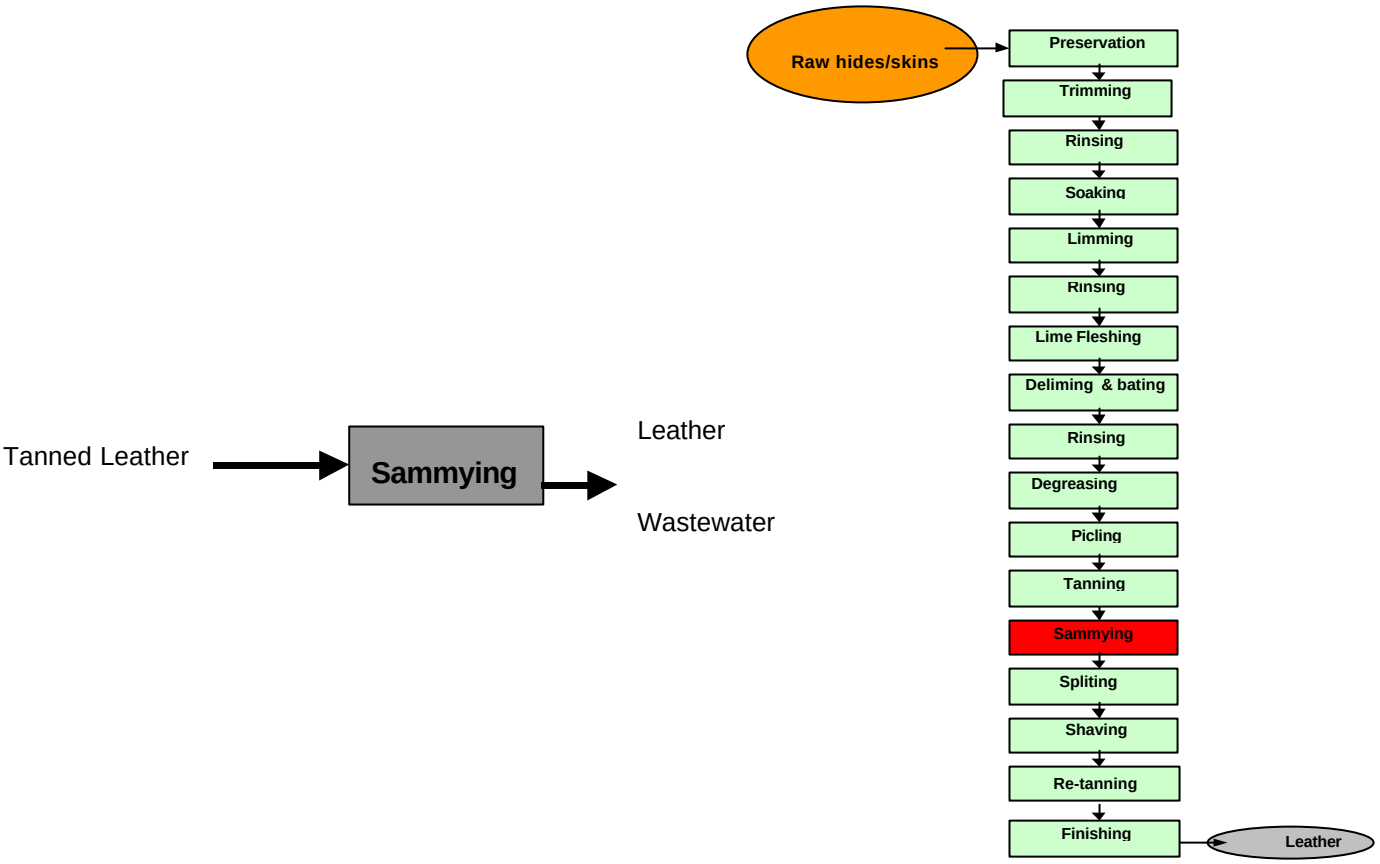
Main Equipment Used	
Drums, Pits or Paddles	
Materials In	**Materials Out**
Chrome Tanning	
Pelts	
Water	
Chrome salts	Chrome tanned Leather (wet-blue)
Sodium Formate	Wastewater
Bicarbonate	
Vegetable Tanning	
Water	Vegetable tanned Leather
Mimosa[17] or other tannins	Wastewater
Quebracho	
Chestnut	

[16] UNEP, Tanneries and the Environment: A technical Guide, UNEP publication, Second Edition 1994, Paris, France, p 18

[17] Vegetable based tannins

Main Environmental Considerations
Chrome tanning *Water Pollution:* BOD, COD, TSS, Chromium, Salts, Acidity *Solid Wastes:* ---- *Air Pollution:* ---- **Vegetable tanning** *Water Pollution:* BOD, COD, Fenolic products will be generated from the tannins or auxiliary synthetics, acidity *Solid Wastes:* Fibers *Air Pollution:* ----

Note: The tanning operation could be conducted in a multitude of ways with a variety of chemicals. However the most common ones are the two methods shown in the drawing above. There are also other less common tanning techniques that could be used, some of which have a different environmental impact than the chrome tanning process. Such techniques could rely on the utilization of chemicals such as titanium; zirconium salts, or also could be a combination of chemicals (i.e. aluminium-chromium, aluminium and vegetable tanning with a chromium retan…)



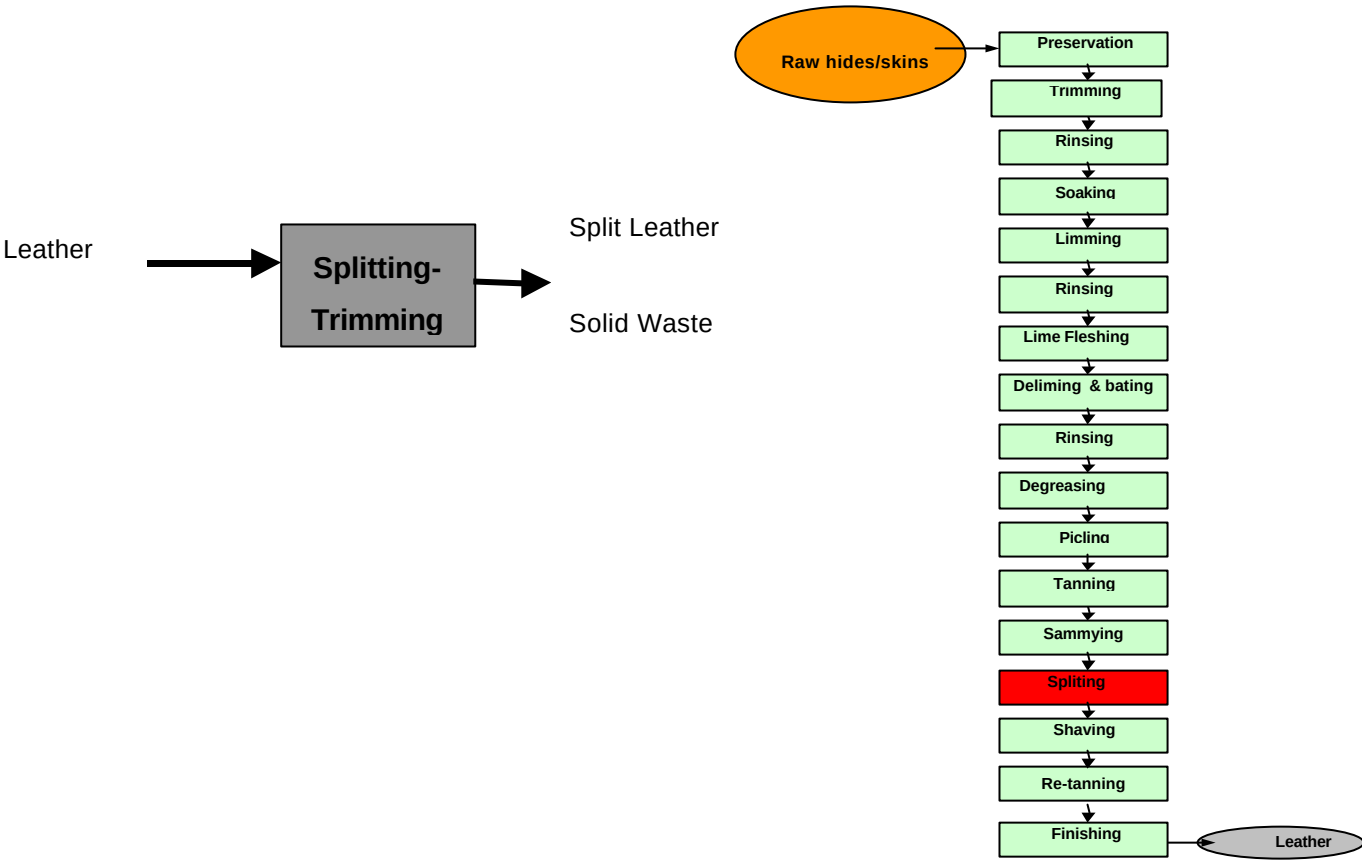
Sammying	
Following the tanning step, the leather is passed through a sammying machine (pressurized rollers) to remove all the excess moisture content. This step would de-water the leather but would nevertheless keep it fairly moist for later processes. A complete drying process of the leather would however take place in subsequent stages either through vacuum machines or by hanging the leather in a dry room for a few days (in the case of vegetable tanned leather the temperature must not be too high).	
Main Equipment Used	
Sammying Machine	
Materials In	**Materials Out**
Tanned leather	Tanned leather (of lower moisture content) Wastewater

Main Environmental Hazards

Water Pollution: Wastewater is generated through this operation with chrome or tannin content depending on whether it comes from chrome or vegetable tanning.

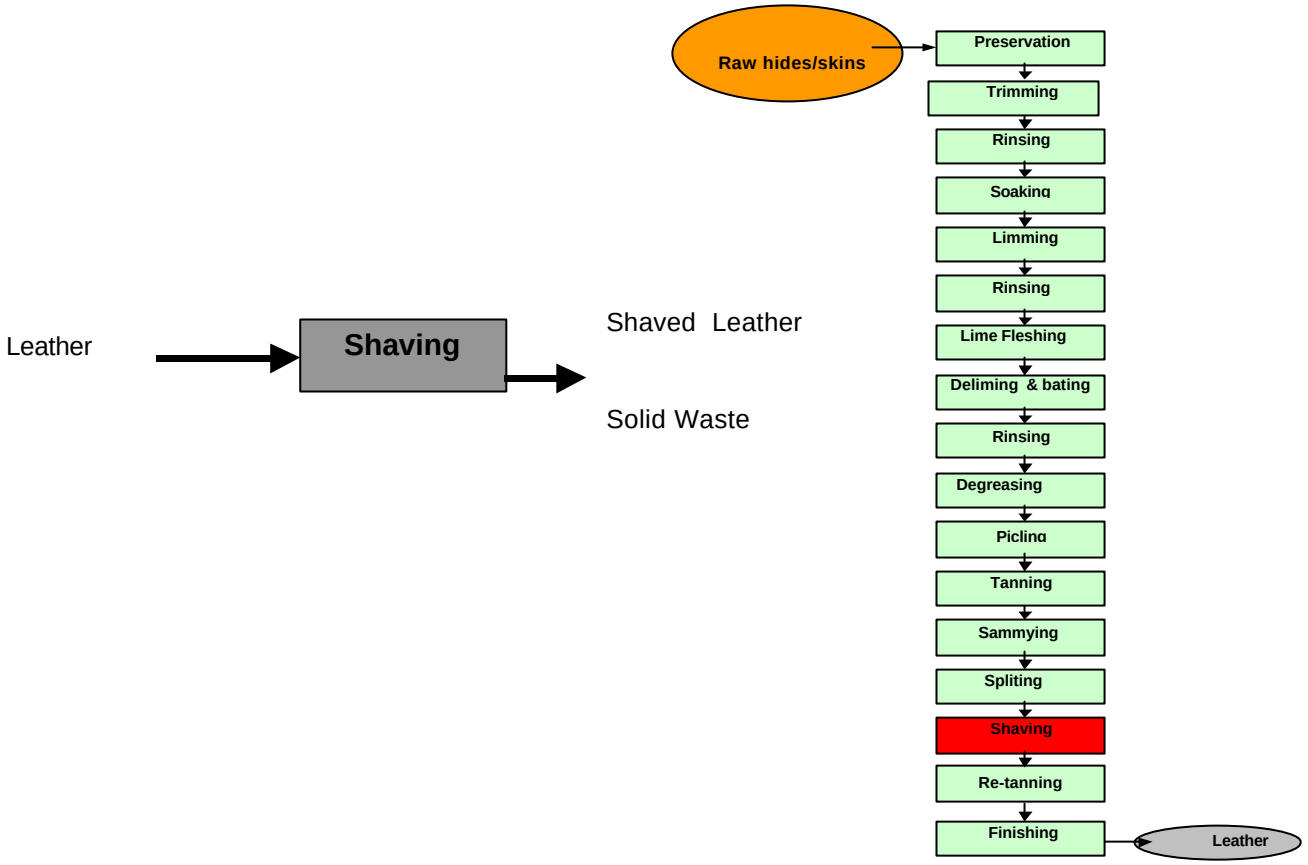
Solid Wastes: Fibers

Air Pollution: ----



Splitting & Trimming	
Hides or skins at this stage are split horizontally into two layers where the upper part and the lower part are collected and used for different end products.	
Main Equipment Used	
Splitting Machine	
Materials In	**Materials Out**
Leather	Split leather Solid Waste
Main Environmental Considerations	
Water Pollution: ---- *Solid Wastes:* Organic matter containing chrome *Air Pollution:* ----	

Note: Some tanneries conduct the splitting at an earlier stage of the tanning process, directly after the liming operation. An early splitting is usually done to obtain a specific leather quality with a grain layer of chosen thickness that could be taken off and tanned separately. In addition the splitting conducted at earlier stages could also have numerous environmental advantages (see pollution prevention options, Chapter 4)



Shaving

The shaving operation is necessary for two reasons:

- Because the leather surface has different thicknesses depending on the parts of the animal, shaving is necessary to render it uniform in thickness.
- Any slight differences in thickness after splitting are corrected by shaving.

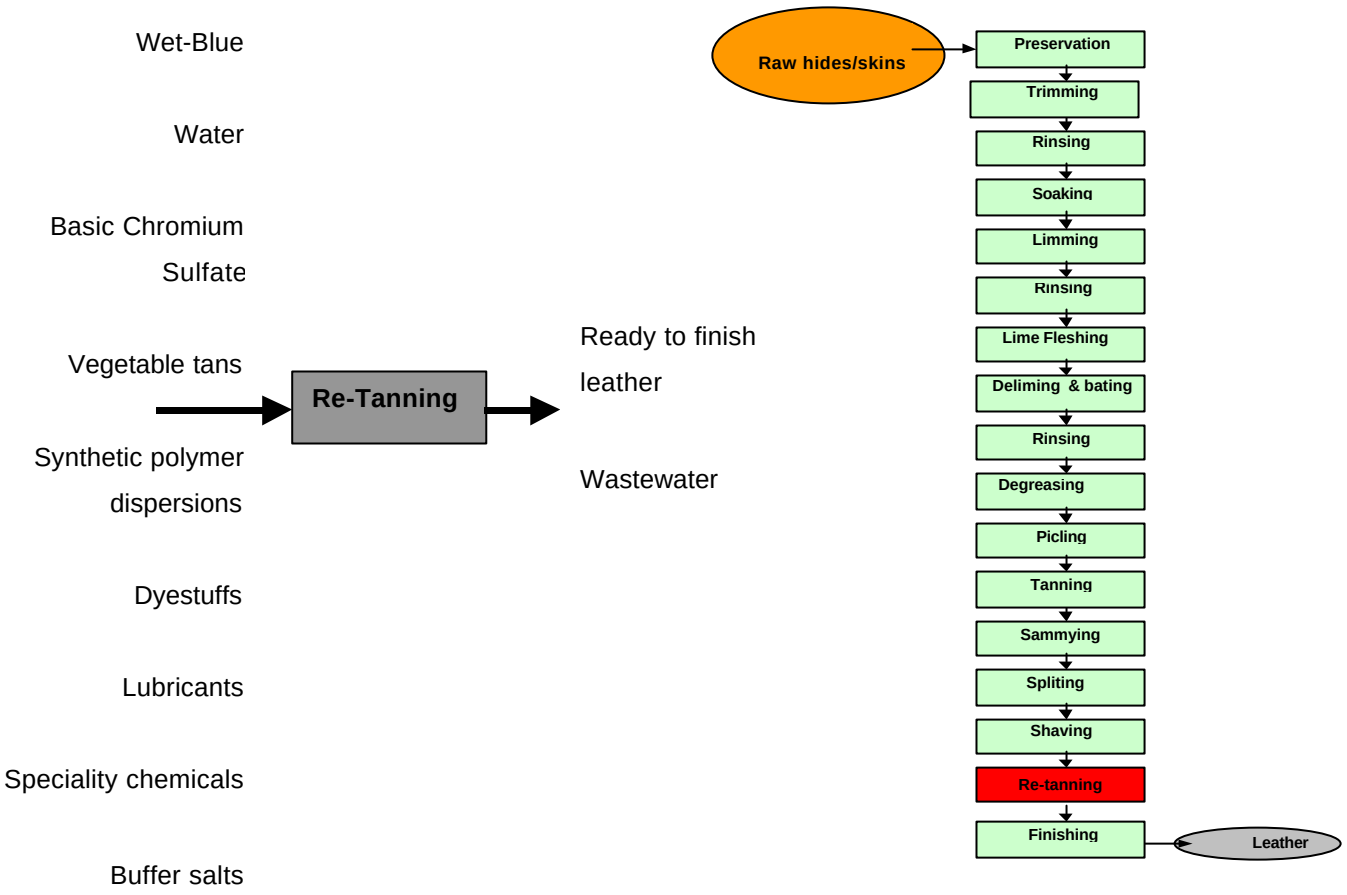
According to the final end product needed the thickness of the shaving could be adjusted to suit the customers' needs depending on the products to be manufactured.

Main Equipment Used

Shaving Machine

Materials In	Materials Out
Leather	Shaved Leather
	Solid waste (shavings)

Main Environmental Considerations
Water Pollution: ----
Solid Wastes: Organic matter containing chrome or vegetable waste
Air Pollution: ----



Re-Tanning

This stage involves some operations that will impart the final physical properties of the leather (i.e. texture, resistance…). The main steps conducted in re-tanning are:

Neutralization: In the case of mineral tanning an additional neutralization step could follow to remove the free acids remaining in the tanned leather. This step however is not mandatory and is conducted according to the final end product quality needed.

Bleaching: Bleaching is conducted in the case of vegetable tanned leathers to remove the stains and prevent the oxidation of the surface tannins.

Re-tanning: This step is conducted to produce a specific leather type with the properties required from general crust leather. Thus, re-tannage is done to improve the feel, fullness and handle of the leather, to improve its resistance to alkali and perspiration, to assist in the production of leather grain leathers…

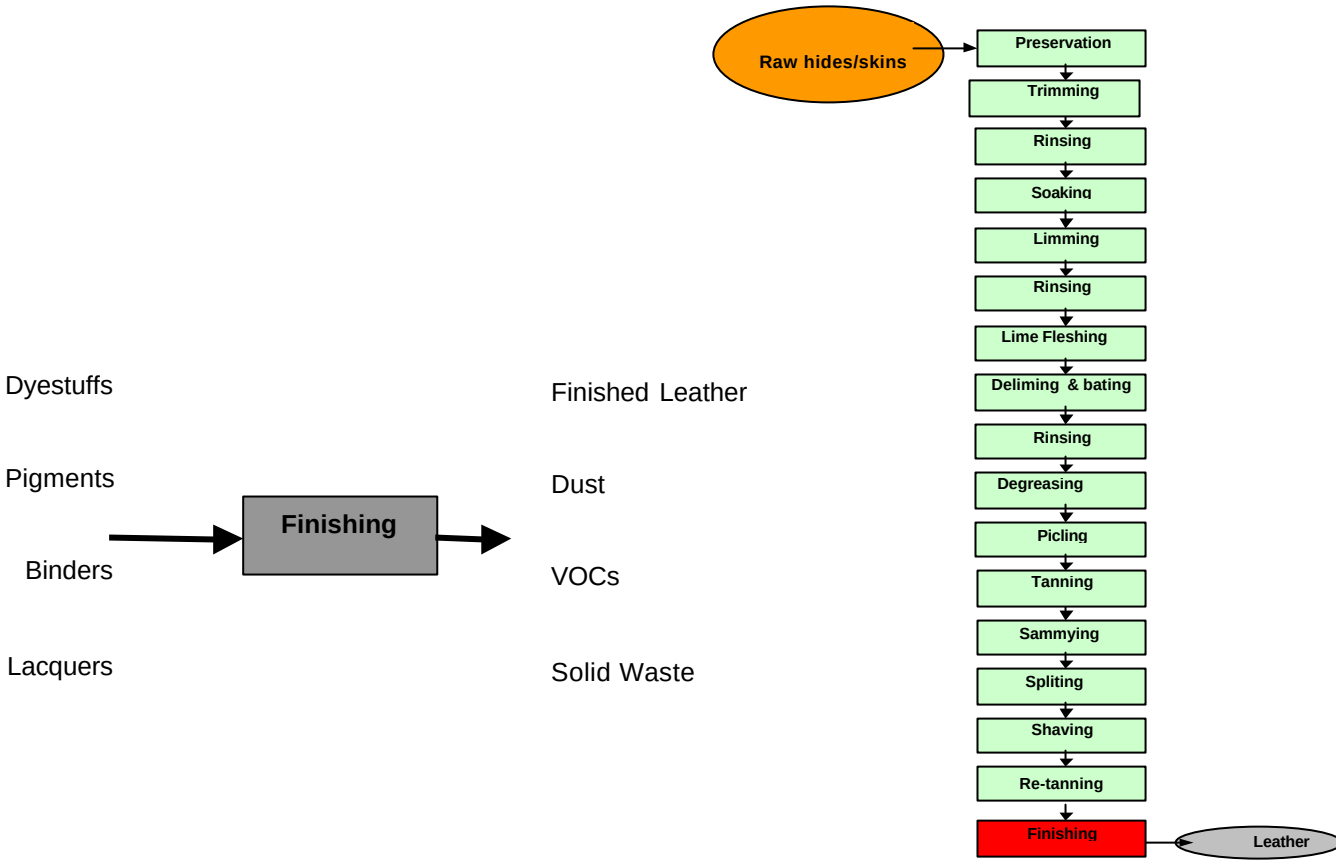
Dyeing: At this stage the desired dyeing agents (i.e. acid dyes, anionic dyes, cationic dyes, reactive dyes, sulfur dyes, etc.) are added to give to the leather its desired shade.

