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Comparative study of environmental impact of three-leather process production by life cycle analysis

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The present work aims to study the substitution of chromium in a very polluting tanning process using an alternative tanning process. For this, three scenarios (S) have been adopted; S1: Vegetal/aluminum combination, S2: vegetable alone and S3: aluminum only. The environmental impact of the three systems has been carried by Life Cycle Analysis (LCA) using the LCA Simapro 8 tool software. The chemical reagents, water process and electricity consumption of the wastewater are responsible for all generated impacts by these scenarios. The results obtained show that the ratio of process water (water / leather) is 2 L / m^2 for S1 and 2.7 L / m^2, 1.56 L / m^2 respectively for S2 and S3. Also, it should be noted that the chemical quantities used for 1 m2 of leather for S1, S2 and S3 are respectively 1.446, 0.099 and 1.44 kg. The LCA assessment shows that S2 has the least environmental impact than S1 and S3. The weighted results (single score) that S2-senario presents advantages such as land use and organic respiration, given that vegetal tannin is biodegradable; because it is mainly exploitation of tannins coming from the forests, necessary for the preservation of flora and fauna.

Keywords: Chromium, Eco-indicator 99, Environmental impacts, Leather, Life cycle analysis, Vegetable tanning agent

The environmental issue is actually recognized as one of the major concerns in all proposed projects[1,2]. The first wastewater treatment plants were designed and operated to reduce pollution, produced by human activities, to minimize the negative effects of urban discharges on the environment health[3-5] and with the development of leather industry, which is well known as a high consumer of water. It can create heavy pollution from effluents containing high levels of salinity, organic loading, inorganic matter, dissolved and suspended solids, and specific pollutants (sulfide, chromium and other toxic metal salt residues)[6].

Traditionally most of tannery industries process all kinds leathers, thus starting from dehairing to tanning processes[7,8]. In recent years, many leather industries have been relocated from industrialized countries to developing countries like Algeria, fleeing very severe environmental regulations in developed countries[9], so the leather dealt with cleaner production and waste management is a major issue for the sustainable development for this type of industry[10]. The tanning process goal to transform leather in stable and rot-proof product, it exists four principal groups of sub-processes required to make finished leather: beam house operation, tanning process, re-tanning and finishing. However, for each type of final product, the tanning process is different and the quality and quantity of waste produced may vary in many areas[11].

The tanning process is wet, consuming large amounts of water and in some processes can generate up to 90% wastewater[12,13]. Tannery liquids effluents carry heavy pollution loads due to a massive presence of chemical compounds, like sodium chloride and sulphate, organic and inorganic substances (dyes), toxic metallic compounds, some products of tanning, which are biologically oxidizable, and a large quantity of putrefying suspended solid[14,15]. The liquid waste from tanning seriously damage the quality of surface water bodies and the surrounding soil, even the sub soil[16,17-19].The beam house workshop effluents, alone, contain high concentration of total solids[20-22]. Only 20% of the large number of chemicals used in the tanning process is absorbed by leather and the rest is released as wastes[23-25]. The main pollutants in the post-tanning process are chromium salts, dyes residues, fats, syntanes and other organic materials[26,27]. New processes are intended to stop using chrome or certain chemical salts, the alternative of vegetal tannin is preferred, as they can use materials such as aluminum salts, syntans. Among the many methods, vegetable pre-tanning has gained attention for its use in tanneries and is considered less toxic to ecosystems and human health[1] and others environmental considerations. The tanning process is made up of several steps associated with the consumption of large amounts of fresh water as well as the discharge of large amounts of liquid waste. Which are characterized by significant organic load and very high concentrations of organic and inorganic compounds[28,29]. In addition, currently used tanning agents pose enormous environmental constraints, which must be analyzed and categorized. A very useful tool to assess the environmental loads associated with a product, a process is the analysis or the assessment of the life cycle (LCA).

Recently the research work has been directed towards the development of an aluminum-based tanning agent (basic aluminum sulphate) with adequate hydrothermal stability, which will form crosslinks with the collagen so that the leather is resistant in the water[30,31]. Moreover, by using aluminum sulphate, in combination with vegetable tannins, or other mineral tanning agents and syntans, tanned leathers obtained have the same characteristics as those tanned with chromium salts[32-37]. In addition we know that the application of aluminum salts before the vegetal tannin generate a moderate withdrawal temperature of the liquid discharges[3, 7] with characteristics of aluminum alone. Therefore, the first and third options are Implausible. The most probable mechanism is for the aluminum (III) to crosslink the vegetal tannins, to stabilize the collagen by a multiplicity of connected hydrogen bonds in the new macromolecule[38,39].