Fatliquoring: Lubrication is conducted in this step to provide the leather with a desirable softness. Furthermore, fatliquoring will affect some additional physical properties such as extensibility, tensile strength, wetting properties, waterproofness, etc.

Drying: A variety of techniques can be applied separately or in combination sometimes to dry the leather (i.e. air drying with/without energy, hot water drying, infrared drying, vacuum drying, high-frequency drying, etc.). It should be noted however, that different techniques might affect the final leather characteristics

Main Equipment Used	
Drums / Drying Machines	
Materials In	**Materials Out**
Varies according to desired end product	Varies according to desired end product
Main Environmental Considerations	
Water Pollution: BOD, COD, TSS, Chromium, and vegetable tans, Dye-agents, organic matter containing Chrome, unset fats *Solid Wastes*: Fibers *Air Pollution:* ----	

Note: For practical reasons and due to the limited scope of the present study, this stage (i.e. re-tanning) was just covered generally, compared to the other pre-finishing stages (i.e. Beamhouse and Tanyard). This is mainly due to the fact that the re-tanning process varies considerably depending on the desired end product and the variety of techniques in application (see Annex R2).



Finishing

The application of a coating to the leather is done through the finishing stage, which is necessary to improve the use properties of the leather in general and to protect it from wetting and soiling. Furthermore the finishing operation is necessary to level out patches and grain faults and to modify the surface properties (i.e. shade, luster, handle, etc.). Thus, in the finishing process, the passage of the tanned leather through various mechanical and other non-mechanical operations would give it its final shape, texture and desired properties. Some of the finishing steps are: conditionings, staking, buffing, dry milling, polishing, plating…

Main Equipment Used

Buffer Spraygun, Roll Coater, etc.

Materials In	Materials Out
Varies according to desired end product	Varies according to desired end product

Main Environmental Considerations
Water Pollution: Remainders of finishing agents *Solid Wastes:* Different kinds of wastes coming from leather finishing such as trimmings… *Air Pollution:* Solvents, Buffing dusts…

CHAPTER III: TANNERIES AND THE ENVIRONMENT

In the past, environmental pollution caused by tanneries was considerable, and still is today in countries where the process is not properly managed or controlled. Typical environmental complaints expressed by the public concerning tanneries are odors and water pollution from untreated effluents. In addition to rapid environmental degradation especially on land and water, problems are mainly related to the increased use of toxic persistent synthetic chemicals such as pesticides, solvents, dyes, and finishing agents.

When there is neither control nor awareness on the part of tanners, the diverse environmental impacts of the tanneries affect many environmental parameters including surface water, soil, ground water, air, and waste management systems. It is important to note that the load of diverse impacts on the environment depend on the actual intensity and the type of control and management practice in this sector.

Impacts that tanneries may cause if pollution prevention measures are not taken

3.1 Impact on Surface Water

If wastewaters are discharged into neighboring surface water bodies, namely rivers or small water canals, and eventually reach the sea, such effluents can deteriorate rapidly the physical, chemical, and biological properties of the receiving water bodies. Loads of organic matters decompose at a high rate in water giving rise to noxious odors, and depleting the dissolved oxygen in water, which is needed for its decomposition. As oxygen is vital for aquatic life, its decrease would highly affect water biodiversity and alter its existence. Furthermore, the amounts of suspended solids (i.e. lime or insoluble salts derived from calcium) cause turbidity, and by settling on the bottom of the water body destroy habitats, microorganisms and other living life found in the same. In addition, the chemicals and toxic residues (i.e. chromium, sulphides, ammonia, etc.) used in tanning, render the water unsafe for any domestic usage or recreational activity.

Water consumption is a critical issue in environmental analysis of an industry and especially a tannery. Water is a sensitive environmental parameter with regards to its quality and quantity. The increased levels of environmental pollution deteriorate water quality, thus decreasing the amounts available for consumption. In addition, with the increase in water consumption for domestic, agricultural and industrial purposes, and the improper management of water resources, water supply is becoming insufficient in some places. In addition to the increase in water demand, the increase in water use in the tanning process would augment the use of chemicals and wastewater loads. Consequently, the higher pollution loads need treatment plants with larger capacities and additional treatment costs.

3.2 Impact on Land

The tannery site and layout, specifically pits, lagoons, storage areas, and waste dumps may severely damage the underlying soil. This damage would alter subsequent land use for agriculture, recreation, or even building. It also accelerates soil erosion. Soil damage occurs when the pollutant load is larger than the neutralizing capacity of the soil. If the soil structure is damaged, its agricultural production capacity would decrease, and it would take a long period of time for soil to recover. Therefore, pollutant levels should be continuously monitored especially if the treated effluent is to be dispersed on land or used for crop irrigation. Disposing of tannery waste in water system used for irrigation purposes can affect the soil fertility level due to the important salt accumulation within the soil[18].

Dumped wastes on land would stagnate and produce noxious odors. All tanning pollutants affect soil, but the most significant are Chrome, which can in certain cases affect the growth and development of crops, and Sodium, which alters the Sodium Absorption Ratio (SAR). The substitutes of Chrome, namely Zirconium, Titanium, and Aluminum also have detrimental effect on plant growth. Land pollution would subsequently lead to groundwater pollution due to high salt content and toxic components. Furthermore, the remaining organic wastes could lead to certain microbiological pollution.

[18] ESCWA, Environmentally Sound Technologies in the Tanning Industry, United Nations, New York, pg. 21

3.3 Impact on Ground Water

Groundwater is an important source of water supply for many communities. Its self-purification capacity is less than that of surface water as it moves slowly and is out of contact with air. Groundwater contamination occurs when wastewater and chemicals seep through soil from unlined ponds, pits, pipes and drains, or from dumps, spills, and direct discharge of effluents on land. Significant tanning pollutants that could be generated through the tanning process are Chlorides, Tannins, Sulphates, Sulphides, and all trace of organic chemicals and solvents. Furthermore, Nitrogen in large amounts in water is a serious threat to health, especially for babies.

3.4 Impact on Air

Air pollution generated from the leather tanning activity can be related mainly to three different sources. These are listed below, along with their various environmental impacts.

- Decaying biological material generated from the tannery's wastewaters can cause some gaseous emissions;

The tanning industry treats generally important amounts of salted or non-salted hides and skins, generating large amounts of solid waste. The fact that, undesired and trimmed chunks of organic material are often left in a state of advanced decomposition, causes the generation of undesired and noxious odors. Additional odors could also come from poor solid waste management practices.

- Gases are generated at some different tanning operations;

Sources of odors from the tanning process are: accidental Sulphide emissions from de-hairing and waste treatment; Ammonia emissions from un-hairing and de-liming liquors, and from the decomposition of proteins. In the finishing operations, emissions from solvents impose a workplace health problem. If efficient technology and controlled operations are used, these emissions would be avoided. Furthermore, Leather dust, produced during the buffing process, is considered as a potential carcinogen for exposed workers.

- The gases emanating from the boilers and generators' activities;

Typical air pollution contaminants such as CO, CO_2, NO_x, and SO_x are also emitted from tanneries through the use of boilers and generators.

3.5 Impact on Waste Management Systems

If solid wastes from tanneries are disposed of in landfills they create highly objectionable odors. Special linings and leachate treatment systems may to control sweepings of chemicals to ground water should be installed in landfills receiving solid wastes from tanneries. Sludge disposal in mismanaged industrial waste dumps has led to severe groundwater contamination. Furthermore, some containers of chemicals used by tanners are found in open dumps and are sometimes re-used by people, which could result in poisoning and adverse effects on health.

Tanneries' wastewaters cause encrustation of Calcium Carbonate in sewers and solid deposition. High Sulphates concentrations would increase the corrosiveness and deterioration of concrete or cement. Furthermore, some toxic components could interfere with the biological processes in sewage treatment plants.

3.6 Effect on Human Health

The tanning process involves the use of chemicals, which might represent potential hazards to human health. These hazards are not only occupational but also they can affect the surrounding environment media and indirectly the public at large. The environmental issues of concern range from mere nuisance such as bad odors generation to more serious problems such as toxic H_2S emissions, or small particles generation, which might have an effect on human heath. Similarly, tanning wastewater, which is often laden with chemicals and heavy metals, can pollute the soil and water resources, leading to serious damage to fauna and flora if not properly managed. Pollutants will then be bio-concentrated through the food chain reaching as such the human beings. The resulting health effects can vary from chronic symptoms, such as fatigue, disability, and illness to other more serious effects. In an effort to reduce the potential health hazards, some governments have issued strict regulations encouraging or enforcing the adoption of cleaner production processes and pollution prevention options.

3.7 Effects of Most Significant Tanning Pollutants

Chromium

The use of Chromium in the tanning industry is still a controversial issue due to its different persistence and potential toxicity with its different chemical forms. The most commonly used form in the tanning industry is trivalent chrome, which has a lower toxicity than the hexavalent form. Trivalent chrome is usually precipitated from solution, and its potential for conversion to more toxic forms is relatively low. The adverse effects of chrome depend on its chemical state. Diverse effects have been noted on humans, aquatic life, and terrestrial plants. This is realized due to its ability to move between media. The re-use of sludge containing Chromium for irrigation purposes is not recommended.

Chrome Substitutes

Chrome substitutes namely Aluminum, Zirconium, and Titanium have a lower acute toxicity than hexavalent Chrome. However, their long-term effects on health and the environment are not well investigated. Consequently, their concentration in effluents should be kept as low as possible.

Hydrogen Sulfide

The use of sodium sulfide, sodium sulfhydrate, and organic sulfides for the unhairing process can cause the development of hydrogen sulfide (H_2S) in an acid medium (pH< 7.5). H_2S is a poisonous gas that has an irritating effect on the mucous membranes and may paralyze respiration cells, and eventually damages the nerves. The signs and symptoms of H_2S poisoning are inflammation of the eyes, bronchials and lungs. High concentration cause cramps, unconsciousness, and eventually death due to respiratory paralysis. In addition, H_2S forms explosive mixtures with air, therefore it is necessary to avoid ignition sources[19].

In the liming process, the pH of the baths are usually above 8.5, which means the appearance of H_2S is merely incidental.

[19] BASF, Pocket Book for the Leather Technologist, BASF, Germany, p 312

Biological Oxygen Demand (BOD)

BOD is a method of estimating the power of the effluent to reduce the oxygen content of water. Over-application of high BOD effluents on land can create anaerobic conditions in the soil. Prolonged oxygen depletion will reduce the soil microorganisms' capability to break down the organic matter in the effluent that may lead to noxious odor generation and surface and ground water pollution.

Chemical Oxygen Demand (COD)

COD is a method of estimating the chemical reduction power of the effluent and hence its ability to destroy any potential oxygen content of the water. High COD values causes water quality to be altered to one which is comparable to septic water quality, resulting in public health problem.

Total Dissolved Solids

The total dissolved solids or salinity concentration in an important water quality parameter. An increase in salinity causes an increase in the osmotic pressure of the soil solution, resulting in a reduced availability of water for plant consumption and possible retardation of plant growth. Parameters of consideration for irrigation water quality are TDS and (SAR). Excessive sodium in irrigation water relative to calcium and magnesium can adversely affect soil structure and reduce the rate at which water moves into and through the soil.

pH level

Untreated wastewater generated from tanneries could have varying pH levels indicating a high acidity or alkalinity, depending on the process. The disposal of such wastewaters without any pre-treatment could cause serious environmental damages to the receiving body or the living life in it.

CHAPTER IV: POLLUTION PREVENTION OPTIONS

4.1 Introduction

In order to increase the environmental performance of the tanneries, this chapter will introduce some of the applicable pollution prevention options helpful in reducing the pollution load generated through tanning activities. However, it should be noted, that the application of most of these measures is influenced by different factors such as:

- Specific governmental regulations;
- Available technologies;
- Economic situation.

Therefore, the implementation of any change will require sometimes a detailed pilot study to investigate the feasibility of their implementation, prior to a full-scale application. These suggested improvements have a number of objectives, such as:

- Reducing water consumption;
- Reduction of salinity in waste waters;
- Reducing wastewater generation;
- Recovering and/or recycling rejected materials;
- Increasing the efficiency of chemical utilization;
- Substitution of toxic raw materials;
- Reducing toxic emissions to the air;
- By-product's valuation.

The above mentioned objectives are often linked, and achieving one may automatically entail the achievement of the others. Measures and procedures needed to achieve these objectives can be subdivided into two categories:

1. In-plant controls and process changes,

These are mainly, conducted to diminish pollutant discharges into the environment, providing also economic benefits through raw material savings… In-plant control could be achieved by applying one of the alternatives listed below:

a) Process Changes

Process changes, are modifications to the basic manufacturing operations of a tannery. The main objectives off such changes are to minimize the environmental impact by reducing raw material or water consumption through the implementation of new processes (i.e. green fleshing, lime splitting…).

b) Material Recovery

Material recovery measures are implemented to reduce processing costs as well as pollution levels. This could represent on the long run a win-win situation as both financial savings and environmental burdens are minimized.

Thus, depending on the type of process, some chemicals may be reclaimed by a variety of methods (i.e. Recycling of Chrome or Pickling liquors...)

c) Chemical Substitution

The objective of chemical substitution is to replace process chemicals having high pollutant potential or toxic characteristics by others that have less impact on the environment (i.e. using CO_2 for deliming instead of ammonium sulphate, etc.), or that are more amenable to wastewater treatment. Typically, the cost to substitute chemicals is usually less than the cost of removal of the toxic pollutants from a facility's discharge by means of end-of-pipe treatment. However the chemicals should be evaluated to ensure that one pollution problem is not being substituted by another. Furthermore, tanners have to keep in mind that any chemical substitution might affect the final quality of the end product.

2. Pollution prevention options applicable through good housekeeping.

In addition to the above-mentioned applications, pollution prevention practices by applying Good House Keeping could be easily applied in any industrial facility. These will also be covered in this chapter. Such practices will have the advantage of affecting several pollution prevention categories (i.e. reducing wastewater generation, reducing water consumption, reducing solid waste generation and air pollution…) as well as realizing certain financial savings. Good house keeping measures are general managerial practices and common sense decisions that could be easily applied within a facility.

3. Enhancing the performances of existing complementary outsider

Considering that only 20 to 25% of the original weight of the pelts is transformed into final leather, the remaining 75 to 80% are water or solid wastes generated through the various tanning processes. The disposal of such quantities of wastes could be an extra burden on the environment especially for some wastes such as chrome trimmings and shavings. One alternative of minimizing the overall pollution is to try and re-use the tanning by-products for other purposes in complementary industries. The latter, could re-collect the solid waste and use it as raw material for the manufacturing of new products (i.e. leather boards…). Thus, this chapter will cover some of the possible opportunities that could be adopted to recover and re-use a number of the tanning solid wastes.

4.2 In-Plant Controls and Process Changes

Method	**Using freshly flayed hides or skins**
Process Stage	This is a way of skipping the preservation step.
Description	Fresh hides/skins if available can be processed without any salt conservation, leading to important savings in water since the soaking process will be avoided. In addition to water savings, wastewater resulting from the soaking procedure will be free of any chemical contents.
Procedure	The location of slaughterhouses within the vicinity of the tanning industry will enable the tanners to receive directly the raw hides or skins that are to be processed.
Category	Process Change

Issues to consider when selected	• Slaughterhouses have to be next to the tanning industry to avoid long distance and costly shipments; • Hides have to be processed on the spot as they cannot be stored. Efficient collection systems must be available or refrigeration for 72 hours at the most.

Using freshly flayed hides or skins	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in chemicals found in effluents

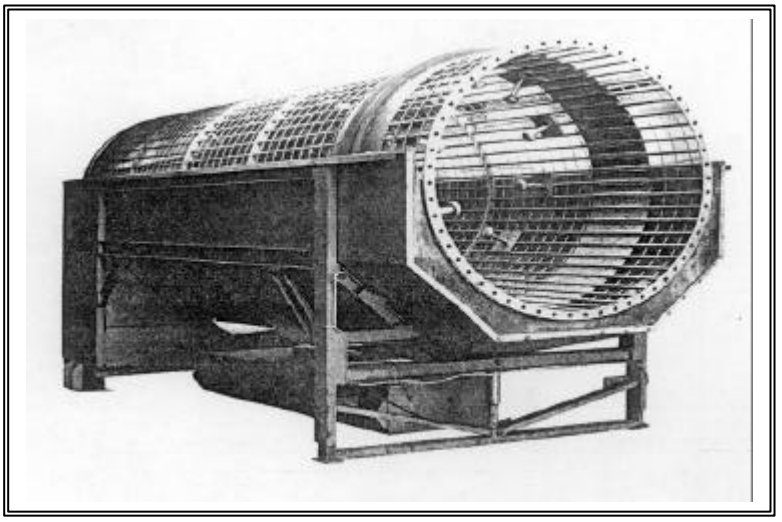
Method	**<u>Salt and chemical free conservation methods</u>**
Process Stage	Preservation.
Description	Tanners usually rely on large amounts of salts and sometimes chemicals to preserve the hides and skins from possible bacterial developments. However, such chemicals and salts necessary for the preservation phase would represent extra environmental loads found into the discharged wastewater of the soaking stage.
Procedure	Tanneries should have access to cooled storage facilities either within their own compounds or common to a set of tanning facilities. Such storage rooms will allow a better and unlimited conservation of the hides over long periods of time. Hides or skins conserved this way would keep their original moisture contents thus requiring less water usage necessary usually for the soaking and rinsing process. Another way of conservation is through a drying process.
Category	Process Change

Issues to consider when selected	• Long periods of cooling can prove very expensive; • Additional space might be required for a convenient storage room with all its equipment (i.e. compressors…); • Dried hides for preservation purposes, might lose some of their quality.

Salt and chemical free conservation methods	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction of chemicals used.

Method	**<u>Shaking the salted hides or skins before soaking</u>**
Process Stage	Pre-soaking.
Description	Reduction of salts present on cured hides or skins, would be necessary to limit the salinity of the wastewater generated during the soaking stage at the beginning of the tanning process.
Procedure	To reduce salinity in the wastewater generated from the soaking process, hides should be <u>properly</u> shaken by hand before soaking. This simple operation will reduce up to 30% of the total salt content of hides or skins. Instead of conducting this operation manually some advanced methods, rely on the usage of a “perforated drum” (see figure below) to shake the hides.
Category	Process Change/ Material Recovery

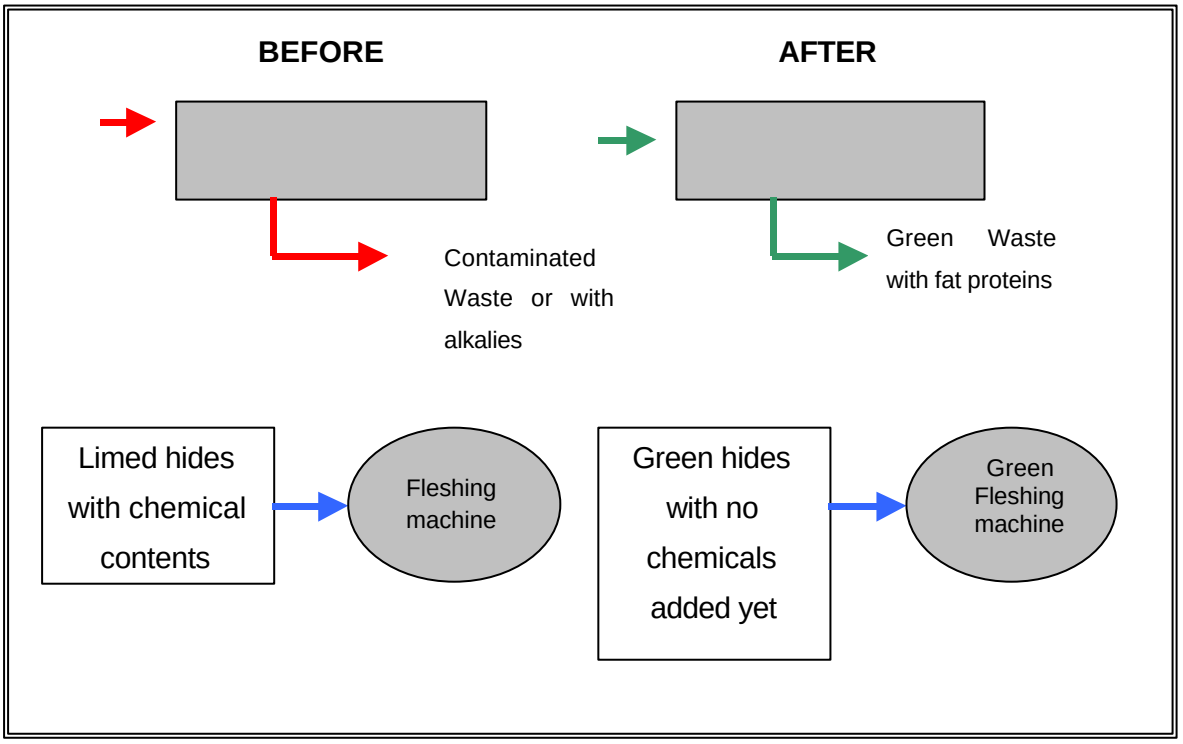
Issues to consider when selected	• Excess salts should be left for future use (treatment might be very costly however) or added to the accumulated solid wastes for a better disposal; • Consider the viability of the salt re-utilization; • The hides should be shaken carefully to avoid any damages to the raw material (i.e. tearing the pelts).



Shaking the salted hides or skins before soaking	
Environmental Benefits	• Reduction of water consumption; • Reduction in the level of chemicals found in effluents.

Method	**<u>Introducing green fleshing</u>**
Process Stage	Pre-liming.
Description	Fleshing the pelts at earlier stages of the tanning process will reduce the overall weight of the pelts and consequently reduce the quantities of necessary chemicals and water needed for the subsequent processes. This eliminates 14-18% of the weight of the pelts.
Procedure	Green fleshing is the application of fleshing just after soaking. This procedure has many advantages; it will result in the production of acceptable fleshing for the production of fats (triglycerides) and proteins for composting and meat meal. Also it will improve the penetration level of chemicals in the pelt, leading to a

	positive influence on the pollution load (by reducing the chemicals used) and on the quality of the finished leather (finer grain and increased area).
Category	Process Change
Issues to consider when selected	• This process has to be conducted carefully as it can cause some mechanical damages to the skin of small animals, if the machine pressure is not properly adjusted or skins which have not been thoroughly washed and have dung stuck to them are defleshed.



Introducing green fleshing	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents; • Reduction in hazardous solid wastes.

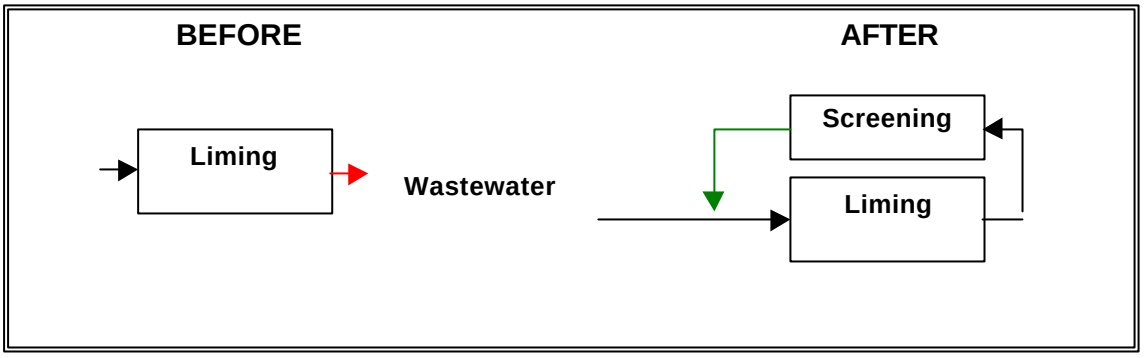
Method	**Hair Recovery from Liming Process**
Process Stage	Liming.
Description	Removing the hair prior to the liming stage would substantially reduce the amount of pollution related to hair (i.e. suspended solids, BOD…) found in the wastewater

	generated. Such initiative would also permit an easier recycling of wastewater.
Procedure	The operation consists of the following phases: 1. **Immunization.** Treatment of skins soaked in an alkaline solution of lime and NaOH for 45-50 minutes. 2. **Chemical shaving.** Sodium sulfhydrate is added (this attacks the roots) for 20 minutes, after which the immunized hair falls out whole. 3. **Bath recirculation.** By passing through a 1-mm filter, the wet hair debris is eliminated with 75% humidity. The hair constitutes 17-20% of the skin's weight. 4. **Attack of the epidermis.** Sodium sulfide is added to attack and dissolve the queratine in the epidermis. 5. **Liming.** Lime is added to bring about controlled alkaline swelling. **Other procedures:** • Mechanical removal of hair from pelts using advanced methods (e.g. The Eastern Regional Research Center (ERRC) process) reduces the total amount of wastewater generated during liming • Sulfur-free processes may also be used (e.g. dehairing with glycolates, using aminos as dehairing agents or enzymes in dehairing.
Category	Process Change
Issues to consider when selected	• Methods might require additional supervision and control; • Avoid dissolving hair in chemicals by making a proper choice of chemicals and using mechanical screens to remove hair from wastewater.

Before	**After**
Soaking→ Rinsing→ Liming→	**Soaking→ Rinsing→ Mechanical Hair Removal→ Liming→**

Hair Recovery from Liming Process	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents; • Reduction in hazardous solid wastes.

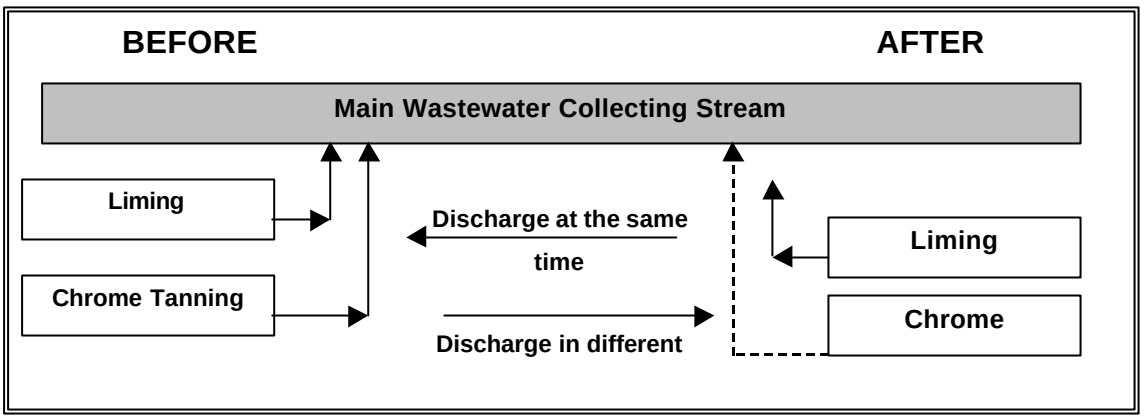
Method	**Re-use of liming wastewater**
Process Stage	Liming.
Description	Many relatively clean rinse and wash waters can be recycled to other processes where the low concentration of residual chemicals will have minimal or no impact on the current process.
Procedure	Lime wash can be recycled to start new lime liquor. This operation can reduce water consumption considerably. Another idea is to conduct direct recycling of lime/Sulfide liquors, with make-up of the lost liquors after each cycle. Such system is particularly applicable if screening (using a 1-mm brushed screen) is carried out to remove solids and hair debris. Up to 40% savings of Sulfide and 50% saving in lime could be achieved.
Category	Process Change/ Material Recovery
Issues to consider when selected	• The engineering requirements, while not over-sophisticated, may nevertheless prove difficult in some old or small tanneries. However, they can be easily incorporated in new facilities to be established; • It is important to note that with efficient screening, protein build-up in the recycle liquor does not appear to be a serious problem. It is advisable to have a high degree of surveillance over the process. Also, the use of such recycling does not obviate the need for further treatment. Liquors will still need to be discharged occasionally.



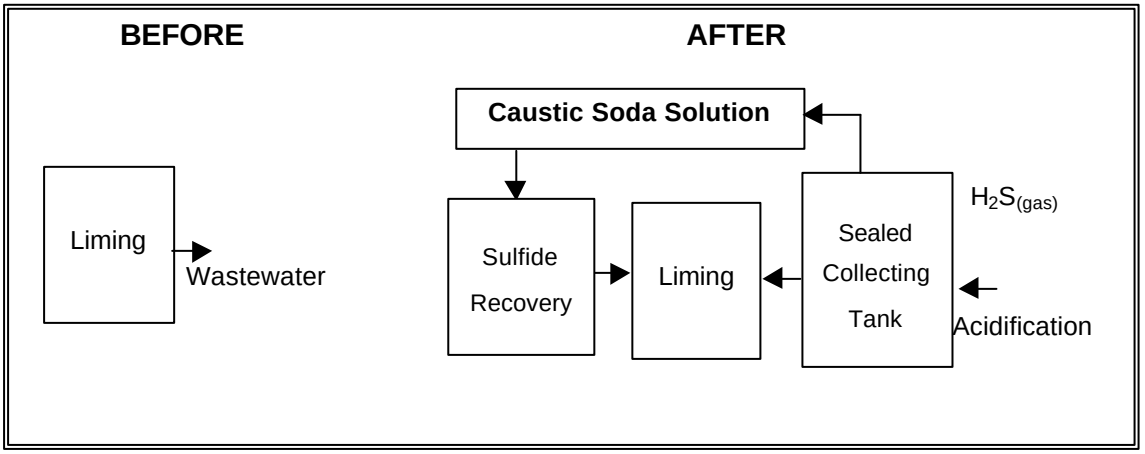
Re-using of liming wastewater in less critical processes	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in chemicals used.

Method	**Separating residual baths after liming and chrome tanning**
Process Stage	Liming & Chrome Tanning.
Description	The separation of the residual liming and chrome baths would prevent the accidental generation of H_2S, which is considered as a highly lethal gas that could cause serious health damages to human beings.
Procedure	It is highly advisable to separate residual baths after liming and residual baths after chrome tanning. Any accidental mixing of these two baths, with a pH lower than 7.5, would generate a highly toxic gas: Hydrogen Sulfide (H_2S). $S^{2-} + 2H_3O^+ \rightarrow 2H_2O + H_2S \uparrow$ A convenient wastewater network should be designed in a way to ensure that the lime and chrome streams are separated from each other and from a third that will hold the rest of the wastewater stream generated from the tanning processes.
Category	Process Change
Issues to consider when selected	• Enough space should be available to perform such installations; • The two baths should be dumped in separate areas to avoid any accidental mixture.

Separating residual baths after liming and chrome tanning	
Environmental Benefits	• Reduction in hazardous gases.

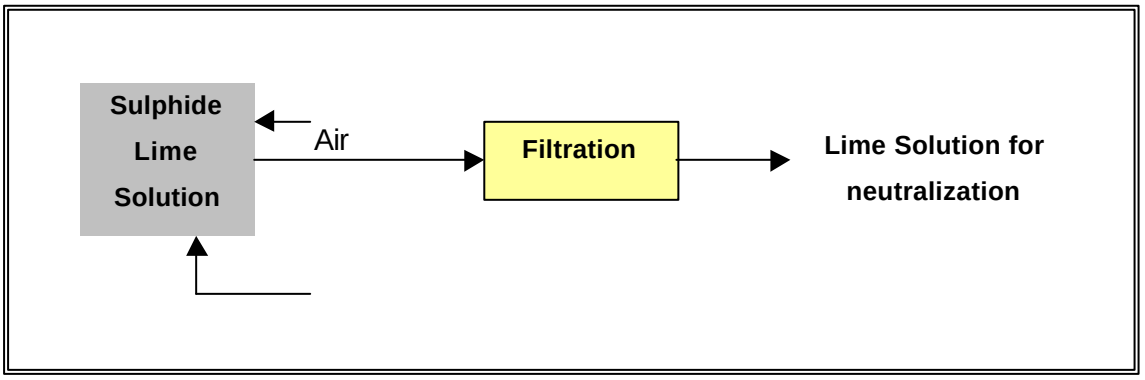


	High tech sulfide recycling
Process Stage	Liming.
Description	Recycling the used sulfides found in the wastewater would limit the environmental impact of the effluent carrying large quantities of sulfide.
Procedure	Sulfide stripping can be practiced in tanneries. The process of stripping can be summarized as follows; liquors are acidified, and H_2S gas released and collected in a caustic soda solution prior to subsequent re-use.
Category	Material Recovery
Issues to consider when selected	• Such systems require rustproof facilities and a high level of careful supervision to prevent any lethal gas leakages; • The systems can be more easily incorporated into new facilities with space already available.



High tech sulfide recycling	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents; • Reduction of noxious odors.

Method	**Segregating sulfides from the effluents**
Process Stage	Liming.
Description	Reduction of sulfides concentrations from effluents to limit the corrosion of pipes, reduce odors, and prevent accidents due to the mixture of liquors with other effluents.
Procedure	The sulfide-lime solution, and washes from the liming process, can be collected without contamination from other solutions. These collected wastes can be placed in a tank and the sulfides oxidized by air with a manganese sulfate catalyst. This is an effective method that could destroy the sulfide content in 4 to 8 hours[20]. The lime solution, free of sulfides can be used to neutralize the acid wastes by adjusting the pH to the acceptable range[21].
Category	Process Change
Issues to consider when selected	• A supervision over the transportation of the liming liquors should be very strict to avoid their mixture with chrome liquors and the generation of H2S vapors.



[20] EP3, case#5, http://www.emcentre.com/unepweb/tec_case/leather_19/
[21] EP3, case#6, http://www.emcentre.com/unepweb/tec_case/leather_19/

Segregating sulfides from the effluents	
Environmental Benefits	• Reduction in the level of chemicals found in the effluents; • Reduction of noxious odors.

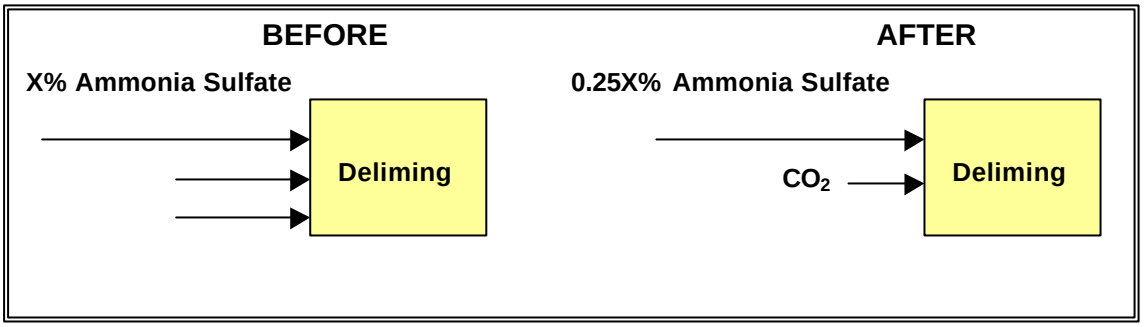
Method	**Split limed hides**
Process Stage	Liming.
Description	Splitting the pelts following the liming process would enhance the capacity in chemical absorption of the pelts thus adhiering savings in the required amounts of chemicals necessary in the subsequent processes. In addition to a reduction in chemical consumption, the water needs and wastewater contents as well as the chrome containing solid wastes will also be reduced.
Procedure	The splitting operation, as well as an additional trimming are conducted directly after the liming step. Such technique would lead to a weight reduction of the pelts and higher exhaustion levels of the hides and skins to be treated. This technique represents several advantages such as: A reduction in the quantity of solid wastes generated with chrome contents; The fact that the pelts are lighter will lead to a reduction in water needs, chemical needs and wastewater generation; Splitting the hides will increase their level of chemical absorption leading to a reduction in chemical requirements necessary for the subsequent processes (i.e. deliming, bating, pickling, and chrome tanning).
Category	Process Change
Issues to consider when selected	• Make sure that the quality of the finished leather corresponds to the customers' needs as the splitting done at early stages might affect the final texture and resistance of the product.

Before	After
Liming→ Rinsing→ Deliming→ Pickling → Tanning→ Splitting →	Liming→ Rinsing→ Splitting→ Deliming→ Pickling → Tanning→

Split limed hides	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents; • Reduction in solid wastes.

Method	**Reducing Ammonium usage in deliming process**
Process Stage	Deliming.
Description	Through the substitution of ammonium salts the level of ammonia in the wastewater are reduced.
Procedure	A number of alternatives could be adopted to limit the usage of ammonium salts, thus improving the final quality as well as reducing the level of nitrogen in the effluents. Boric acid, magnesium lactate, organic acids, such as lactic acid, formic acids, etc. can be used to substitute the ammonium used. Another new technique would be to use of carbon dioxide in deliming to limit the use of ammonium salts. Such operation would allow a reduction of close to 75% in ammoniacal nitrogen[22]. In addition to the nitrogen reductions, the chrome tanning agents work better on skins delimed with the carbonic gas than with the salts which reduces the quantity of the chrome residues in the tanning effluents[23]. CO_2 forms carbonic acids which dissolves the residual lime.
Category	Chemical Substitution
Issues to consider when selected	• Avoid intermittent gas inputs, which form carbonate; • Add bisulfate to avoid H_2S formation.

[22] EP3, case #14, http://www.emcentre.com/unepweb/tec_case/leather_19/
[23] International Cleaner Production Information Clearinghouse, *Leather Industry- A french Tannery Has Set Up a Deliming Process for Hides Without Ammonia Sulfate*, http://www.unepie.org/icpic/catsu/catsu268.html

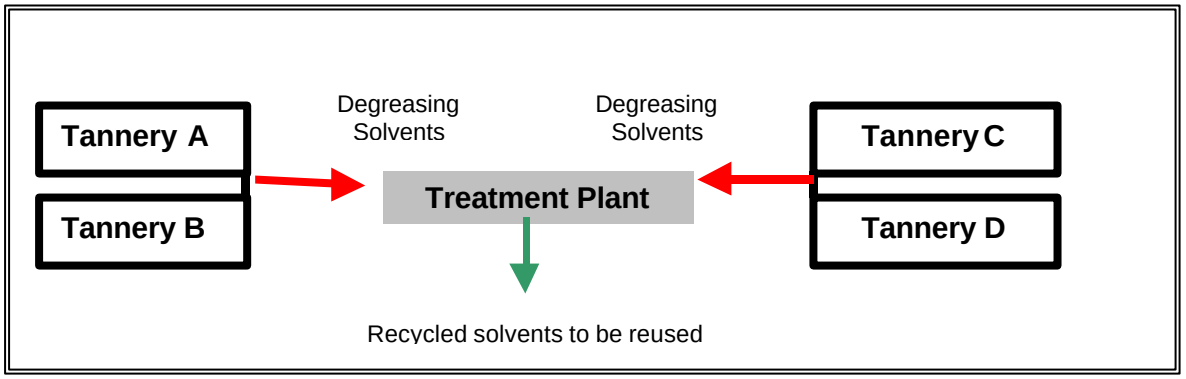


Reducing Ammonium usage in deliming process	
Environmental Benefits	• Reduction in the level of chemicals found in effluents; • Reduction in hazardous solid wastes; • Reduction of noxious odor.