The aim of this study is to determine and compare the environmental impact of the leather tanning process, with the environmental analysis tool which is the life cycle analysis (LCA) using the method of eco-indicators 99 and the "Simapro 8" software by replacing the chromium with other tanning agents (vegetable tannin and / or aluminum).

To be able to identify all the impact, we opted for the use of three tanning products according to three scenarios (Figure 1).

Life Cycle Assessment (LCA) is considered as one of the best tools for assessing the environmental impact of a product, service or process[40-44]. It makes it possible to assess inputs, outputs and a whole range of environmental impact throughout the life cycle of the systems studied (ISO 2006)[45,46], it is a recognized approach for carrying out life cycle assessments because it is supported by international standards ISO 14040 and ISO14044 (ISO 2006). These standards establish the guidelines and the framework for the conduct of life cycle assessments[47-49].

Experimental Section

Tanning Process Description

Animal skins are first sent to tanneries, where they are picked by species and quality. In large containers, they are then soaked to remove dirt and other impurities before treatment. Then the soaked material is chemically treated in a lime bath, to remove hair and other unwanted elements from the product then the skins are shown, in an enzymatic solution to remove the proteins and the fibrous material. After that, the skin is ready for tanning.

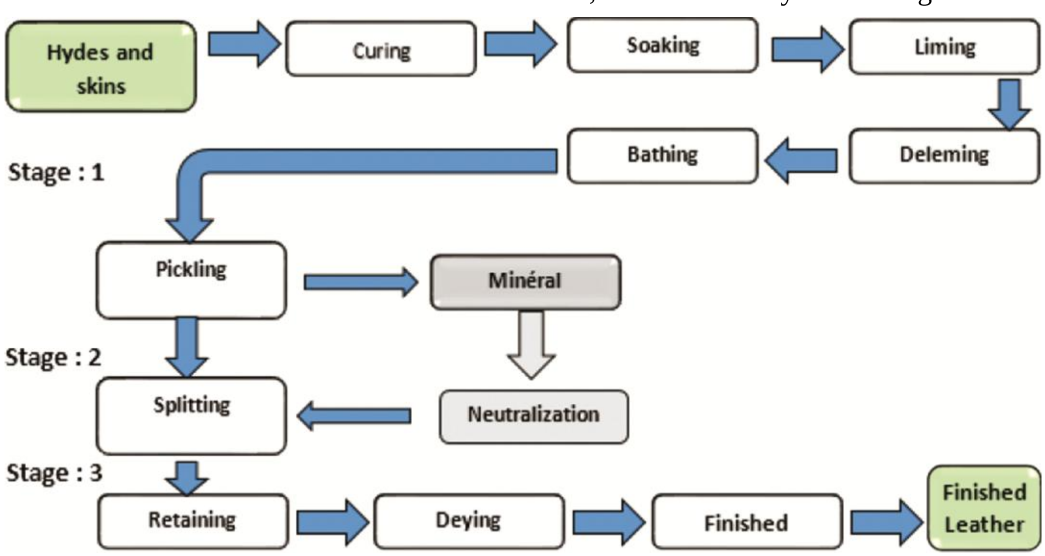

Fig. 1 — Flow chart Leather production processes

Then the product is spread out to drain it, to allow the fixation of chemical agents in the fibers. Then the product undergoes a fatliquoring. Oils are rubbed on the fibers to soften them and resist environmental constraints. Today, the oils used are of mixed variety - vegetal, animal and mineral. This product is then dried, in special rooms equipped with a fan to accelerate drying.

The Staking stage remains the most traditional. The procedure can be performed manually, adhering to traditional techniques, but specialized machines have been developed to complete this step. The material is then stretched. This is called staking because it remains the most useful tool for the work. A special machine that gently pushes the leather, spreads the fat liquor and ensures that the finished product remains flexible completes the operation.

Finally, and depending on its destination, the last step is the leveling, which consists in standardizing the thickness of the leather according to its use.

According to the process shown in Fig. 1, the three scenarios proposed for this study (Fig. 2) differ only by tanning agents. Other major upstream (stage 1) and downstream (stage 2) processes are the same for the three leather-manufacturing scenarios.

Scenario 1: Vegetal tanning (mimosa)

For vegetal tanning, the samples were fragmented to 1.0-1.5 mm. 8% mimosa and 92% water were added and the process was implemented at 30°C, 1°C and 10 rpm for six hours. The temperature was then raised to 35°C and the *p*H was first adjusted to 6.0 to 6.5 in six hours, then to an additional 7.5 to 8.0 over 10 hours by addition of sodium bicarbonate. After washing and draining, the samples were dried; at room temperature (22-24°C) and crushed, so it is ready for tanning.