Method	**Recuperation or substitution of degreasing solvents**
Process Stage	Degreasing.
Description	Experience has shown that an important quantity (in some cases 95%) of the solvents used for degreasing purposes could be recovered and re-used.
Procedure	The installation of an external recovery plant could be done, to filter and treat the wastewater generated through the degreasing operation. The unit capable of recovering the solvents used (usually perchloroethylene) might require an investment of close to 39,690 for recovering 50 liters of perchloroethylene per hour[24]. To avoid the formation of greasy residues, degreasing solvents could be replaced by environmentally friendly and biodegradable surfactants especially if no recovery is conducted. In this case consider treating the wastewater[25].
Category	Material Recovery
Issues to consider when selected	• The recycled solvents cannot be used indefinitely and tanners should make sure that sufficient quantities of unused solvents are being added to the recycled

[24] ESCWA, Environmentally Sound Technologies in the Tanning Industry, United Nations, New York , 1997, pg. 50
[25] UNEP, Tanneries and the Environment- A Technical Guide, pg.17

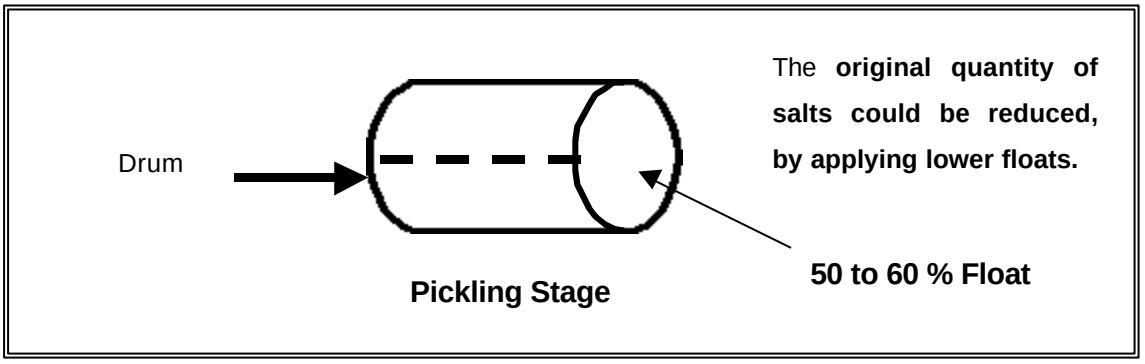
	concentrations so that the final leather quality is not affected; • The installation of a system for recovery of the solvents used might be expensive. It is thus recommended to install a centralized recovery system, which could be used by more than one tannery.



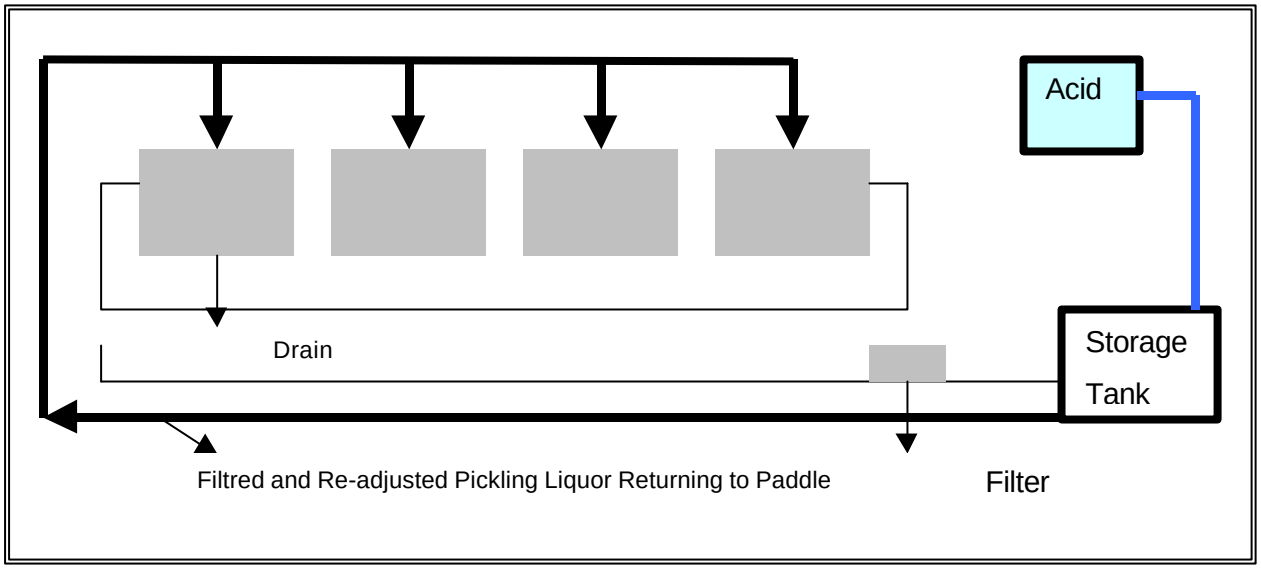
Recuperation or substitution of degreasing solvents	
Environmental Benefits	• Reduction in wastewater generation; • Reduction of chemicals used; • Reduction in the level of chemicals found in effluents.

Method	**<u>Reducing salt consumption in pickling</u>**
Process Stage	Pickling.
Description	The levels of salt usage in the pickling stage could be reduced by up to 80%, through the application of new processes or by their replacement with new chemicals.
Procedure	One of the three methods below could be used to achieve a lower salt consumption during the pickling stage: • The amount of salts used in the pickling process can be reduced by a simple reduction of the float volumes to 50 or 60% of the weight of pelts. • Another way of reducing the salt consumption would be by optimizing the mixture of the pickling liquor, or by recycling it after a preliminary filtration, then adjusting its pH through the addition of strong or weak acids. Such technique will in addition permit a reduction in the quantities of acids used.

	• Replacing the salts by newly developed chemicals (i.e. acid sulphone polymers).
Category	Process Change
Issues to consider when selected	• Recycled pickling liquors, will have to be replaced by a newer one after a certain number of usages, so not to affect the final quality of the leather product.

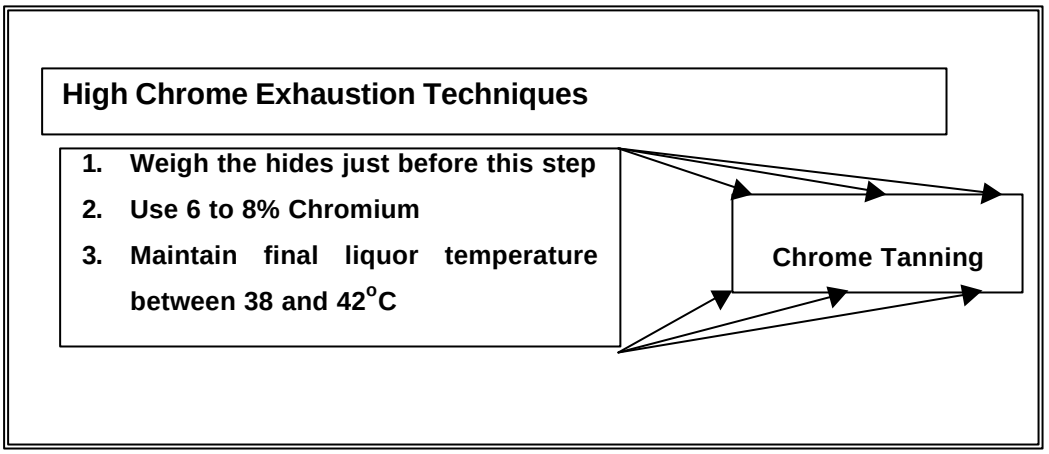


Method	**<u>Recycling pickling liquors</u>**
Process Stage	Pickling.
Description	Recollection of the pickling liquors at the end of the process to re-use them in subsequent pickling processes.
Procedure	The technique consists in recuperating the pickling liquor and re-introducing it in the process, after being filtered and its pH re-adjusted accordingly. At the bottom of every paddle (or Drum…), a filter was installed to eliminate the impurities such as the pelt remains, the dirt remains, etc. Once filtered, the liquor is sent to a storage tank. This pickling liquor is re-adjusted for its re-utilization after the elimination of any remaining impurities (i.e. oils and grease). Out of this re-cuperated liquor, 50% (sometimes more) of it could be re-utilized in subsequent processes. To be able to facilitate the re-adjustment of the pickling baths, the types of acids used have to be unified. Thus, Sulfuric Acids could be completely replaced by Formic Acids.
Category	Process Chage/Material Recovery
Issues to consider when selected	• Recycled pickling liquors, will have to be replaced by a newer one after a certain number of usages, so not to affect the final quality of the leather product.



Recycling pickling liquors	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents; • Reduction in chemicals used.

Method	**Use only trivalent chrome**
Process Stage	Chrome Tanning.
Description	Limit the impact of chrome effluents by using trivalent chrome chemicals as much as possible instead of other kinds of chrome.
Procedure	Trivalent chrome has much less impact on the environment than hexavalent chrome.
Category	Chemical Substitution
Issues to consider when selected	The use of trivalent chromium is only a way of limiting the environmental impact related to chrome tanning agents. However, tanners should bear in mind that the use of mineral tanning agents such as chrome, still has a certain amount of impact on the environment.



Use only trivalent chrome for tanning	
Environmental Benefits	• Reduction in the level of chemicals found in effluents; • Reduction in hazardous solid wastes.

Method	**<u>High chrome exhaustion techniques</u>**
Process Stage	Chrome Tanning.
Description	Chrome fixation can be raised by a combination of practices leading to a reduction in chrome residuals in the wastewater to minimum levels.
Procedure	Using shorter floats, maintaining optimum initial temperatures of the floats, increasing the tanning time, optimizing the pH and raising the temperature towards the end of tanning will always favour a high chrome fixation. In addition to the above, a continuous monitoring of the pH level will assure maximum levels of exhaustion, thus limiting the final chrome residuals in the effluents.
Category	Process Change
Issues to consider when selected	• The use of a portable pH meter as well as a thermometer will help monitor the chrome tanning process. However the tanners should make sure that their equipment is in good operating condition and that all readings are accurate. One way of doing so is by a regular maintenance and check-ups of the measuring equipment.

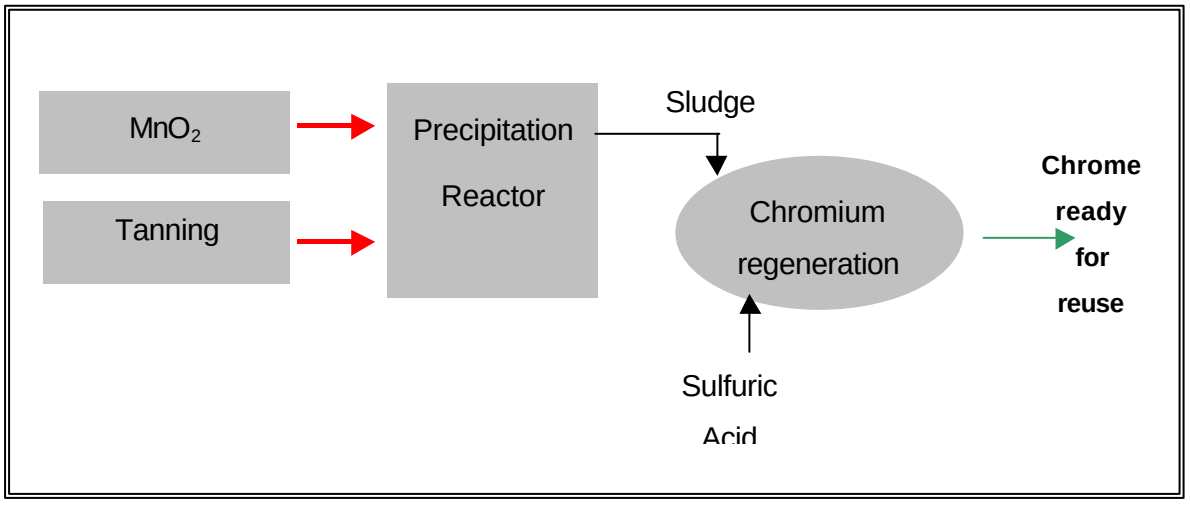
High chrome exhaustion techniques	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents; • Reduction in hazardous solid wastes.

Method	**Chrome substitution**
Process Stage	Chrome Tanning.
Description	Substituting chrome with other chemicals such as titanium or sometimes Zirconium.
Procedure	From an environmental standpoint Titanium is generally less toxic than chromium and could be also used as a tanning agent, proving to be an alternative to chrome salts. Thus, a tanning agent based on titanium sulfate was developed in Europe. The latter can be used with existing conventional tanning equipment. As titanium uptake is very high, the amount of titanium carried over into the effluent stream is minimal and simple neutralization is the only treatment that could required. Some solid residues containing titanium may result from shaving and trimming. However, the inertness of the solid residues containing titanium material represents little problem either in the disposal or in agricultural re-use.
Category	Chemical Substitution
Issues to consider when selected	• Usually titanium tanned leathers are stiffer than chrome tanned hides or skins. The titanium or other chemicals usually affect the final quality of the end product by modifying its texture. Hence, the tanners might find the products more difficult to sell due to limited market interests in such leather qualities.

Use Titanium or Zirconium Instead of Chromium

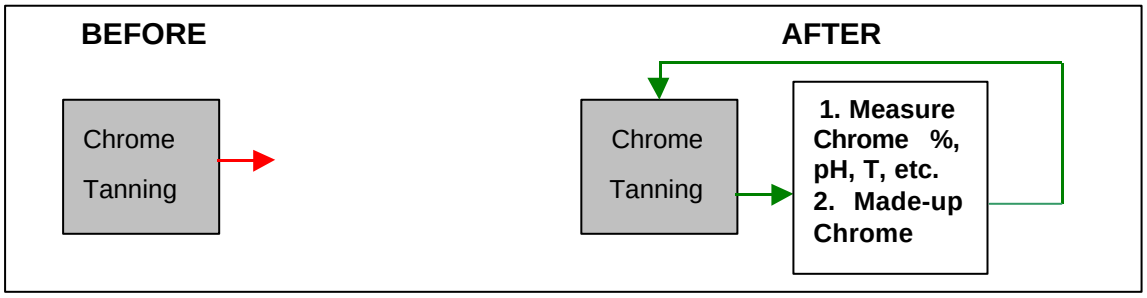
Chrome substitution	
Environmental Benefits	• Reduction in the level of chemicals found in effluents; • Reduction in hazardous solid wastes.

Method	**Chrome precipitation and recovery**
Process Stage	Chrome Tanning.
Description	The purpose of this option is to collect the chrome bearing liquors for treatment with alkali, precipitating the chromium as hydroxide, before its final re-usage.
Procedure	Two possible means to recover the chrome are[26]: 1. Alkali - NaOH or MgO- is added to the chrome liquor, up to pH 8.5-9. The hydroxide sludge may be passed after thickening to a filter press or belt, the cake so formed then being re-dissolved with sulfuric acid and re-used. 2. The liquor is left undisturbed overnight. Virtually "chrome-free" supernatant can then be drawn off and discharged to the effluent system. The remaining settled hydroxide sludge is re-dissolved with acid in situ and reused. The alkali utilized for precipitation depends on the subsequent recycling system.
Category	Material Recovery
Issues to consider when selected	• The first method is very expensive and might require lots of space; • The second method although cheaper requires a strict process control since a small mistake could ruin the quality of the end products.



[26] UNEP, Tanneries and the Environment- A Technical Guide, pg.40

Chrome precipitation and recovery	
Environmental Benefits	• Reduction in the level of chemicals found in effluents • Reduction in chemicals used; • Reduction in hazardous solid wastes.
Method	**Reusing made-up chrome for tanning**
Process Stage	Chrome Tanning.
Description	To limit the amount of chrome contents in the tanning effluents, chrome liquor could be re-used for pickling or tanning purposes all over again. Such operation would be able to reduce the chrome content from the effluents by as high as 90% in some cases[27].
Procedure	Tanners will be conducting tests, allowing them to determine exactly the chrome level remaining in the wastewater generated. Such tests will allow the discharged chrome liquors to be re-used after filtration and collection in a storage tank, by determining the required balance of missing chrome quantities to be added to the wastewater generated.
Category	Chemical Recovery
Issues to consider when selected	• The recycled liquors cannot be re-used indefinitely and might have to be changed after a certain number of usages.



Reusing made-up chrome-tanning	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents; • Reduction in chemicals used.

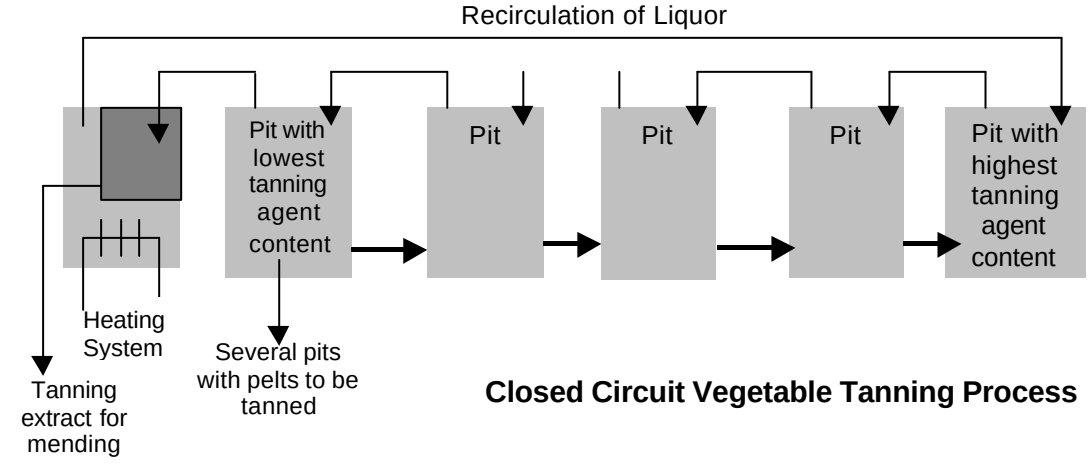
Method	**Wet-white tannage (Chrome free tanning methods)**
Process Stage	Tanning.
Description	One way of tanning the hides is by relying on chrome free methods. Leathers tanned through these methods usually have a whitish color and represent a series of ecological advantages. Ecological advantages of wet white: • No restrictions on dumping or potential incineration of solid waste (shavings and trimmings); • Solid waste can be composted; • No need to recycle chrome; • Wastewater does not have to be pre-treated to precipitate chrome.
Procedure	There are three main Chrome-free techniques[28] leading to the production of wet white leather: • Vegetable/Syntan/Polymer tannage • Syntan/ Polymer tannage • Polymer tannage In addition to the advantages found in the final elimination of chrome needed in the conventional tanning process, the full polymer technique presents the following advantages: 1- Excellent exhaustion and fixation 2- Leathers can be dyed to high level, brilliant shades 3- Excellent light fastness. 4- Best results are obtained for perspiration resistance and wash fastness in comparison with other chrome-free systems For a comparison of chrome & chrome free methods (see Annex R3).
Category	Chemical Substitution
Issues to consider when selected	• The final quality of the leather product has to be taken into consideration, as the wet-white will lead to a different texture suitable for specific types of leather production;

[27] EP3, case #5, http://www.emcentre.com/unepweb/tec_case/leather_19/
[28] BASF, Leather Topics-6/96, BASF, Germany

	• Due to reduced heat resistance, the drying of the chrome-free tanned leather has to be done carefully. The end product is not suitable for the manufacture of vulcanized footwear.

Wet-white tannage	
Environmental Benefits	• Reduction in the level of chemicals found in effluents; • Reduction in hazardous solid wastes.

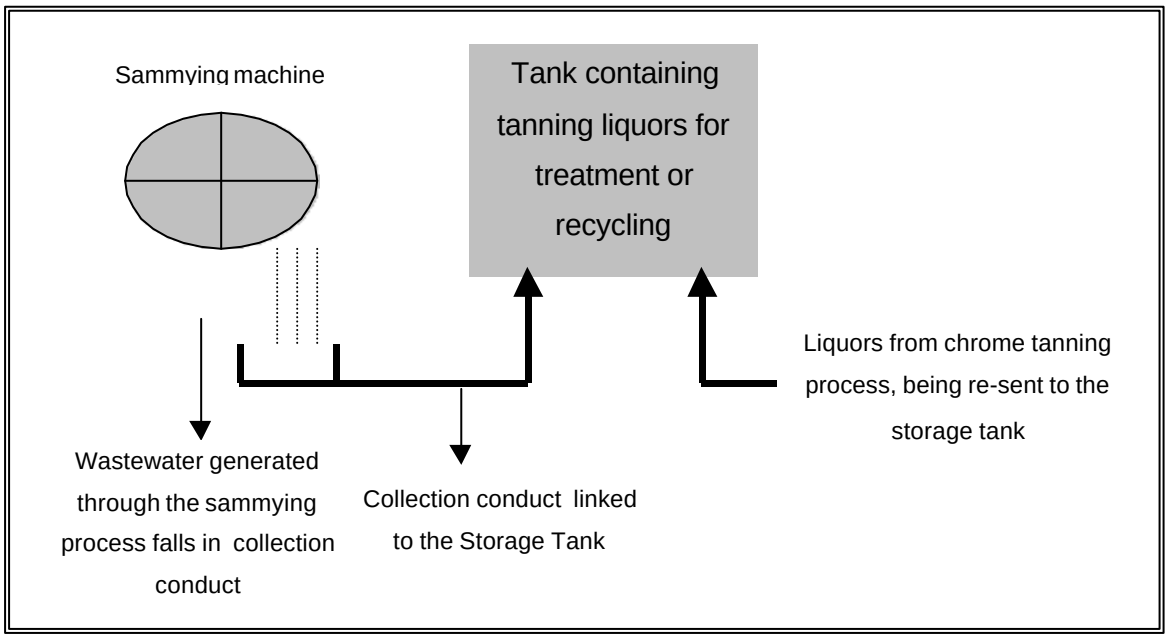
Method	**<u>Recycling vegetable tanning liquors</u>**
Process Stage	Tanning.
Description	A process could be adopted for conducting vegetable tanning which will limit the amount of wastewater generated through countercurrent pit systems.
Procedure	The pre-tanned pelts are introduced first in a pit containing reused tanning baths with a low concentration of tanning liquor. The pelts are then passed through several pits with increasing tanning concentration and cleaner water, until they reach a last stage with the highest tanning agents concentration and cleaner water. To improve the final fixation and penetration results, a pre-condionning step is conducted, following the deliming operation, by applying for a period of one day, a bath of 5% naphtholsufonic acid and 1% sulfuric or formic acid.
Category	Process Change/ Material Recovery
Issues to consider when selected	• The application of this process might require additional space as several pits have to be used.



Closed Circuit Vegetable Tanning Process

Recycling vegetable tanning liquors	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents; • Reduction in chemicals used.

Method	**Recycling sammying liquors**
Process Stage	Sammying
Description	Some savings in chemicals and water consumption could be achieved by treating and re-using the wastewater generated through the sammying operation and treating it together with the tanning liquors.
Procedure	A collection system capable of receiving the sammying wastewater could be installed below the sammying machine. Thus, the water collected could be sent for treatment, along with the rest of the chrome tanning liquors. This could be easily achieved as the characteristics of the wastewaters of both processes are identical.
Category	Material Recovery
Issues to consider when selected	• The collection of the sammying wastewater should be done with care, to avoid any mixture of the liquor with liming wastewater, which might lead to the generation of H_2S gases.



Recycling sammying liquors	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents; • Reduction in chemicals used.

Method	**Minimizing the impact of re-tanning effluents**
Process Stage	Re-Tanning.
Description	Regular monitoring combined to some chemical substitutions would help limiting the amount of wastewater pollution.
Procedure	The re-tanning operation could be conducted by selecting chemical agents with a low number of monomers (i.e. fenol, formaldehyde, etc.) and low contents in inorganic salts. Furthermore, through a correct pH and temperature monitoring, the exhaustion could be optimized thus limiting the final amount of chemical residues found in wastewater discharges.
Category	Chemical Substitution
Issues to consider when selected	----

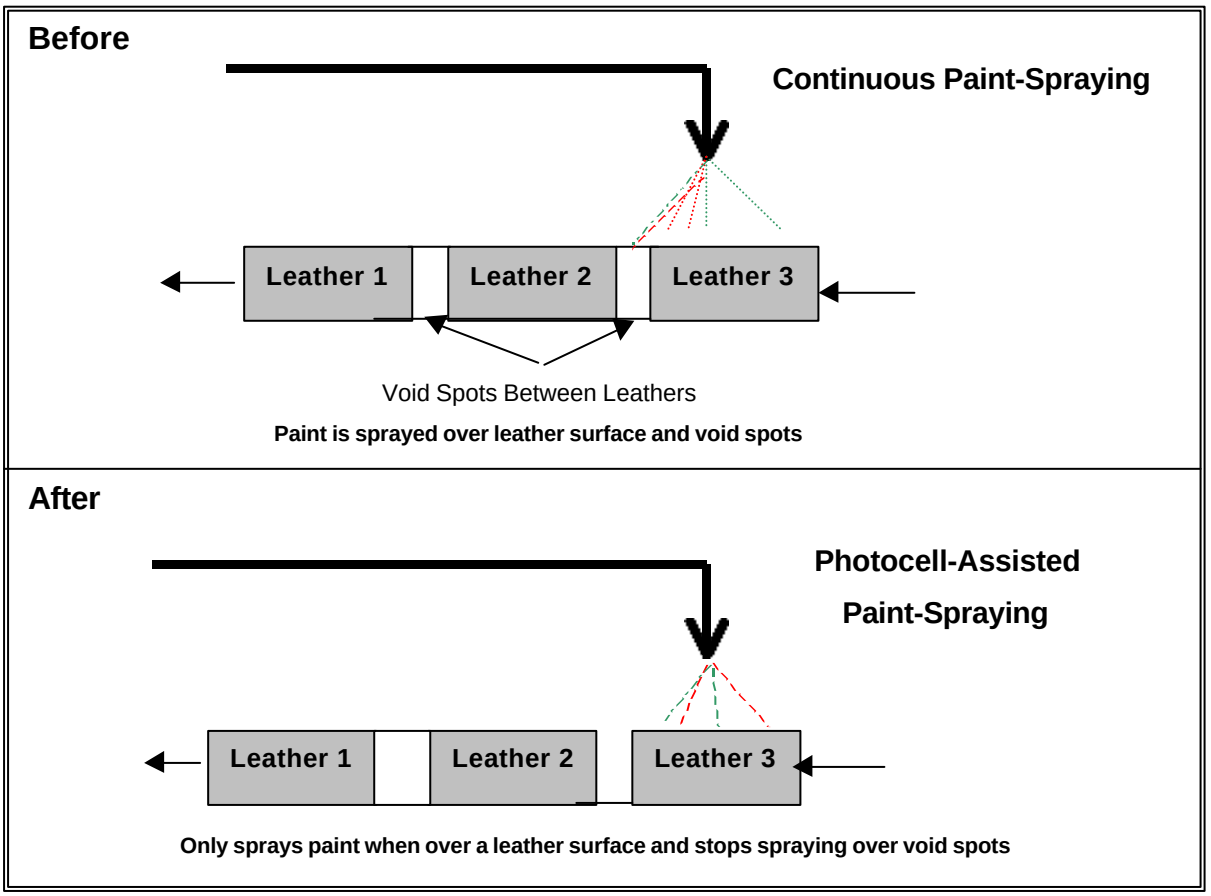
- Enhance the exhaustion level by regular pH & Temperature monitoring;
- Use products with low inorganic slats contents;
- Use products with a low number of monomers (Fenol, Formaldehyde, etc.).

↓

Reduction in Wastewater Discharges

Minimizing the impact of re-tanning effluents	
Environmental Benefits	• Reduction in wastewater generation; • Reduction in the level of chemicals found in effluents.

Method	**<u>Use photocell-assisted paint-spraying techniques to avoid overspraying</u>**
Process Stage	Finishing.
Description	The photocell-assisted paint-spraying technology would save important quantities of paints by spraying over the leather only when required. In addition to the savings in chemicals that could be achieved, such method would ultimately reduce the air pollution caused by over spraying activities.
Procedure	A special painting machine with photocell detection capability would pass over the leather hides or skins and spray the chemicals only when it is over a leather surface. The machine would stop spraying if it does not detect a leather surface beneath the painting hoses. Such process would save important amounts of chemicals and limit air pollution.
Category	Process Change
Issues to consider when selected	• Tanners might face space limitations for the installation of such equipment.



Use photocell-assisted paint-spraying techniques to avoid overspraying	
Environmental Benefits	• Reduction in air pollution; • Reduction in noxious odors.

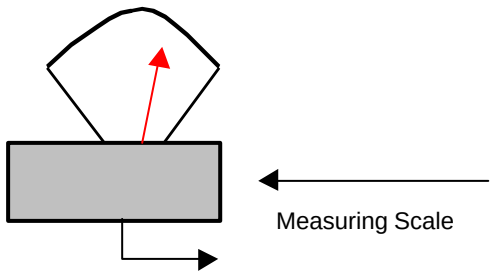
Method	**Decrease the VOCs by using new finishing material**
Process Stage	Finishing.
Description	The high amount of VOC could be reduced substantially by changing the kind of chemicals required for the finishing process.
Procedure	Water-soluble lacquers were manufactured in an effort to replace solvent-soluble lacquers. The new product have a significantly lower volatile solvent content and are presently widely accepted as quality products. Furthermore, their use is strongly advised for better environmental results. The process of switching to water-soluble lacquers will eventually decrease the VOC emissions due to volatile solvents by 60 to 90 percent[29].
Category	Chemical Substitution
Issues to consider when selected	----

Substitute solvent-soluble Lacquers

with water-soluble Lacquers

Decrease the VOC by Using New Finishing Material;	
Environmental Benefits	• Reduction in air pollution; • Reduction in noxious odors.

Method	**Correct determination of respective weights along the process line**
Process Stage	Applied in More than One Stage.
Description	One way of limiting the consumption of raw material, is by determining the correct respective weights of the pelts before each process, enabling them to calculate the exact weight of chemicals needed for each step. Without correct information about the pelts' weights, surpluses of chemicals are frequently observed. Thus, simple correct weighing will help reduce negative environmental impacts. In addition to savings in chemicals the correct determination of weights would allow savings in water consumption.
Procedure	A good measuring scale should be available and used to measure the weight of the hides or skins before each phase of the tanning process. The exact determination of the weight of the pelts would allow a better control of the water and chemicals to be added. An accurate scale would also permit a better weighing of the chemicals themselves as they are to be added for the tanning process.
Category	Process Change
Issues to consider when selected	• The scale should remain clean to avoid any reaction due to the different chemicals used as pelts from different processes are weighed. • It is a good idea to have 2 scales: 1 for pelts, with 1,000-3,000-kg capacity, and 1 electronic 100-kg scale with 100-g sensitivity.



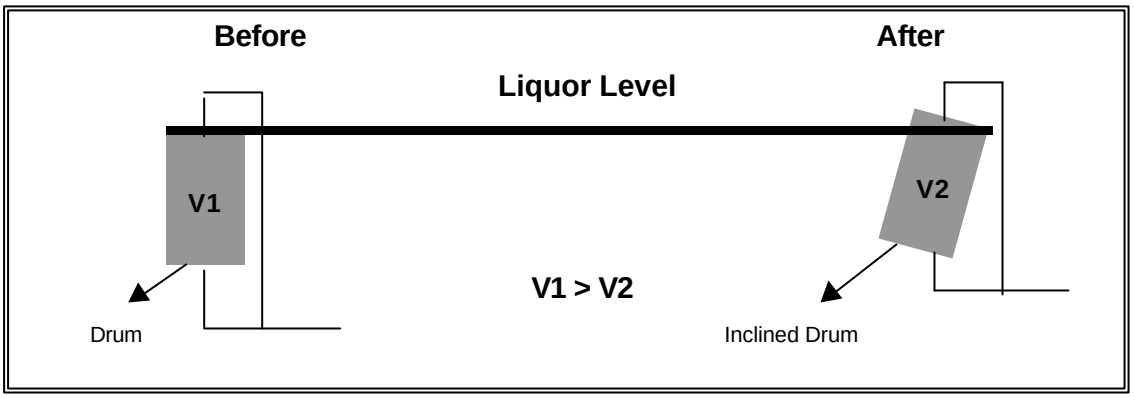
Pelts should be weighed regularly and as much as possible during the tanning process to determine the exact amount of raw material necessary for sub-sequent processes

[29] EP3, case#6, http://www.emcentre.com/unepweb/tec_case/leather_19/

Correct determination of respective weights along the process line	
Environmental Benefits	• Reduction of water consumption; • Reduction of wastewater generated; • Reduction in the level of chemicals found in effluents; • Reduction of chemicals used.

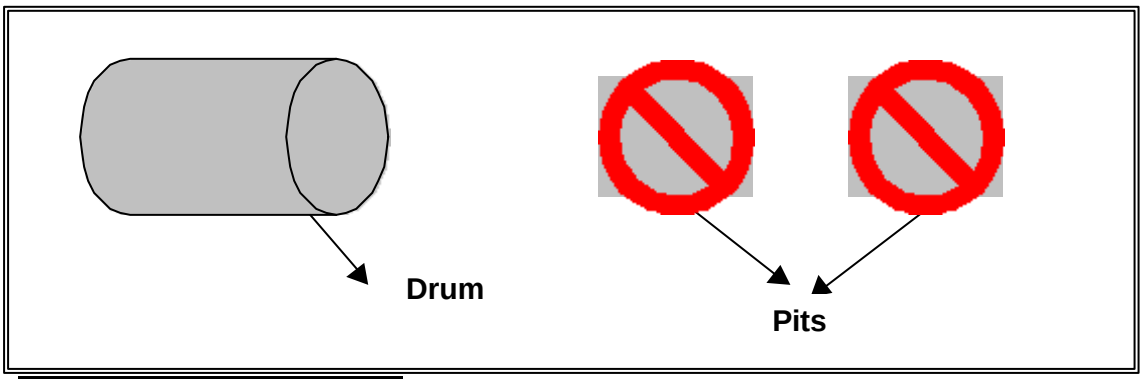
Method	**Use low-float methods**
Process Stage	Applied in More than One Stage.
Description	Cement-mixer-type drums are used to process the Hides and Skins. Such technique requires smaller amounts of water to achieve the same process results. The final benefits in relying on similar methods allow larger water savings to perform the usual traditional processes, a reduction in the generation of wastewater and a reduction in chemical needs.
Procedure	Equipment could be possibly modified to utilize short floats, for example 40-80% floats in place of the traditional 100-250%. As well as yielding savings in water consumption and processing time, this can also bring about savings in chemical inputs due to higher effective concentration and increased mechanical action. Furthermore, the technique of intermittent washing combined with low floats together can save upwards of 70% in water[30] consumption.
Category	Process Change
Issues to consider when selected	• The increased temperature of goods in the drums, due to increased friction and less coolant, may not always be technically acceptable, and might require some additional adjustments.

[30] UNEP, Tanneries and the Environment- A Technical Guide, pg. 37



Use low-float methods	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction of chemicals used.

Method	**Use drums instead of pits**
Process Stage	Applied in More than One Stage.
Description	Rotating drums in opposition to static pits require lower water quantities to perform the same process. As drums are rotated mechanically less water is needed to achieve the same results usually obtained over longer periods of time in paddles or pits which utilize 300-1000% water[31].
Procedure	Replace pits by drums as necessary.
Category	Process Change
Issues to consider when selected	• It must be not however that paddles and pits are also essential sometimes for certain processes, such as the first soaking of dried hides and processing of long-haired or wooled skins[32].



[31] UNEP, Tanneries and the Environment- A Technical Guide, pg. 37
[32] UNEP, Tanneries and the Environment- A Technical Guide, pg. 37

Use drums instead of pits for immersion of pelts	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation; • Reduction in chemicals used.

4.3 Pollution Prevention Methods Applicable through Good House Keeping

Method	**Just in Time Management**
Process Stage	General.
Description	Applying such strategy would reduce the number of chemicals and hides or skins in storage. Hence odors reduction, and accidents reduction due to over storages of chemicals or pelts is achieved. In addition to the environmental advantages that could be reached, extra financial savings are realized by limiting the stock availability to what is strictly needed.
Procedure	The concept consists in making sure that the products necessary for the leather production are just received on time and not stored over long periods of time.
Category	Good House Keeping
Issues to consider when selected	• Making sure that there is a close follow up of the different customers' needs and raw materials availability on the suppliers' side. This strategy would optimize and shorten the amount of time needed for the leather production and would make sure that the raw material is always available when needed.

Just in Time Management	
Environmental Benefits	• Reduction in noxious odors.

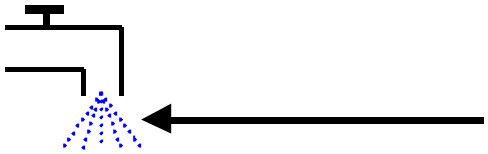
Method	**Regular cleaning to control odor problems**
Process Stage	General.
Description	Applying good house keeping procedures by cleaning

	regularly the equipment in use would limit the amount of odors generated through the accumulation of waste, or wastewater discharges…
Procedure	One example could be the acquisition of a good and efficient fleshing collector, which could be placed in an adjacent position to the fleshing machine. The latter would lead to a better collection of the fleshings, resulting in a reduction of unnecessary washing and odor generation. In addition, a regular washing of the equipment would limit odors due to accumulation of waste or disposal of wastewater...
Category	Good House Keeping
Issues to consider when selected	• Equipment cleaning has to be conducted on a regular basis, however any cleaning should be done at specific times where it does not hinder the work of other employees (i.e. cleaning the fleshing machine while other employees are working next to it, might lead to possible accidents…).

Control odor problems by good housekeeping	
Environmental Benefits	• Reduction in noxious odors.

Method	**<u>Monitor and control process waters</u>**
Process Stage	General.
Description	Water consumption and wastewater generation could be reduced by up to 50% if good maintenance and monitoring over the water usages is done.
Procedure	Water conservation measures include a variety of steps that can be taken to reduce pollutant discharge in tanning facilities. These consist primarily in maintaining close control over facility operations to avoid accidental loss of process chemical batch, checking network leakage and making the necessary repairs and regular maintenance. Supervision to ensure reduction of dirt in production areas to avoid unnecessary washing and processing of soiled

	material also contributes to conservation. Other measures that should be considered to reduce water usage, include the use of new monitoring technologies designed to reduce water consumption, such as liquid level controls, flow indicators, water hardness verification and automatic shut off valves.
Category	Good House Keeping
Issues to consider when selected	• Extra monitoring of processes should be limited to necessary verifications as this could be time consuming when overdone.



Regular Control of:

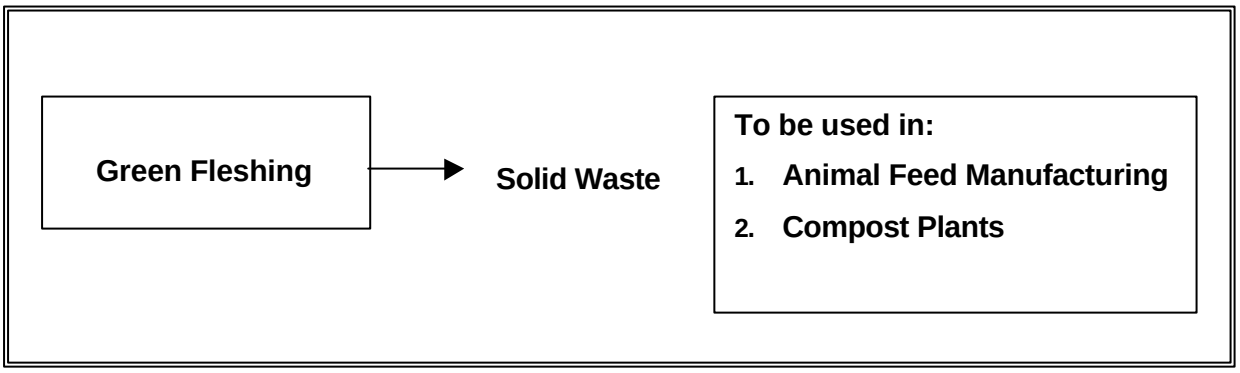
- **Water Consumption**
- **Water Quality**
- **Leakage Controls**
- **Etc.**

Monitor and control process waters	
Environmental Benefits	• Reduction in water consumption; • Reduction in wastewater generation.

4.4 Enhancing the Performances of Existing Complementary Outsider Facilities

Method	**Re-usage of green fleshings**
Process Stage	Green Fleshing.
Description	The by-products of the green fleshing process could be re-used as raw material in other industries such as the animal feed industry and for obtaining grease. This option would reduce the total amounts of solid wastes generated from tanneries.
Procedure	The solid wastes generated following the green fleshing are usually free of any amount of chemicals and could be used as raw material in the animal feed industry and for obtaining industrial grease.
Category	Material Recovery

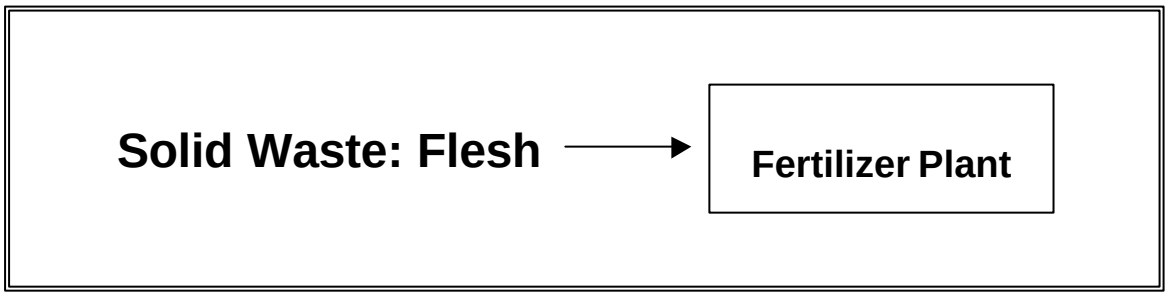
Issues to consider when selected	• To maximize the quality of the raw material, the solid wastes needed for the animal feed industry should be separated from other kinds of wastes generated through other processes (i.e. Chrome trimmings, sand, other garbage, etc.); • A low cost method for the collection of all the green fleshing should be available to minimize transportation costs. One alternative is to have the animal feed facility as close as possible to the tanning industries.