Scenario 2: Pre-tanning of aluminum

Aluminum pre-tanning was carried out in the solution of Al_2 (SO_4) $18H_20$, a 12% and 88 % of water, with sodium citrate as a masking agent. The temperature was increased to 35°C and the process lasted ten hours at eight rpm. The *p*H was then adjusted firstly to 4.0 to 5.0 during six hours, then to 5.0 to 6.0 in an additional six hours with the addition of sodium bicarbonate, then. The samples were

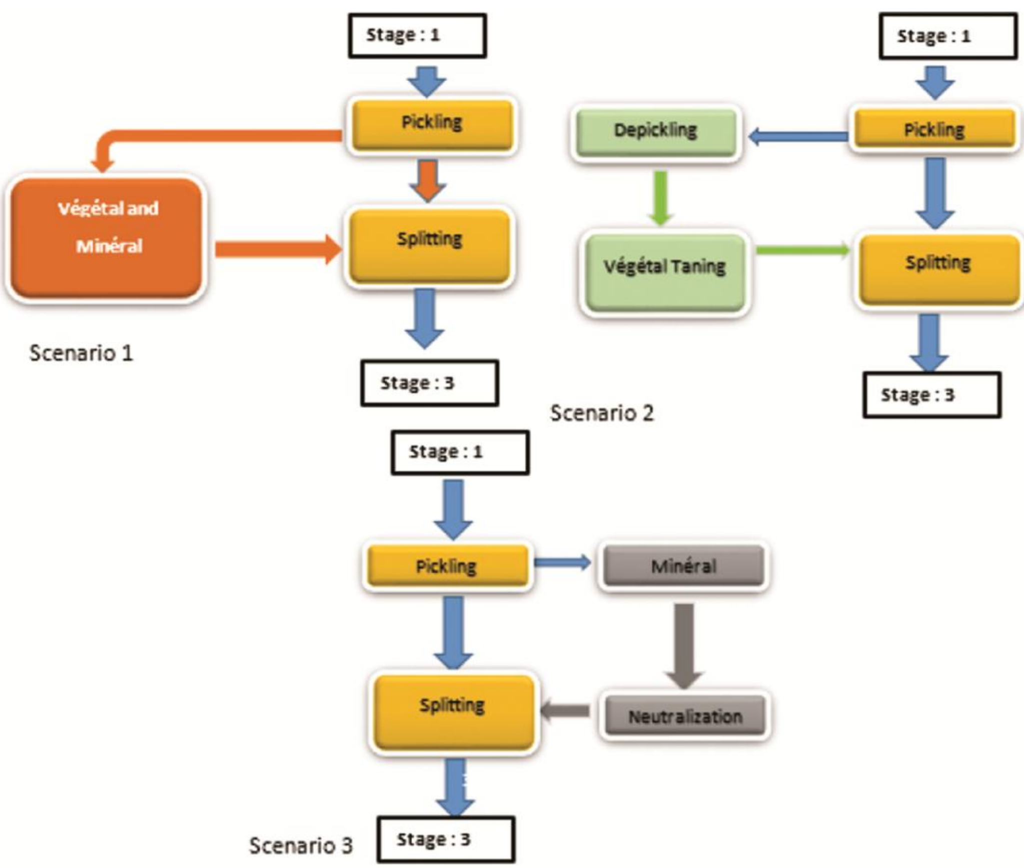

Fig. 2 — The three scenarios of leather tanning

washed twice with 200% water, drained and dried with classic chrome filter paper.

Scenario 3: Vegetal pre-tanning / aluminum

The combination offers full and supple leathers, which have a shrinkage temperature comparable to conventional chrome tanned skins. Among the combined systems evaluated, a vegetable pre-tanning followed by an aluminum re-tanning was better than an aluminum pre-tanning followed by a vegetable re-tanning. Optimal results were obtained using 10% plant tannins and 2% aluminum sulphate.

Life Cycle analysis

Complete life cycle, starting from the production of raw materials to the final disposal of the products, including material recycling if needed, the most important applications for an LCA are:

- Identification of improvement opportunities through identifying environmental hot spots in the life cycle of a product.
- Analysis of the contribution of the life cycle stages to the overall environmental load, usually with the objective of prioritizing improvements on products or processes.
- Comparison between products for internal or external communication, and as a basis for environmental product declarations.

The basis for standardized metrics and the identification of Key Performance Indicators used in companies for life cycle management and decision support.

There are three ISO standards specifically designed for LCA application (ISO, 2006).