Re-usage of green fleshings	
Environmental Benefits	• Reduction in solid wastes; • Reduction in hazardous solid wastes.

Method	**Recycle wastes to the extent feasible in the manufacture of fertilizer**
Process Stage	Applied in More than One Stage.
Description	The by-products generated form the fleshing process especially could be re-used for other purposes, thus limiting the final amount of solid wastes.
Procedure	Some solid wastes from the tanning processes could have some useful properties that could stimulate the soil quality. Thus, some of the solid wastes generated could be used as fertilizer in the agricultural industry.
Category	Material Recovery

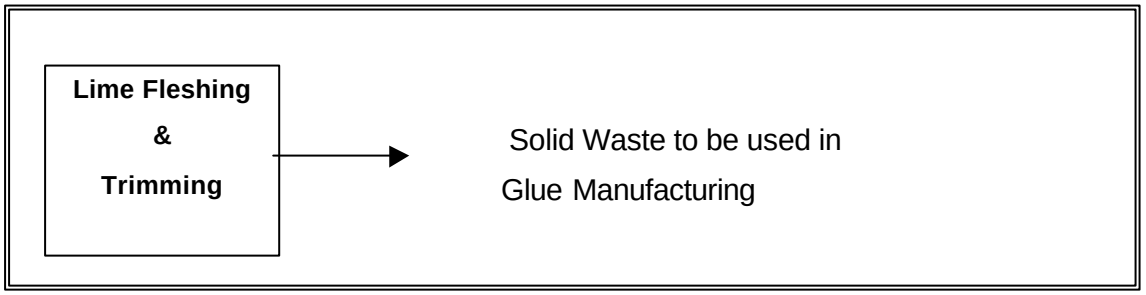
Issues to consider when selected	• To maximize the quality of the raw material, the solid wastes needed for the fertilizer industry should be separated from other kinds of unwanted wastes generated through other processes (i.e. chrome shavings, chrome trimmings, etc.); • A low cost method for the collection of all the solid wastes should be available to minimize transportation costs. One alternative is to have the fertilizer facility as close as possible to the tanning industries; • Due to the potential decomposition of the fleshing by-products, the conservation of such solid wastes could cause some problems if not used quickly enough.



Recycle wastes to the extent feasible in the manufacture of fertilizer	
Environmental Benefits	• Reduction in solid wastes.

Method	**<u>Recovery of lime fleshing and limed trimmings</u>**
Process Stage	Fleshing.
Description	The recovery of limed fleshings and limed trimmings for the production of glue and grease, could be another option for limiting the amount of solid waste generated through the tanning process.
Procedure	Glue manufacturers can use fleshings and trimmings generated after the lime process as raw material for glue and grease production.
Category	Material Recovery

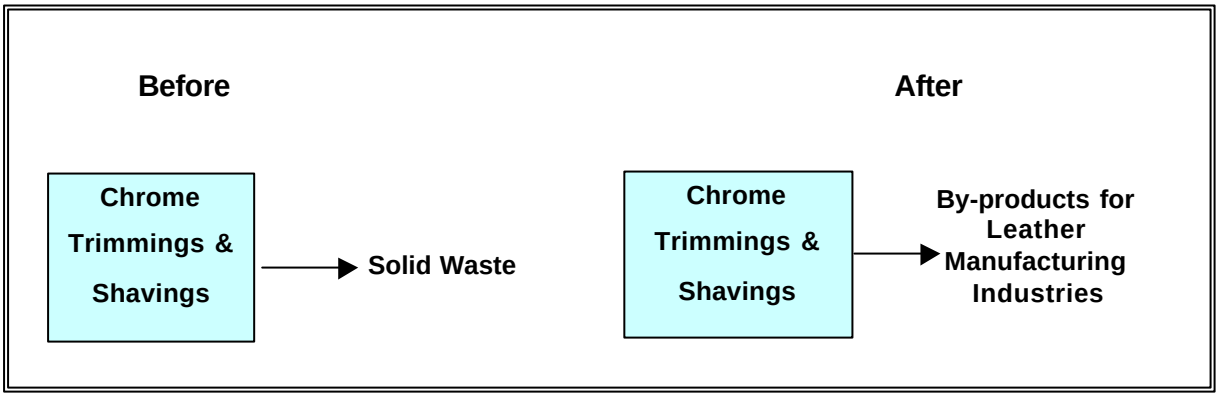
Issues to consider when selected	• To maximize the quality of the raw material, the solid wastes needed for the glue industry should be separated from other kinds of wastes generated through other processes (i.e. Chrome trimmings and other garbage, etc.); • A cheap method for the collection of all the limed fleshing and trimmings should be available to minimize transportation costs. One alternative is to have the glue production facility as close as possible to the tanning industries.



Recovery of lime fleshing and limed trimmings	
Environmental Benefits	• Reduction in solid wastes; • Reduction in hazardous solid wastes.

Method	**Recovery of chrome trimmings and shavings**
Process Stage	Tanning.
Description	The solid wastes generated through the chrome trimming and shaving processes could be saved and used as raw materials for the leather board industry.
Procedure	Leather board manufacturers have the capability of recycling the tanned shavings and trimmings resulting from the leather hides and skins production. The by-products collected are the raw materials needed to manufacture leather-boards, which could be used for the production of shoe heels, shoe insoles, belts, book bindings, etc.
Category	Material Recovery
Issues to consider when selected	• To maximize the quality of the raw material, the solid wastes needed for the leather board industry should be separated from other kinds of wastes generated

	through other processes (i.e. fleshings, trimmings after fleshing, sand, other garbage, etc.) • A low cost method for the collection of all the chrome solid wastes should be available to minimize transportation costs. One alternative is to have the leather board facility as close as possible to the tanning industries.



Recovery of chrome trimmings and shavings	
Environmental Benefits	• Reduction in solid wastes; • Reduction in hazardous solid wastes.

4.5 Summary Table

According to the selected process this table shows the main reductions in:										
Process	**Water consumption**	**Wastewater Generation**	**Noxious Odors**	**Air Pollution**	**Hazardous Gases**	**Solid Waste**	**Hazardous Waste**	**Chemicals Used**	**Chemicals Found in Effluents**	**Financial Savings**
In-plant Control & Process Changes										
Using Freshly Flayed Hides or Skins	✔	✔							✔	✔
Salt & Chemical Free Conservation methods	✔	✔						✔		
Shaking the Salted Hides or Skins before soaking	✔								✔	
Introducing Green Fleshing	✔	✔					✔		✔	✔
Hair Waste Reduction	✔	✔					✔		✔	
Re-use of Liming Wastewater	✔	✔						✔		
Separating Residual Baths of Liming and Chrome					✔					
High Tech Sulfide Recycling	✔	✔	✔						✔	✔
Segregating Sulfide from Effluents			✔						✔	✔
Split Limed Hides	✔	✔					✔		✔	✔
Reducing Ammonium in Deliming			✔				✔		✔	
Degreasing Recuperation/Substitution		✔						✔	✔	✔
Salts Reduction in Pickling Stage	✔	✔						✔	✔	✔
Recycling Pickling Liquors	✔	✔						✔	✔	✔
Using Trivalent Chrome							✔		✔	
High Chrome Exhaustion Technique	✔	✔					✔		✔	✔
Chrome Substitution							✔		✔	
Chrome Precipitation and Recovery							✔	✔	✔	✔
Re-using Chrome	✔	✔						✔	✔	✔
Wet White							✔		✔	
Recycling Vegetable Tanning Liquor	✔	✔						✔	✔	✔
Recycling Sammying Liquor	✔	✔						✔	✔	✔
Minimizing Re-tanning Effluents		✔							✔	
Use of Photocell Assisted Spraying			✔	✔						✔
Decrease VOCs Using new lacquers			✔	✔						
Correct Weight Determination	✔	✔						✔	✔	✔
Shaking the Salted Hides or Skins	✔								✔	
Use of Low-Float Method	✔	✔						✔		✔
Use of Drums Instead of Pits	✔	✔						✔		✔
Moisture Control	✔	✔					✔		✔	✔
Good Housekeeping										
Just in Time Management			✔							✔
Housekeeping for Odor Reduction			✔							✔
Monitoring of Process Water	✔	✔								✔
Outsider Facilities										
Re-using Green Fleshing						✔	✔			✔
Recovery of Limed Solid Wastes						✔	✔			✔
Recycling of Wastes for Fertilizers						✔				✔
Recovery of Chrome Solid Wastes						✔	✔			✔

It is important to note that depending on the country's environmental regulations, certain pollution prevention options listed above could also show some financial savings.

The list of the different pollution prevention options seen above should not be considered as an exhaustive one. Research is continuously being conducted to improve the performance of the available equipment or to make the leather production an environmentally friendly industry.

The study has just covered some of the main pollution prevention options but for interested readers, further literature (such as the, BLC Journal, Journal of the American Leather Chemical Association, etc.) is available, covering the latest findings and other developments in the tanning industry.

Some additional examples of different pollution prevention options not detailed in the above sections are:

- Short term preservation using CO_2 Snow Flow-Ice to reduce salt or chemical usage in curing purposes;
- Use of Airless Guns to reduce VOC's;
- Implementation of High Volume Low Pressure (HVLP) spray guns to reduce VOC's;

4.6 Pollution Prevention- Financial Case Studies

The following case studies will provide examples of tanning facilities in some Mediterranean countries that have applied some of the pollution prevention opportunities mentioned before. These case studies will also present some economic data regarding the financial benefits of applying pollution prevention options.

However, the reader should be very careful in analyzing the given cases as the economic benefits vary considerably from one country to another due to the different costs of raw material, energy used, man labor… In addition, to cost variations, certain MAP countries (i.e. Spain, France, Italy, etc.) have in application some strict

environmental regulations, forcing the tannery owners to pay fines if they fail to comply with existing environmental laws. Thus, taking into consideration the presence of such environmental penalties, some pollution prevention options will become more profitable in some countries than in others.

Nevertheless it should be noted that the application of pollution prevention options represents in the largest number of cases a win-win situation both at the environmental and financial levels and means an improvement in product quality and consistency.

In addition to the above, the correct application of pollution prevention measures would cut important financial expenses related to the necessary installation of end of pipe treatment plants.

Lebanon. Shaking the Salted Hides

Background

To be able to evaluate the environmental impact of the tanning activity in Lebanon, a full audit of a typical Lebanese medium sized facility was conducted. The audited facility, which processed about 250 tons of hides and skins (80% hides and 20% skins) yearly, relied on the chrome tanning process for leather production. The visited tannery had the capacity of conducting the whole process from the soaking stage up to the re-tanning and finishing steps. However, the tanning operations were mainly conducted without any environmental considerations and the pollution and odors generated were subject to a series of complaints from the neighboring population and the concern of the Lebanese Ministry of Environment. Based on the case of the audited tannery, figures were projected relative to the whole tanning sector in Lebanon, which processes about 1000 hides a day.

Cleaner Production Principle

Shaking the salted hides;

Recycling the wastewater.

Cleaner Production Application

This consists in shaking the salted hides to reduce the amount of salts contained in them for curing purposes. Experience showed that through this pollution prevention option, residues of chlorides in rinsing batch could be reduced by up to 40%. Thus, effluents with such characteristics could be reused easily after simple bacteriological screening and salinity control as feed water for soaking and rinsing of new batches. The action to be implemented does not require the purchase of any expensive equipment or any complicated installation. This pollution prevention option could be applied directly in any tanning facility.

Environmental and Economic Benefits

- Reduction in water consumption;
- Reduction in wastewater generation;
- Reduction in salinity concentration of soaking and rinsing effluents.

Below are the financial figures related to the potential investments and money savings that could be achieved through the application of such method:

- Approximately 500% in Water Savings (i.e. 5liters per Kg of salted hide could be saved, if the water from rinsing stage is recycled and re-used)

- Production 1000 hides/day (average 35kg/hide), 141.12E/year represents the price of 1m^3 /day of water.

Costs

Equipment	Price
Screening Filters	705.6 E
Holding Tank	3,087 E
Centrifugal Pump	441 E
Plumbing	0 E
Total (new)	4,233.6 E

Savings

(35kg x 1000 hides x 5 liters x 141.12E)/1000 = 24,696 E/year

Payback Period: 12months / (24,696/4,800) = 2 months

Constraints

No major constraints reported.

Lebanon. Introducing Green Fleshing

Background

See previous case.

Cleaner Production Principle

Process change.

Cleaner Production Application

Applying “Green Fleshing” before the liming stage will reduce close to 18% of the hides’ weight. The resulting fleshing can be reused for agricultural purposes (i.e. animal feed, soil conditioner, etc.) while at the same time allowing savings in the chemicals and water used. The application of this pollution prevention option would require the purchase of a green fleshing machine to conduct the fleshing operation prior to the liming stage.

Fleshing treatment should separate fat from protein.

Environmental and Economic Benefits

18% savings in water and chemicals due to weight reductions

Costs

Actual cost of green fleshing machines, or acquiring a used one would vary substantially. However, such a second hand machine could be acquired for close to 66,150 E.

Savings

Quantity of raw material used:

2.3% Sodium Sulfide used, price 352.8 E/ton

3.6% Lime used, price 105.84 E/ton

Price of $1m^3$/day of water is 141.12 E/year

Production is 1000 hides/day (average 35 kg/hide)

500% water necessary for liming

Sodium Sulfide: (2.3% Sodium Sulfide quantity used x 352.8 E x 35 tons x 250 days) x 18% (total weight reduction) = 12,780.18 E/year

Lime: (3.6% Lime quantity used x 105.84Ex 35 tons x 250 days) x 18% (total weight reduction) = 6,001.128/year

Water: (35 tons x 5 x141.12 E) x18%= 4,445.28/year

Approximate salvage value of old fleshing machine: 4,410 E

Retail price of green fleshing if sold (1575 ton/year): not available

Approximate payback period: (Price- Salvage Value)/(yearly savings) =

(66,150- 4,410) / (12,789+ 5,997.6+ 4,445.28) = 2.6 years

Constraints

None reported.

Lebanon. Correct determination of Weights

Background

An audit completed in a Lebanese tannery, demonstrated that due to incorrect weighing, excess chemicals and water were used in the tanning process. The audited facility processed close to 350 tons of salted hides a year.

Cleaner Production Principle

Process change.

Cleaner Production Application

To be able to strictly apply the correct chemicals needs in leather production, the tanners should use as often as possible an accurate measuring scale during the tanning process. Thus, if the hides and chemicals are correctly weighed, this should help the tanners to prevent any excess usage in raw material consumption (i.e. chemicals or water).

Environmental and Economic Benefits

By limiting the usage of chemicals and water needs to the required theoretical values, the tanners should be able to achieve important savings as well as limit the pollution load resulting from their tanning activities.

- Reduction of water consumption
- Reduction in wastewater generation
- Reduction in raw material
- Reduction in pollution load
- Better product quality

Costs

Proper Weighing Scale 1,764 E

Savings

The audit showed that there were some differences between the theoretical figures given first by the tanner and the actual figures relative to the total amounts of chemical used. Considering the fact that the tannery processed 350 tons of hides a year, the overall savings per chemicals used are shown in the table below. The water savings were not included as the tannery had access to free water sources. The last column is the difference in percentage

Material	Practice%	Theoretical%	Savings
Lime	3.6	3	222.26 E
Ammonium Chloride	2.4	2	648.27 E
Sodium meta-bisulfide	0.79	0.3	831726 E
Formic acid	0.82	0.7	277.83 E
Sulfuric acid	1.05	0.8	192.27 E
Sodium formate	1.6	1.2	648.27 E
Total Annual Savings			**2,820.63 E**

If price of 1 ton of Lime is 105.84 E, thus savings for 350 tons will be: (3.6% - 3%) x 350 tons x 105.84 E= 222.26 E

- Price of 1 ton of Ammonium chloride 463.05 E
- Price of 1 ton of Sodium meta-bisulfide 485.1 E
- Price of 1 ton of Formic acid 661.5 E
- Price of 1 ton of Sulfuric acid 220.5 E
- Price of 1 ton of Sodium formate 463.05 E

Considering the initial investment of 1,764 E and the yearly savings of close to 2,822.4 E, the payback period should be close to 7.5 months.

Constraints

The above prices of chemicals might vary from one country to another thus changing the final amounts of savings that could be achieved.

Tunisia. Re-Use of Chromium in Leather Tanning

Background

The following case study is taken from an EP3 project[33].

The audited facility is a tannery in Tunisia, which produces leather from sheep and goatskins.

The facility tans approximately 600,000 sheep hides per year and, periodically, tan goat hides.

At the time of the cleaner production (CP) assessment, a number of pollution problems existed at the facility, including the generation of sulfide, excessive chromium discharge, excessive effluent volume, inefficient chromium fixation and inefficient use of dye chemicals. In addition, the company's wastewater pre-treatment station was not functioning adequately, resulting in the discharge of wastewater exceeding the required norms.

Cleaner Production Principle

- Recovery, reuse and recycle;
- Process modification;
- Good Housekeeping.

Cleaner Production Application

The CP assessment identified four solutions that would bring significant environmental and economic benefits. The solutions, which are now being implemented, are:

- Recycle chromium effluent with the addition of one third of the initial requirements to reduce chromium discharge into wastewater. This is done by constructing a

[33] *Re-use of Chromium in Leather Tanning*, http://www.emcentre.com/unepweb/tec_case/leather_19/recovery/r3.htm, EP3

holding pit into which the used tanning bath is pumped after having been screened. The solution can be used five times before discharging it;

- Recycle used black dye solution, with the addition of half of the initial requirements to reduce the dye discharged into the wastewaters. This is done by installing tanks, plumbing and filters needed for recycling.
- Raise temperature and control pH of the tanning baths to increase chromium fixation on the hides. This is done by repairing the boiler to pre-heat the tanning bath, and by installing continuous, digital temperature and pH probes for each bath;
- Segregate the liming and washing wastewaters from other acidic waste waters to eliminate sulfide generation. This is done by constructing a sump that intercepts wastewater from the liming and washing operations. The sulfides are oxidized.

Environmental and Economic Benefits

The CP solutions reduce the quantity of toxic chemicals released. The amount of wastewater to be treated is reduced by 8.5 percent (2,000 m^3 per year); the loading of toxic chromium salts by 55 percent and of dye baths by 25 percent. Isolating incompatible waste streams for separate treatment enables the pre-treatment station to operate more efficiently, and avoids the generation of foul smelling and toxic hydrogen sulfide gas.

Costs & Savings

Overall, the implementation of the CP project will result in an annual saving of 86,436 E for a total investment of about 22,050 E. Specifically, recycling used chromium effluent is expected to result in a financial benefit in the first year of 37,044 E, requiring a total investment of just 4,410 E. The implementation of the solutions will also result in improved productivity and increased quality of products.

Constraints

None reported.

Greece. Chrome Recovery and Recycling in the Leather Industry

Background

The following case study is taken from an EP3 project[34].

The project was carried out with the aim of enabling a tanning facility located near Athens in Greece to comply with discharge standards for trivalent chromium (Cr^{3+}) as recent limits for discharge to the environment have limited Cr^{3+} discharge to levels as low as 2mg/liter in wastewater.

The audited facility produces good quality upper leather from cattle hides, processing 2200 tons per year.

Cleaner Production Principle

Recovery, reuse and recycle of Cr^{3+}

Cleaner Production Application

The technology developed involves the recovery of Cr^{3+} from the spent tannery liquors and its reuse.

Tanning of hides is carried out with basic chromium sulfate, $Cr.(OH)SO_4$, at a pH of 3.5-4.0. After tanning, the solution is discharged by gravity to a collection pit. The liquor is sieved during this transfer to remove particles and fibers that have come from the hides. The liquor is then pumped to the treatment tank and a calculated quantity of magnesium oxide is added with stirring until the pH reaches at least 8. The stirrer is switched off and the chromium precipitates as a compact sludge of $Cr.(OH)_3$. After settling, the clear liquid is decanted off. The remaining sludge is dissolved by adding a calculated quantity of concentrated sulfuric acid (H_2SO_4) until a pH of 2.5 is reached. The liquor now contains $Cr.(OH)SO_4$ and is pumped back to a storage tank for reuse.

[34] *Chrome Recovery and Recycling in the Leather Industry*, http://www.emcentre.com/unepweb/tec_case/leather_19/recovery/r1.htm, EP3

In conventional chrome tanning processes, 20-40% of the used chrome is discharged into wastewater. In the new process, 95-98% of the waste Cr^{3+} can be recycled.

Environmental and Economic Benefits

The project benefits include:

- More consistent product quality;
- Much reduced chromium content of effluent waters.

Costs

For the audited tannery, which has a chrome recycling capacity of 12m^3/day, the approximate costs were as follows:

- Capital Investment 35,280 E
- Operating cost 26,636.4 E
- Total 61,916.4 E

Savings

Savings 65,047.5 E

The payback period was 12/ (66,047/61,916.4)= 11 months.

Constraints

This technology is expected to be economical only for chrome recovery plants processing more than 1.7m^3/day.

France. Deliming using CO_2

Background

The following case study is taken from an EP3 project[35].

This case study demonstrates reduction in residual chromium use in a tannery in France. The tannery produces 80 tons of leather per month and uses 1.5 tons of ammonia sulfate per month in the form of deliming salt.

Cleaner Production Principle

Material substitution;

Process / Product modification.

Cleaner Production Application

This case study demonstrates reduction in residual chromium from the tanning process by adopting a deliming process using carbonic anhydride. Following satisfactory trials carried out in 1990, a semi-industrial operation of several months established the definitive equipment. The trials carried out were as follows:

1. Deliming of glove making with ammoniacal salts
2. Deliming of glove making with carbonic gas; (both followed by an identical tanning pickle in two different fullers)
3. Deliming of shoe uppers with ammoniacal salts
4. Deliming of shoe uppers with carbonic gas after a pre-deliming for 20 minutes using salts (following a tanning pickle within the same fuller)

The results showed that:

- Process 2 improves the surface output, as well as scouring and polishing of hides due to the action of the gas bubbles.
- Process 4 improves the suppleness and the curve of the leather, but requires a careful drying, by pasting or vacuum, to obtain an even surface.
- The chrome works better with the carbonic gas than with the salts.

Environmental and Economic Benefits

The project benefits include,

[35] *Deliming Using CO_2*, http://www.emcentre.com/unepweb/tec_case/leather_19/material/m2.htm, EP3

- Improvement in the reliability of the process. (For example, excess CO_2 was found to be well tolerated in the operation of the system);
- Possibility of automation of the gas supply;
- Improvement in the quality of the leather;
- Improvement of the company's image;
- Suppression of nitrogenous waste, in anticipation of future directives;
- Discontinuance of deliming products (citric acid and ester);
- Reduction of pollution taxes.

Costs & Savings

Cost of direct investment for CO_2 feeding was close to 17,640 E in 1993. Against this investment, costs saved were due to elimination of 1.5 tons/month of ammonium salt.

Constraints

Intermittent gas inputs may result in formation of carbonate. Addition of bisulfate may be done to avoid H_2S formation.

Italy. Waste Segregation for Producing Fertilizers

Background

The following case study is taken from an EP3 project[36].

This case study illustrates a design change in a process component, which resulted in a remarkable upgrading of the whole manufacturing process, transforming an intrinsically polluting process into a cleaner one. The process was implemented by a group of Italian leather tanning companies

Cleaner Production Principle

Process modification;

Recovery of by-products.

[36] *Waste Segregation for Producing Fertilizers*, http://www.emcentre.com/unepweb/tec_case/leather_19/process/p3.htm, EP3

Cleaner Production Application

The process makes use of a newly designed tumbler that allows a continuous external circulation of chemicals, thereby requiring a smaller quantity of input chemicals. Cleaner production was achieved through the following depilation processes:

1. Raw hide soaking by sodium sulfhydrate

2. Calcium hypo chloride treatment for sodium sulfhydrate liming.

3. Sodium hydroxide addition to increase the pH.

These depilation processes allow the separation of the undissolved pilus, which is then recovered by filtration, resulting in sludge reduction and an extended use of pilus and skin for organic fertilizer production.

On-going research is looking into the possible substitution of chemicals with enzymes in the process and setting up special desiccators to improve the quality of the organic fertilizers.

Environmental and Economic Benefits

- The reduction of chemicals needed for the process leads to material conservation and minimization of handled waste material. At first stage of the leather tanning process (depilation), the use of the newly designed tumbler, with lower maintenance, reduces the needed chemicals, thus reducing overall operating costs.
- The cost saving due to reduction of chemicals.
- The recycling of pilus and skin to agricultural applications as organic fertilizer reduces the sludge to be treated and disposed. A sludge reduction up to 45% is claimed. The Italian production of sludge is estimated at about 1300-1500 tons per day. Application of this technology could reduce sludge to approximately 600-700 tons/day. Although information from the source document was not clear, it is assumed that the process allows the conversion of a disposable waste material (pilus sludge) to a product (fertilizer) which can be used successfully in agriculture.
- The increase in the life span of the disposal facilities;
- The improvement in the nitrogen cycle results in reduced wash out;
- The overall operational and maintenance costs can be broken down as follows:

- Cost of head-end leather tanning process about 0.35 E/kg
- Cost of waste treatment (traditional technology) about 0.11 E/kg
- Cost of waste treatment (new technology) about 0.08 E/kg
- Overall costs reduction was found to be 8% while the cost reduction in waste treatment was 25%.

Constraints

None reported.

Syria. Liming of Hides in Drums

Background

A research study conducted in Syria showed that a majority of the tanneries there still relied on paddles and pits for their tanning process[37].

Cleaner Production Principle

Process change.

Cleaner Production Application

Although the space availability in the tanning facilities' area is considered to be very limited, tanners should be encouraged to switch from the old traditional way of liming (using pits and paddles) to newer techniques relying on drum utilization.

Environmental and Economic Benefits

- Wastewater reduction;
- Chemical reduction (up to 50% reduction in the quantity of Sodium Sulfide found in effluents);

Costs

Fees related to acquiring & installing new drum

Savings

The study showed that if the liming process was to be conducted in the drum instead of pits or paddles, the quantity of sodium sulfide in effluents would be decreased by close to 50%. Such reduction will also signify that the tanners will be using 50% less chemicals, which will result in direct financial savings.

The exact financial savings will depend highly on the price of drums as well as chemicals needed for the process. However, the payback period should not be too long especially if the drums are locally made.

Constraints

The following constraints are just limited to the area where the research was conducted.

- Lack of electric energy availability in the concerned area;
- Lack of sufficient financial resources in the concerned area;
- Lack of space availability in the concerned area;

Thus the above constraints are just limited to the Syrian case. In other countries having sufficient space availability or countries that are planning to relocate the tanning industry, the usage of drums should be highly encouraged even if this could require an additional financial investment at the beginning. On the long or even on the medium term, such investment would prove highly economic and environmentally friendly.

Developing Country. Pollution Prevention Audit for a Sheep Hide Tannery

Background

The following case study is taken from an EP3 project[38].

[37] THE PROJEKT HIDRO, Preparatory Assistance in the Treatment of Tannery Waste in Zablatani- Damascus Industrial Area- Syria, UNIDO, 1994

[38] *Pollution Prevention Audit for a Sheep Hide Tannery*, http://www.emcentre.com/unepweb/tec_case/leather_19/material/m5.htm, EP3

An environmental assessment evaluated a sheep hide tannery. The objective of the assessment was to identify actions that would:

- reduce the quantity of toxics, raw materials, and energy used in the manufacturing process, demonstrate the environmental and economic value of pollution prevention methods to the tanning industry, and improve operating efficiency and product quality.

This facility is a tannery producing leather from sheep and goat hides. The facility tans approximately 2,000 sheep hides per day, for a total of 600,000 hides per year. Between 90 and 95 percent of the annual production hides are sheep hides for clothing, while the rest are goat hides for shoes. The wastes generated by the tannery come from the hides and the chemicals used in the production process. The facility provides on-site effluent pre-treatment prior to discharging the wastewater to the municipal sewer system.

At the time of the assessment, there were a number of pollution problems at the facility, including, excessive chromium discharge, excessive effluent volume, inefficient chromium fixation, hyposulphuric acid generation, and inefficient use of dye chemicals.

Cleaner Production Principle

- Process modification;
- Good Housekeeping;
- Recovery, reuse and recycle;
- Material substitution.

Cleaner Production Application

Below are listed the opportunities recommended for the facility, and presents the environmental benefits and implementation costs for each.

Pretanning:

1. Recycle improved secondary treatment waste effluent.
2. Liming - Segregate from other waste streams and oxidize separately
3. Liming wash water Reuse effluent from liming wash

Tanning:

1. Chromium Fixation -- Increase temperature and control pH.
2. Chromium Effluent Recycling - recycle used chromium effluent with addition of 1/3 of initial requirements reduces chromium in water.
3. Chromium recovery - precipitate chromium wastes with hydroxide, settle, and re-dissolve with acid and re-use chromium in later batches.

Chromium reuse and recovery, black dye recycling, and water recycling will produce equal quality tanned hides while simultaneously reducing the quantity of chemical toxics released into the environment. Effluent from each virgin tanning bath can be reused up to five times by adding one-third the normal amount of chromium sulfate before each tanning bath. In addition, chromium recovery will reduce emissions and reduce production costs.

The recommendations can reduce the amount of wastewater treated by 2,000 m^3 per year, reduce the loading of toxic chromium salts and dye baths, and isolate incompatible waste streams for separate treatment. While it is not practical for the tannery to eliminate the need for its wastewater pre-treatment facility, the recommendations will enable the treatment system to operate more efficiently. Further, separation of waste waters will avoid the generation of foul smelling and toxic hydrogen sulfide gas.

Environmental and Economic Benefits

- Reduction in water consumption;
- Reduction in wastewater generation;
- Reduction in odors;
- Savings in chemicals consumption;

Costs & Savings

Pre-tanning

1. Recycle improved secondary treatment waste effluent yields a 30 percent reduction in water consumption. Implementation cost of 14,994 E.
2. Liming - Segregate from other waste streams and oxidize separately - eliminates the generation of H_2S. There are no costs to implement and the payback period is immediate.
3. Liming wash water - Reuse effluent in pre-liming wash - reduces wastewater. Implementation costs of 882 E, with a financial benefit of 882 E and a payback period of 1 year.

Tanning

1. Chromium Fixation - Increased temperature and controlled pH reduce chromium in wastewater. Implementation costs of 1,764 E.
2. Chromium Effluent Recycling - recycle used chromium effluent with addition of 1/3 of initial requirements reduces chromium in water. Implementation costs of 1,764 E with financial benefits of 4,410 E per year and a payback period of 5 months.
3. Chromium recovery - precipitate chromium wastes with hydroxide, settle, and re-dissolve with acid and re-use chromium in wastewater. Implementation costs of 1,764 E and a financial benefit of 882 E per year and a payback period of 2 years.

Total costs for the options are estimated at 21,168 E with financial benefits of 6,174 E per year.

Two major environmental issues for the tannery are the extensive use of chromium in the black dye and tanning salts, and direct worker contact with these toxic materials. Successful implementation of the recommendations would cut chromium sulfate purchased by 55 percent or 25 metric tons per year, and black dye purchases by 25 percent or 6 metric tons per year.

Overall, the assessment identified five pollution prevention opportunities at this facility that can save as much as 83,790 E in the first year after implementation for an overall investment of at most 19,404 E. If implemented, these pollution prevention changes

will reduce the amount of chromium sulfate used for tanning by 25 metric tons per year, eliminate the generation of H_2S, reduce the amount of waste water generated by 2,000 cubic meters per year, and reduce the chemicals needed to treat waste water. All five of the options identified can be quickly and easily implemented by the plant's staff. None require complicated, expensive, or new technologies.

Constraints

None reported.

Spain. Hair Recovery from Liming Process

Background

The following pollution prevention option, consisting in changing the traditional way of conducting the liming process, was successfully adopted by 13 Spanish tanneries.

The elimination of the hair from the hides is traditionally achieved through the usage of chemicals in baths with a high level of alkalinity. Under the action of the added Sodium Sulfide the binds of the keratin are destroyed, and the hair is eliminated in the form of suspended solids or dissolved in the wastewater. This traditional practice leads to residual baths with a high content in suspended solids, a high level of COD, high concentrations of Sulfides and an important water usage of approximately 18-22 liters/kg of hide.

The main incentives that led to the development of this project were the following: the necessity of respecting the available regulations relative to the permissible wastewater discharges. the possibility of using a residual matter with a high nitrogen content for agricultural purposes; the possibility of achieving a high water saving by eliminating the hair in its solid form; the possibility of reducing the consumption of sodium sulfide.

Cleaner Production Principle

Process change.

Cleaner Production Application

The new technology is based on an immunization of the hair with an alkali such as the Sodium Hydroxide or lime at a pH of 12.8-13 during 45-60 minutes. Sodium Sulfide or Sodium Sulfhydrate are then added in quantities of 1-1.2% and after 30 minutes, a

chemical shaving of the hair happens. At this moment the bath is emptied from the drum and in a closed circuit passes through a filter separating the hair in its solid form. In the same filter the hair is washed diminishing its salt content, thus facilitating its usage for agricultural purposes due to its high content in nitrogen. The re-circulation of the water continues during approximately 90 minutes. Afterwards, a small quantity of Sodium Sulfide is added (0.5%) and lime (0.5%) to destroy any remaining hair roots. Smaller quantities of water are needed in the following steps, thus realizing the same soaking and liming operation with a quantity of 15-16 liters/kg of hide.

Environmental and Economic Benefits

- The environmental advantages are achieved on a multitude of levels such as:
- Savings in chemicals due to a possible reduction of Sodium Sulfide
- Savings in water usage
- Reduction in wastewater generation
- Re-usage of solid wastes as fertilizers in agriculture

Costs & Savings

		Traditional Process	New Process	Savings
Material Balance	Raw Material	2,000 tons/month	2,000 tons/month	-
	Water	42,000 m^3/month	30,000 m^3/month	12,000m^3/month
	Chemical Products	190 tons/month	145 tons/month	45 tons/month
Pollution Level (in %)	COD	100	60	40
	Suspended Matter	100	40	60
Waste with Potential Recovery Value	Hair (25% dry matter)	-	400 tons/year	-
Water and Chemical Consumption	Annual Consumption	462,000 m^3/year	330,000 m^3/ year	132,000 m^3/ year
	Consumption Fees	47,124 Euro/ year	33,660 E/ year	13,464 E/ year
	Discharging Fees	1,302,000 E/ year	750,000 E/ year	552,000 E/ year
	Sodium Sulfide	158,400 E/ year	110,880 E/ year	47,520 E/ year
	Lime	52,800 E/ year	40,920 E/ year	11,880 E/ year
	Miscellaneous	528,000 E/ year	462,000 E/ year	66,000 E/ year
Managerial fees	Control and supervision	-	132,000 E/ year	-132,000 E/ year
	Maintenance	-	108,000 E/ year	-108,000 E/ year
	Waste Management	-	79,200 E/ year	-79,200 E/ year
Annual Savings			371,664 E/ year	
Investment Costs			600,000 E/ year	
Payback Period			1.6 year	

Constraints

None reported.

Spain . Recuperation and Recycling of Pickling Liquors

Background

A Spanish tannery decided to take part in a European pilot study promoting the adoption of cleaner production technologies in the tanning sector. The facility taking part in this project decided to experiment a new technique for the recuperation and re-use of the pickling wastewater, the final objective being:

- The reduction of the salinity level found in the effluents
- The reduction of raw material, especially the acids and salt necessary for pickling
- The reduction of water consumption
- The reduction of the polluted discharges

One of the stages in the beamhouse process is the pickling stage. The latter, which consists in treating the hides or skins with a mixture of acids and salts before conducting the tanning operation The pickling step is necessary to allow higher Chrome penetration.

Following this process effluents, called pickling liquors are generated. The latter contain salts and acids, which if not recuperated, will have to be treated before being discharged.

The traditional application conducted by the facility consisted in introducing the pelts in 4 pits where they were treated with a mixture of formic acid, sulfuric acids and salts, the all dissolved in $12m^3$ of water per pit. Once finished the water in each pit was emptied by a lower opening. The waste water generated was of high acidity, containing suspended particles and residues of grease and oils, to which a final treatment had to be conducted before emptying the wastewater.

Cleaner Production Principle

Recovery re-uses and recycles

Cleaner Production Application

The main principle of the new technique consisted in recuperating the pickling liquor and re-introducing it in the process, after being filtered and its pH re-adjusted accordingly. At the bottom of every pit, a filter was installed to eliminate the impurities of large dimension such as the pelt remains, dirt remains, etc. Once filtered, the liquor is sent to a storage tank of a 112 m^3 capacity. This pickling liquor is then re-adjusted for its re-utilization after the elimination of any remaining impurities (i.e. oils and grease). Out of this re-cuperated liquor, 50% of it could be re-utilized in subsequent processes where the other half is just re-sent to be treated before being discharged.

To be able to facilitate the re-adjustment of the pickling baths, the company has unified the types of acids used during this process, in such a way that the utilization of Sulfuric Acids was completely replaced by Formic Acids.

Environmental and Economic Benefits

This initiative allowed the company to achieve important savings in raw materials and water consumption. Furthermore the need for Sulfuric Acid was completely eliminated.

This new technique permitted an additional reduction in the load of Chlorides; conductivity and soluble salts usually present in the wastewater.

Costs & Savings

	Traditional Process	New Process	Savings
Material Balance per Pit			
Treated Pelts	1,333 units	1,333 units	-
Salt	1,000 kg	500 kg	50%
Sulfuric Acid	12 Liters	0 liters	100%
Formic Acid	70 kg	100 kg	-42%
Water	12,000 liters	6,000 liters	50%
Financial Balance			
Raw Material Expenses	59,754 E/ year	56,262 E/ year	6%
Treatment Expenses	7,944 E/ year	3,972 E/ year	50%
Mud/Dirt Management Expenses	4,320 E/ year	2,160 E/ year	50%
Total Expenses	**72,018 E/ year**	**62,394 E/ year**	**13.3%**
Savings	9,624 E/ year		
Investment	20,942 E/ year		
Payback Period	2.2 year		

Constraints

None reported.

CHAPTER V: CONCLUSION AND RECOMMENDATIONS

The set of recommendations necessary to facilitate the adoption of pollution prevention options by the tanning industry will require previously an appropriate country classification. This country division will determine a number of categories to which every state could be assigned and would ultimately advance a number of initiatives to be implemented accordingly.

Thus, in an effort to suggest the correct set of recommendations to limit the environmental levels of degradation resulting from their respective tanning activities, countries are to be distributed in one of the four categories below, based on their actual pollution prevention options practiced or promoted.

Hence, the following classification could be used as a general guideline to categorize the different MAP countries. Based on the latter this chapter will suggest some helpful measures to be eventually implemented.

- Category A: This first category would designate countries having conducted studies and fully implemented the necessary pollution prevention options to limit the overall level of environmental degradation related to their tanning activities.

- Category B: This second category refers to countries having conducted the studies required, to evaluate the pollution impact of the tanning industry and to suggest the necessary limitations to the environmental degradation. However, this second category would refer to countries that only partially implemented the required pollution prevention measures.

- Category C: This category reflects the number of countries that are still standing at a very early stage in the available studies or that did not conduct any study yet relative to the tanning sector. In addition Category C could also refer to countries with relatively weak environmental regulations or standards, low level of enforcement or poor infrastructure. These might not have yet seriously considered

the advantages of applying pollution prevention initiatives to limit the overall pollution level resulting from the activity of their tanning industry.

- Category D: This last category is not a category as such but had to be added, as the survey showed that at least one country did not have any tanning facility and another had only one conducting the tanning process partially.

Based on the above classification, the purpose of this chapter would be mainly to help the concerned MAP countries implement pollution prevention options that will improve the environmental performance of their tanning industry.

Thus, any country that could potentially fit in a low category will be advised to apply certain initiatives and guidelines that would ultimately help its tanning facilities in implementing a set of pollution prevention measures. Conducting such initiatives, will allow countries at lower levels to reach higher ones, until a set of full-scale applicable pollution prevention practices ends up being adopted.

As it was clearly demonstrated through the previous chapter, those environmentally friendly processes and production techniques would ultimately result in lower pollution levels, as well as help the concerned facilities in achieving additional financial savings.

Reaching a higher category is not an evident process. Such a decision would require a set of strong commitments, a number of detailed planning skills and could prove time consuming. However, concerned governments and industrialists in the tanning sector, should not be discouraged. They should always keep in mind that although challenging, such decision is not impossible, and could prove in some cases vital not only in limiting their high pollution levels but also in increasing the overall level of competitiveness of their industry. Before listing the necessary pollution prevention recommendations, it will be important to note at this stage that adopting pollution prevention measures do not require any environmental pre-established regulation. Tanners in countries with no environmental law or regulations can apply a set of pollution prevention options careless of any legislation availability. At the end, such measures have to be looked at or considered as an environmentally cost-effective way of production that will result ultimately in financial savings and quality improvements.