ISO 14042: Life Cycle Impact assessment ISO/TR 14047 5).

ISO 14040: Principles and framework ISO 14041: Goal and Scope definition and inventory analysis.

ISO 14043: Interpretation (ISO 14040:2006 and ISO 14044:2006.

LCA software Sima Pro 8

The software "Sima-Pro" Impact assessment exists in a variety of impact assessment methods available in Sima-Pro[50-51]. In this study, The Eco-indicators 99 method was used to determine the environmental impactsm of the treatment plant linking all types of LCI results, via the categories (human toxicity, respiratory effects, ionizing radiation, ozone layer depletion, photochemical oxidation, aquatic ecotoxicity, terrestrial ecotoxicity, terrestrial acidification/nitrification, aquatic acidification, aquatic eutrophication, land occupation, global warming, non-renewable energy and mineral extraction) to the damage categories (human health, ecosystem quality, and resources)[52-53].

Goal and scope definition

The goal of this study, is to determine and compare the environmental constraints, of the leather tanning process, by replacing the chromium salt (very toxic and ecotoxic and whose chemical behavior is the most complex), with aluminum salt combined with vegetable tannin and vegetal tannin alone, which will allow us to identify different categories of impact. Therefore, we know where environmental performance can be improved. In addition, it serves, as a source of information for other tanneries or industries, which might be interested to study the impact of their processes by applying the LCA methodology with the software SimaPro 8.

System boundary

Depending on the limitations of the detail system shown in Fig. 3, it differs only by the tanning agents used in the three scenarios. The three types of tanning,

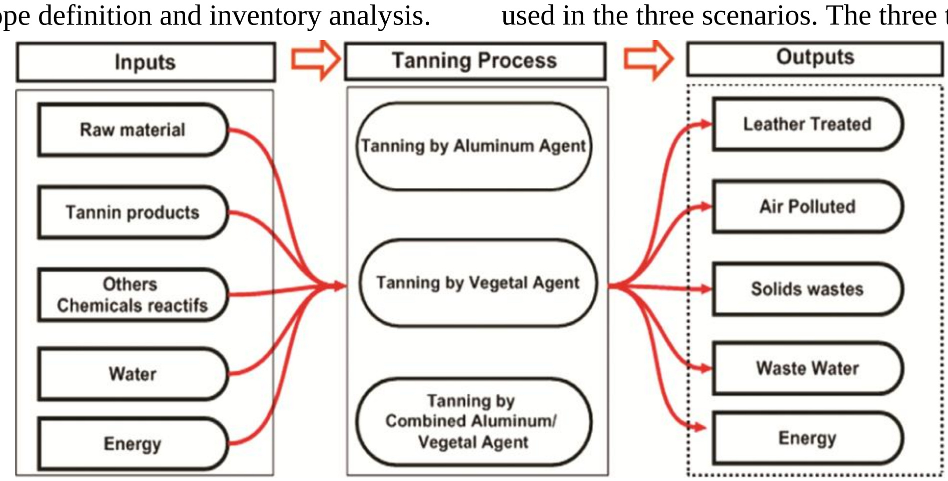

Fig. 3 — System boundary for pre-tanning process using (the three scenarios)

such as slaughter, preservation, pre-soak, soaking, liming, delimitation, threshing and pickling, are the same for three leathers. Leather (scenario 1) is pre-tanned with aluminum sulphate and mimosa, Leather (scenario 2) is pre-tanned with tannin plant (mimosa); leather (scenario 3) is tanned with aluminum sulphate. All data are based on the Algerian and Moroccan system which reasonably. In addition, used here are less than 5 years old.

The system limits for a liquid waste management study are defined because the materials do not have their initial value. Therefore, they must be sent to processing plants for recycling, recovery or release into the wild. In this study, the limits of the system begin with the collection of materials used in the manufacture of leather; and the recovery of wastewater from the process.

The balance of inputs and outputs is established according to "the functional unit: P" SimaPro software "Eco 99 indicators" for each impact assessment and transform the inventory of inputs and outputs per 1m^2 of leather/1m3 of water of wastewater. The values are in Table 1.

Environmental considerations

In tanneries, wastewater treatment plants, contribute to environmental degradation through excess chemicals released and energy consumption[55]. The design and operation of sewage treatment plants should be designed with energy consumption in mind first. Aeration process and sludge treatment[56-57].

Evaluation procedure

In this study; Eco-indicator 99 model was used for life cycle impact analysis (LCA) to evaluate the environmental impacts. Which is one of the most widely used and the most reliable environmental .impact assessment models in the world.

Table 1 — Material balance of inputs and aoutputs of the three scenarios

	Units	Scenario 1	Scenario 2	Scenario 3
Inputs				
Raw Leather	m^2	1	1	1
Water	M^3	0.153	0.210	0.185
Natural gas	MJ	30	27	28.23
Fuel oil	MJ	2.16E-05	1.98E-05	2.11E-05
Electric energy	Kwh	15.45	13.25	15.89
Chemical products	|Kg	1.32	0.09	0.55
Vegetal products	Kg	/	1.28	0.97
Outputs				
Treated Leater	m^2	0.85	0.85	0.85
Wastewater	m^3	0.129	0.213	0.196
solidwaste	kg	0.107	0.181	0.0171
Liquid Sludge	m^3	0.022	0.0313	0.025

The accuracy of the output results can be ensured from the inventory data acquisition and the model selected. The Eco-indicator 99 includes 18 midpoints environmental impact categories (figure 8, 9, 10), Life cycle impact analysis using EcoIndicator 99 methodology must have a starting point in the life cycle inventory analysis of 1m^2 of treated leather using 1m^3 of water. The results of life cycle impact analysis were calculated by the Eco-indicator 99 (EI/99) methodology, using the software "simapro 8". this method uses, in first step, the characterization of the impact phases for each impact category (according to ISO 14040), the normalization step, where all indicators (impact categories) are assembled into classes of impact which will be expressed in one same unit of measurement after the normalization step, the results are stated as a single global indicator (single score), only after the weighting phase.

The representation and interpretation of results can be obtained, with more detail, opting for the total impact of the functional unit (10m^2 leather-le/m^3 water). Figure 4 shows the impact distribution of the manufacturing processes, which significantly contributes in all impact categories. The comparison of impact values across different impact categories can only be possible by normalization.

Results and Discussions

Impacts assessments

The environmental impact generated by the system is described in the impact assessment. The link with eco-indicators is associated with some conversion factors for each pollutant and conversion to damage categories is associated with damage factors[60-61].

Modeling results global

In this part, the modeling results were calculated using the EcoIndicator 99 method. Based on the life cycle approach, the Eco-Indicator 99 method assigns a score to each impact and allows, in a perspective of improvement, to compare the different impact with each other.

The diagram below is a tree diagram representing the relative impact of leather production by three different processes.

For scenario 1, the software flowchart (Figure 5) shows that the water process (consumption: 18.22%, wastewater: 19.2% and sludge: 16.2%) is the first

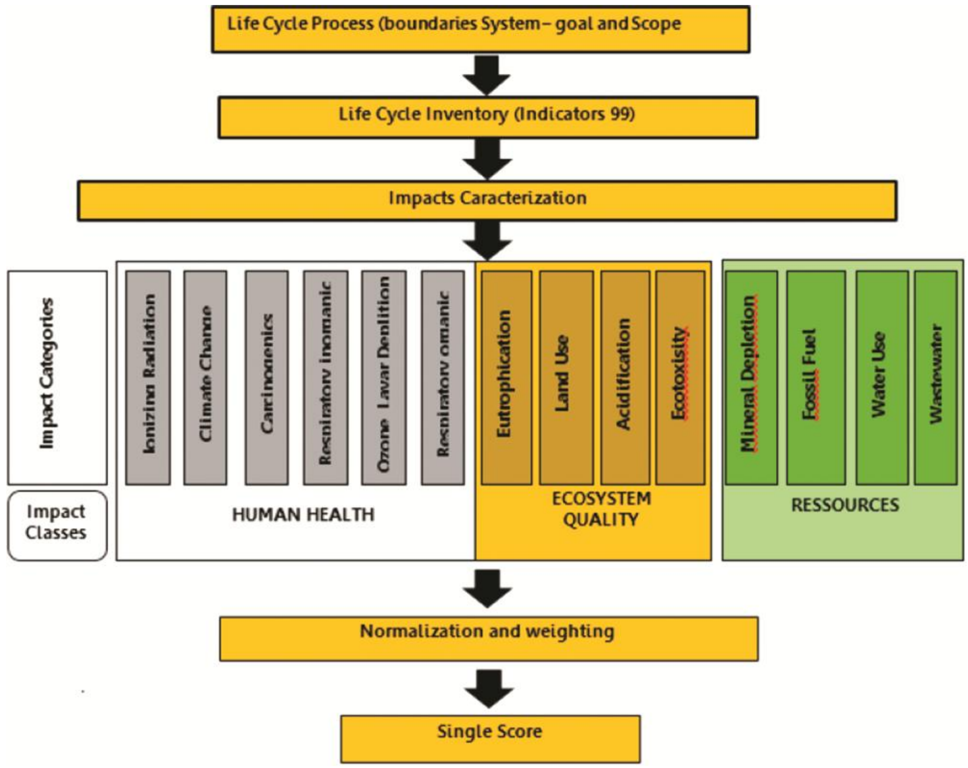

Fig. 4 — Method of evaluation of impacts "Eco-indicators99"