5.1 Incremental activities needed to pass from level C to B

These are a set of recommendations in form of activities that will help countries of category C to reach level B, thus getting closer to the possible application of the necessary pollution prevention measures to be implemented in their respective tanning industries. The activities mentioned below are presented as possible guidelines or actions that are highly encouraged and that could be adopted if a certain country is to go up in level.

Conduct a series of awareness campaigns

Concerned institutions and organizations should establish a series of awareness campaigns demonstrating the real benefits of adopting pollution prevention measures in the tanning sector. These benefits should not only be covering the different environmental issues, but they should also stress out the fact that such measures could also represent cost effective production practices. This will encourage tanneries in the concerned MAP countries to step towards conducting the necessary studies, evaluating the environmental gains but also the potential financial savings realized as well as the enhanced product qualities that could be produced.

Conducting audits and implementation of pollution prevention measures

The governments and concerned institutions in the category C countries should encourage and implement a series of environmental audits in selected tanneries. The audit results will help point out the weak practices in the audited tanning facilities. The latter will enable the tanners' association and other concerned institutions to tailor corresponding pollution prevention measures that could be applied to their respective tanning facilities.

Create a partnership between R&D institutions and tanners

To enhance every day experiences of tanners, and to be able to respond quickly and accurately to their needs, a continuous co-operation between the tanners' syndicate and the R&D team is a must. It is mainly through the promotion of a close contact between those two parties that R&D will be able to develop novel, environmentally friendly and improved processes.

Joint tasks for category C with Countries of higher categories

The promotion of joint tasks will contribute to better experience sharing among all the concerned parties, such as the tanners' association, or institutions involved in environmental issues in C countries and others in A or B category. The experience of countries from higher categories in the introduction of pollution prevention options to the tanning industry could prove an invaluable source of information for countries at lower levels. The tanners' association or other concerned institutions should conduct when necessary informational meetings and practical visits to be able to accelerate the experience sharing.

In addition to the above, these initiatives would facilitate the distribution of information as well as contribute to a capacity building and transfer of know-how between all stakeholders.

Developing sound environmental regulations

Environmental regulations in some MAP countries remain incomplete or in some cases almost in-exsitant. Thus, the concerned authorities should develop a set of appropriate environmental measures that would suggest a number of standards and thresholds to be followed by the most polluting industries. However, governments should make sure that the environmental regulations are being fully enforced, ensuring thus the application of pollution prevention options and other cleaner production techniques when necessary.

Encourage the adoption of pollution prevention options through financial incentives

For tanners to be able to comply with inner and international environmental regulations the adoption of pollution prevention options should be highly encouraged. Thus, economic and financial instruments should be put in place by the concerned authorities, in an effort to stimulate the adoption of prevention measures, and to facilitate the application of any environmental legislation. The tanners could profit from such incentives to alleviate partially the overall financial burden that could result from the implementation of new processes, the acquisition of new equipments, and eventually the installation of wastewater treatment facilities. These incentives could be in the form of low interest loans or also some tax exemptions, etc.

5.2 Incremental activities needed to pass from category B to A

These are a set of recommendations in form of activities that will help countries of B category to reach level A, thus getting closer to the possible promotion and application of the necessary pollution prevention measures in their respective tanning industries. The activities mentioned below are presented as guidelines or possible actions which are highly encouraged and that have to be adopted if a country is to reach the highest Category level.

Conduct financial feasibility studies for the existing suggested options

A number of detailed financial feasibility studies should be undertaken relative to the potential implementation of pollution prevention options as well as adopting cleaner technologies in the tanning sector. This will clearly demonstrate the environmental and financial advantages gained through the adoption of such measures. Plant owners will be encouraged to go further into the implementation of different pollution prevention options. The final results offering a win-win situation on both sides, at the environmental level, as well as at the tanners levels, who will be achieving financial savings and improving their product quality.

Conduct a series of demonstration projects

The implementation of a series of pilot projects will definitely be useful to encourage facility owners to apply similar initiatives in their tanneries. Tanners will be invited to attend different demonstration events where novel equipment and new processes will be introduced to them.

The new pollution prevention options should be however carefully presented, to make sure that they take into consideration the tanners' needs and that they are fully understood by the tanners themselves.

Encourage the adoption of pollution prevention options through financial incentives

For tanners to be able to comply with inner and international environmental regulations the adoption of pollution prevention options should be highly encouraged. Thus, economic and financial instruments should be put in place by the concerned authorities, in an effort to stimulate the adoption of prevention measures, and to facilitate the application of any environmental legislation. The tanners could profit from

such incentives to alleviate partially the overall financial burden that could result from the implementation of new processes, the acquisition of new equipments, and eventually the installation of wastewater treatment facilities. These incentives could be in the form of low interest loans or also some tax exemptions, etc.

Providing the R&D needs for the industry

The necessary funds for the establishment of R&D activities related to the tanning sector should be secured.. Through the implementation of some successful projects, tanning industries should be encouraged also to supply on the long run their own funding of R&D activities related to leather tanning.

Improving links with international organizations

A number of international organizations are in certain cases highly involved in problems related to the environmental impacts of tanning activities. In an effort of promoting pollution prevention options and cleaner technologies, the latter have been conducting a multitude of studies and demonstration projects in a number of tanning facilities world wide. These institutions should be approached regularly and links among them and the concerned authorities and tanners' representative should be strengthened. Such initiative will facilitate the dissemination of information as well as contribute to further experience sharing.

Joint tasks to disseminate relevant information

The establishment of a facility responsible for the dissemination of information related to the tanning industries should be considered for several reasons as a way of:

1. Providing access to all the new environmentally friendly technologies available;
2. Providing access to all information concerning the available institutions and organizations, etc. working in this field;
3. Providing a link with equipment suppliers, environmental experts, etc.
4. The facility should be a way of supplying all relevant information and contacts to promote the application of pollution prevention options and cleaner production related to the tanning industry.

Joint tasks for category B with Countries of A category

The experience of countries from higher categories in the introduction of pollution prevention options to the tanning industry could prove an invaluable source of information for countries in the lower categories. The tanners association or other concerned institutions should conduct when necessary informational meetings and practical visits to be able to accelerate the experience sharing. In addition these initiatives would facilitate the distribution of information as well as contribute to a capacity building and transfer of know-how.

5.3 Maintaining Level A

Tanning facilities in countries already listed in the highest category (i.e. Category A) are also responsible towards their country's environment, and would also have to take into consideration a number of measures to limit the final pollution levels generated through their activities.

Continuous support of R&D

Continuous support of R&D is extremely crucial if the tanning industry should develop and improve the already existing environmentally friendly techniques. This field could be supported through the participation and experience sharing of the various tanners association and interested institutions. Hence, the promotion of pollution prevention options and new developments could be accelerated through the joint efforts of all the parties, thus limiting the overall financial costs incurred.

Promoting Eco-labelling

If possible, promote continuously ideas such as eco-labelling to increase the level of awareness among the different tanning industries and to keep at all time the environmental standards as high as possible at all times. Such labels should end up representing attractive marketing tools for the tanning industrialists, used to promote their own products at the local as well as international levels.

Improving links among the different tanning organizations or concerned institutions in MAP countries

Information should always be shared not just for research and development purposes, but also to be able to ensure a continuous follow-up of all strategic developments related to the tanning industry. Positive as well as negative experiences will be an

invaluable source of information providing additional lessons to learn. The MAP governments, institutions, tannery associations and concerned parties, should maintain tight links among each other to ensure a good co-operation aiming at the promotion of pollution prevention options and avoiding any unnecessary project overlaps.

This cooperation should also include as well the participation of related leather industrialists (i.e. Shoe industries, bag industries, belt industries, leather garments, etc.) which rely on tanning facilities for their supply of raw material

Applying new environmental regulations related to pollution prevention

A number of MAP countries have set up a series of new regulations, such as the Integrated Pollution Prevention and Control (IPPC) or the Volatile Organic Compounds (VOC) directive. Those new standards leading to the adoption of cleaner technologies, Best Available Techniques (BATs) and better process controls, will eventually have to be fully adopted by the new tanning industries or implemented by the existing facilities in the near future. However, complying with such regulations is not an easy task, and will certainly need the support of additional instruments, which will on the long run, facilitate the adoption of the newdirectives. Thus, as new regulations are enforced, the governments and concerned institutions will have to take a continuous and active role providing a sound support to the industries, which are forced to implement them.

5.4 Conclusion

The aim of this study was just to present a brief idea of the environmental situation relative to the tanning sector, in the various MAP countries, while suggesting some of the main pollution prevention options that could be applicable in this industry.

The results achieved through the adoption of one or several of the above mentioned measures allow the concerned facilities to enhance their environmental performance as well as their social image. In addition, a number of pollution prevention options could be applied very easily and with a minor investment, representing at the end a win-win situation both on the financial level as well as on the final product quality. Such economic incentives would provide the tanners with a leading edge relative to competition, especially in a market where environmental issues are becoming an increasing concern and in certain cases used as marketing tools.

This study was only a mean to present some pollution prevention options, without intending to seek their concrete implementation, as this would ultimately depend on the characteristics and needs of each facility. Furthermore, it would be always advisable for the concerned tanner to take into consideration the financial and technical feasibility of each option before adopting them.

Finally, experience has shown that the associations and joint investments among industries belonging to the same sector, have often reduced the overall financial burden, necessary to achieve the required objectives. Thus, the relocation of the tanning facilities as well as related industries (i.e. Slaughter houses, Leather board industries…) to one region, would on the long run accelerate the operations and reduce additional costs or loads such as the logistics supports…

ANNEXES AND GLOSSARIES

Annex R1: Pollution limits for discharge of tannery effluents

The figures below provide a general idea about the different pollution standards that affecting the tanning industries in some of the studied MAP countries[39].

CROATIA	Surface	Sewer
pH	*	6.0-9.0
Temperature ºC	*	40
Suspended solids mg/l	*	400
Settleable solids ml/l	*	15
BOD_5 mg 0_2/l	*	450
COD mg/l	*	700
Sulfide mg S^{2-}/l	*	1
Chrome (lll) mg/l	*	*
Chrome (IV) mg/l	*	*
Chrome total mg/l	*	*
Chlorides mg/l	*	*
Sulfates mg/l	*	300
Ammonia mg N/l	*	15
TNK mg N/l	*	80
Oil/grease mh/l	*	100
Phenols mg/	*	1.5
Solvents mg/l:	*	Trace
Hydrocarbons mg/l	*	*
Nitrogenous mg/l	*	*
Organochlorinates mg/l	*	*

EGYPT	Surface	Sewer
PH	6.5-8.5	6.5-9.0
Temperature ºC	30	35
Suspended solids mg/l	30	*
Settleable solids ml/l	*	*
BOD_5 mg 0_2/l	*	*
COD mg/l	*	*
Sulfide mg S2-/l	2	*
Chrome (lll) mg/l	*	*
Chrome (IV) mg/l	*	*
Chrome total mg/l	0.2	2
Chlorides mg/l	*	*
Sulfates mg/l	300	*
Ammonia mg N/l	2.0	*
TNK mg N/l	5	*
Oil/grease mh/l	5	*
Phenols mg/	*	*
Solvents mg/l:	*	*
Hydrocarbons mg/l	*	*
Nitrogenous mg/l	*	*
Organochlorinates mg/l	*	*

[39] J.Buljan, M. Bosnic, http://www.cepis.org.pe/muwww/fulltext/repind60/pld/pld.html, UNIDO

FRANCE	Surface	Sewer
PH	5.5-8.5	6.5-8.5
Temperature ºC	30	30
Suspended solids mg/l	30-100	500
Settleable solids ml/l	*	*
BOD_5 mg 0_2/l	40-200	1000
COD mg/l	*	1000
Sulfide mg S2-/l	2	*
Chrome (lll) mg/l	1	*
Chrome (IV) mg/l	0.1	*
Chrome total mg/l	1	*
Chlorides mg/l	30-100	500
Sulfates mg/l	*	*
Ammonia mg N/l	15-80	*
TNK mg N/l	10-60	*
Oil/grease mh/l	*	*
Phenols mg/	*	*
Solvents mg/l:	*	*
Hydrocarbons mg/l	*	*
Nitrogenous mg/l	*	*
Organochlorinates mg/l	*	*

ITALY	Surface	Sewer
PH	5.9-9.5	5.5-9.5
Temperature ºC	30-35	30-35
Suspended solids mg/l	40-80	200
Settleable solids ml/l	*	*
BOD_5 mg 0_2/l	40	250
COD mg/l	160	500
Sulfide mg S2-/l	1	2
Chrome (lll) mg/l	*	4
Chrome (IV) mg/l	0.2	0.2
Chrome total mg/l	2	4
Chlorides mg/l	1000	1200
Sulfates mg/l	1000	1000
Ammonia mg N/l	10-15	30
TNK mg N/l	*	*
Oil/grease mh/l	20	40
Phenols mg/	0.5	1
Solvents mg/l:	*	*
Hydrocarbons mg/l	0.2	0.4
Nitrogenous mg/l	0.1	0.2
Organochlorinates mg/l	1	2

SPAIN	Surface	Sewer
PH	5.5-9.5	5.5-9.5
Temperature ºC	30	30
Suspended solids mg/l	80	300
Settleable solids ml/l	*	*
BOD_5 mg 0_2/l	40	300
COD mg/l	160	500
Sulfide mg S2-/l	1	1
Chrome (lll) mg/l	*	*
Chrome (IV) mg/l	0.2	0.5
Chrome total mg/l	2	4
Chlorides mg/l	2000	2000
Sulfates mg/l	2000	2000

Ammonia mg N/l	15	50
TNK mg N/l	*	*
Oil/grease mh/l	20	40
Phenols mg/l	0.5	1
Solvents mg/l	2	6
Hydrocarbons mg/l	*	*
Nitrogenous mg/l	*	*
Organochlorinate mg/l	*	*

Annex R2: Re-tanning End Products

Re-tanning end products[40]:

Re-tanning End Products	
1. UPPER LEATHER	1.1 Calf 1.2 Side 1.3 Vegetable tanned hide 1.4 Suede (including splits & nubuck) 1.5 Kip and other hide 1.6 Grain printed splits 1.7 Goat and kid 1.8 Sheep and Cabretta 1.9 Pig 1.10 Reptile, crocodile, ostrich 1.11 Reptile and other prints 1.12 Patent and wet look 1.13 Gold and silver 1.14 Other
2. LIMING LEATHER	2.1 Kip, calf and hide 2.2 Goat and Sheep 2.3 Socking 2.4 Splits 2.5 Other
3. SOLE AND INSOLE LEATHER	3.1 Sole 3.2 Insole 3.3 Splits 3.4 Cut soles
4. CLOTHING LEATHER (Excluding Sheepskin and Lambskin)	4.1 Sheep and lamb grain 4.2 Sheep and lamb suede 4.3 Hide (excluding splits) 4.4 Hide splits 4.5 Calf 4.6 Washable
5. GLOVING LEATHER	5.1 Cape and Sheep 5.2 Hide 5.3 Industrial 5.4 Other

[40] Directory, http://www.blcleathertech.com/directory.htm , BLC

6. SHEEPSKIN AND LAMBSKIN	6.1 Bootees, Linings, Insoles 6.2 Clothing Suede Shearlings 6.3 Clothing Lambskins 6.4 Grain Finished Shearlings 6.5 Beaver, Curly Lambskin, Similar 6.6 Gloving Shearling and Lambskins 6.7 Rugskins 6.8 Polishing Bonnets and other Industrial Purposes 6.9 Car Seat Covers 6.10 Other
7. LEATHERGOODS LEATHER	7.1 Calf 7.2 Hide & Kip 7.3 Splits 7.4 Morocco and other Goat 7.5 Sheep and Skivers 7.6 Reptile, Crocodile, Seal and Ostrich 7.7 Printed Reptile and other Grains 7.8 Pig 7.9 Other
8. BOOKBINDING	
9. FOOTBALL AND SPORTS LEATHERS	
10. UPHOLSTERY LEATHER	
11. CHAMOIS	
12 LACE LEATHERS	
13. MECHANICAL, TEXTILE AND HYDRAULIC LEATHER	
14. HARNESS, BRIDLE AND SADDLERY LEATHER	
15. ROUGH TANNED AND CRUST LEATHER	15.1 Wet Blue 15.2 Chrome Crust 15.3 Split Hides 15.4 Dressing Hides 15.5 Splits 15.6 Bellies and Shoulders 15.7 Crust Chamois 15.8 Crust Basils and Skivers 15.9 Offboard Skivers 15.10 Other

16. PICKLED AND LIMED	16.1 Pelts 16.2 Grains and Fleshes 16.3 Splits 16.4 Bellies
17. ORTHOPAEDIC LEATHER	
18. TOOLING LEATHER	
19. LEATHER PIECES	
20. CONTRACT DRESSING	

Annex R3: Physical Properties - leather comparison

The table below shows the difference between the physical properties of chrome-tanned leather and metal free leathers. The reader should however keep in mind that chrome free leathers are still difficult to market and in certain cases do not always have the correct physical properties necessary for the manufacturing of certain leather end products.

Physical Properties- Chrome-tanned leathers and metal-free leathers in comparison				
	Basic chrome tanned leather	**Veg./Synth./Polymer**	**Synth./Polymer**	**Polymer**
Dimensional Stability	1	3	4	4
Resistance to migration	4	4	4	4-5
Perspiration resistance	3	3	3	3
Resistance to Yellowing	3	1	3	4
Washfastness	3-4	3-4	3-4	3-4
Permeability to water vapor	3	2	2	3
Tear strength	4	3-4	3-4	3-4
Tensile strength	4	3-4	3-4	3-4
Lightfastness	3	2	3-4	5

Annex R4: Water Consumption Variation

The table below provides an idea about the difference in water consumption according to the different equipment used for leather tanning.

Water consumption according to the various techniques used[41]	
Technique	***Water %***
Low Floats	*40-80%*
Drums	*100-250%*
Paddles	*300-1000%*
Pits	*300-1000%*

[41] UNEP, Tanneries and the Environment- A Technical Guide, UNEP, Paris, p37

Annex R5: Listing of Main Persons Interviewed or Contacted

Name	Organization
Dr. José Maria ADZET	GERIC & AIICA
	Research Director
	Spain
Ms. Maite ARRILLAGA	COTANCE & ACEXPIEL
	Economic Consultant
	Spain
Ms. Soha NASSAR	**Tannery Specialist**
	Syria
Mr. Yahia OUWAYDA	**Advisor to the Minister**
	Syria
Mr. Rafic DIAB	SET
	General Manager
	Syria
Dr. Mohamad KAYYAL	SET
	Syria
Mr. Rami ABU SALMAN	UNDP, Capacity 21
	Lebanon
Mr. Hagop CHIRIKIAN	***Lebanese Tanners Association***
	Lebanon
Mr. Giusepe PAPULI	UNIDO
	Regional Representative
	Lebanon
Mr. Tarek GENEINA	Global Environment
	Technical Advisor
	Egypt
Mr. Miquel VILA	Miguel Vila Guitart, S.L.
	Manager
	Spain

Glossary of Some Chemicals Used in the Tanning Process

The listing below refers to the main chemicals used in the tanning process. This list however is not an exhaustive one and is meant to provide the reader with a basic general idea of the main chemical products necessary for the leather production[42].

General Purpose Chemicals

Sodium Sulfide

Calcium Hydroxide

Hydrochloric Acid

Ammonium Sulfate

Sodium Bisulfate

Sodium Chloride

Calcium Formate

Sulfuric Acid

Sodium Carbonate

Sodium sulfhydrate

Basic Tanning Materials

Chrome Salts

Vegetable Tanning Materials

Auxiliary Chemicals

Bates

Bactericides

Fat Liquors

Dyeing Auxiliaries

Dyes

Finishes

[42] Economic and Social Commission for Western Asia, Environmentally Sound Technologies in the Tanning Industry, United Nations, New York, 1997, p 132

Glossary of Main Leather Terms[43]

The Material

Skin: Skin of small animal such as sheep, goat, pig, etc

Hide: Skin of large animal such as cow, buffalo, etc

Definitions

Suede: Produced from the flesh surface, or from an inner surface exposed by splitting the hide, or by abrasion of the grain surface

Nobuck: A very fine suede effect produced by abrasion of the grain surface

Laminated leather: Has a coating greater than one third of the total thickness, but less than half

Coated leather: Has a finish greater than 0.15mm and less than one third of the total thickness

Leather: Has a finish less than 0.15mm thick

Skin Areas

Butt: The part from the back of the animal, which produces the best leather

Belly: Thinner, softer, more stretchy area from the belly of the animal

Neck: Often shows wrinkles

Axilla: Thin stretchy areas between the legs - usually has a coarser grain pattern

Surfaces

Grain: The outer surface of the hide or skin

Flesh: The inner surface of the hide or skin

[43] Glossary of Leather Terms, http://www.blcleathertech.com/information/glossary.htm, BLC

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