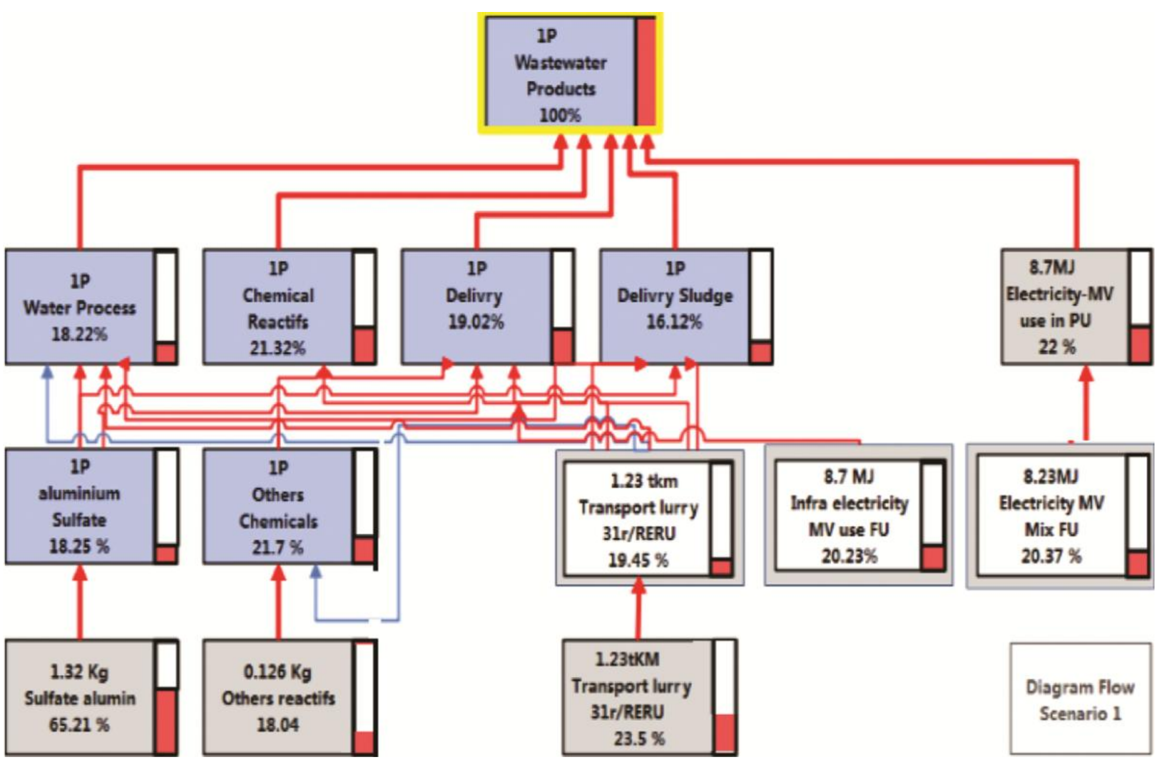

Fig. 5 — Tannery tree modeling ACV (scenario 1)

cause of environmental impacts, the second is due to chemical reagents (aluminum and other reagents): 21.2%, electricity and energy is the third cause of impact with 2.256%.

The flowchart of scenario 2 (Figure 6) shows all categories of environmental impact, the first cause is the water treatment process (consumption: 28.23%, wastewater: 20.5% and sludge 13.5%) is the main cause, the second cause is electricity consumption - energy (25.2%) of environmental impacts. The chemical reagents added to the process cause the third chemical impact (13.3%).

The software flowchart of scenario 3 (figure 7), shows that the water process (consumption: 17.89%, wastewater: 23.34% and sludge: 23.11%) is the first cause of environmental impact, the second is due to electricity and energy is the third cause of impact with 19.24%, the third is due to chemical reagents (aluminum and other reagents): 61.22%.

It is noted that regardless of the process used, the environmental impacts are the same and ranked in the same order, as tanning consumes a lot of water, energy and chemical additives.

Characterization assessment

Following the identification of the data and the introduction of the data into the Simapro 8 software, the analysis of the software gives a flowchart (Figures 8 ,9 and 10) which represents the distribution of the different flows according to the encoded data, compared to the process (three scenarios). The wastewater treatment process is the most impacting at the tannery level. The second stream is electricity and oil.

Releases of aluminum salt and tanning plants play a dominant role in increasing the impact on ecosystem quality and human health. It is clearly stated that the tanning plant has a serious impact on aquatic ecotoxicity and eutrophication, resulting in an increased contribution to the ecosystem quality damage category. The impact on non-carcinogen and acidification takes the following position. Supply chain processes such as chemical use and transport of plants (mimosa) of raw chemicals and products, electricity and packaging were the main contributors in the impact categories:, which ultimately contributed to damage to categories of climate change and human health. Transport of raw materials has mainly contributed to the impact categories of terrestrial ecotoxicity/acidification, organic and inorganic respiratory materials, while electricity generation governed the impact categories of mineral extraction, ozone depletion and ionizing radiation.

Figures (7, 8 and 9) provide a comparison of the standardized results for the three scenarios analyzed

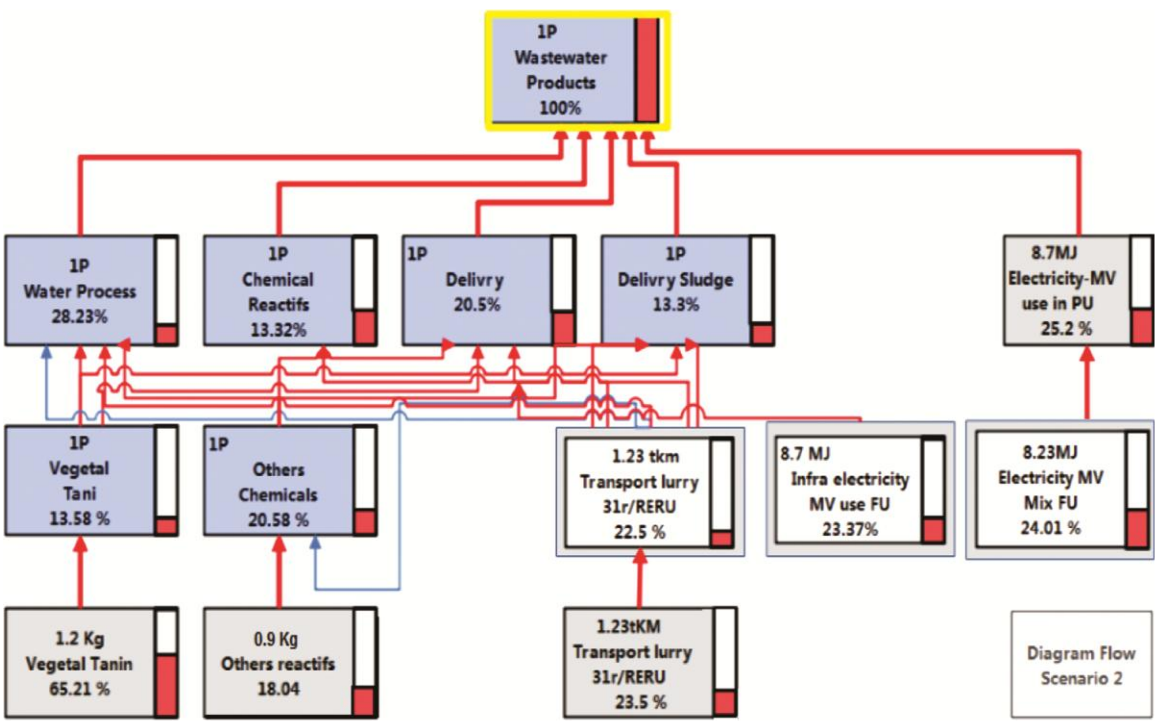

Fig. 6 — Tannery tree modeling ACV (scenario 2)

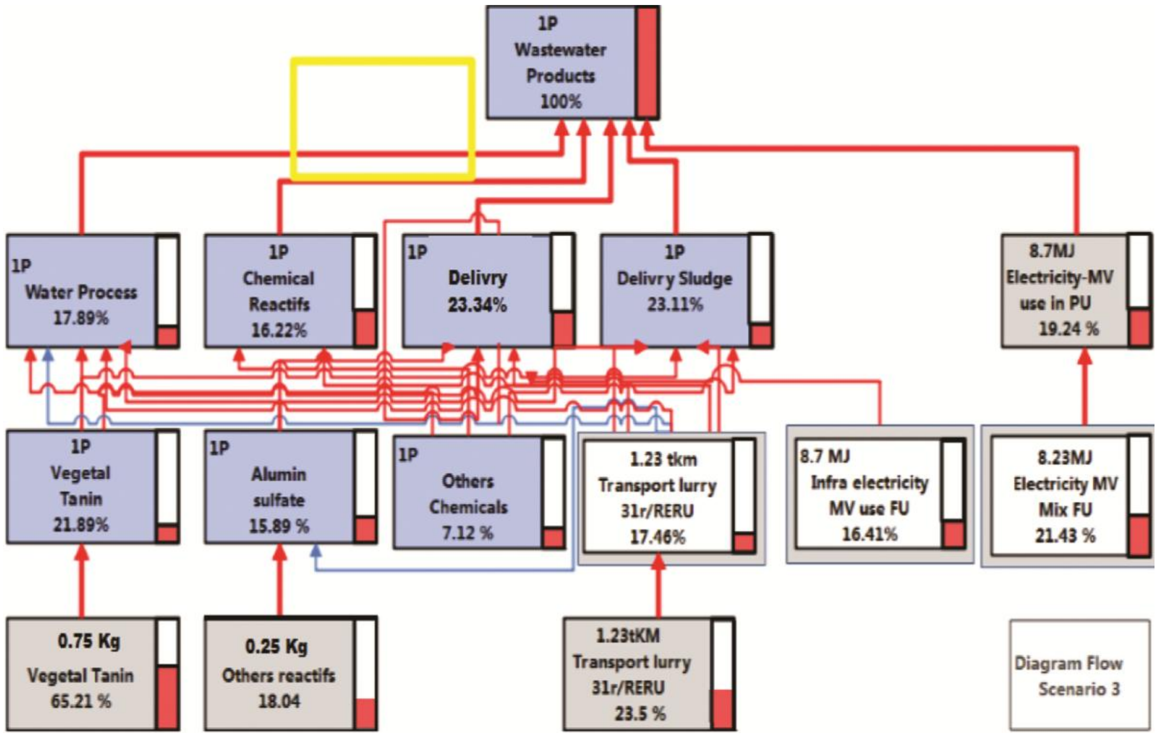

Fig.7 — Tannery tree modeling ACV (scenario 3)

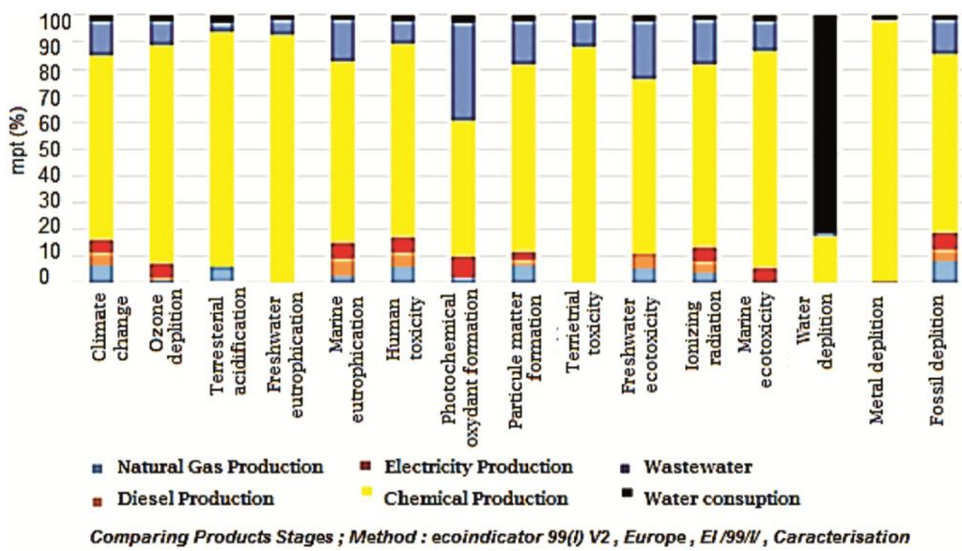

Fig. 8 — Scenario 1 Characterization –ecoindicators 99

(excluding sludge treatment, disposal and long-term emissions). The most important impact is related to the eutrophication of fresh and marine waters, resulting from the most influential impact resulting from the use of chemicals and mimosa prosin (tannin plant), This seems very logical because the wastewater (even treated) discharged into rivers and bodies of water (ponds, lakes) is considered an catalyst for eutrophication, as explained previously in this work.

The comparative results show that Scenario 3 has an overall higher environmental performance than the other two in terms of eutrophication of waters (marine and freshwater). Indeed, eutrophication processes are generally dictated by the availability of a limiting nutrient. It is generally accepted that eutrophication processes are limited by the availability of phosphorus and, in marine ecosystems, by the availability of nitrogen[62,63] shows that the environmental impact due

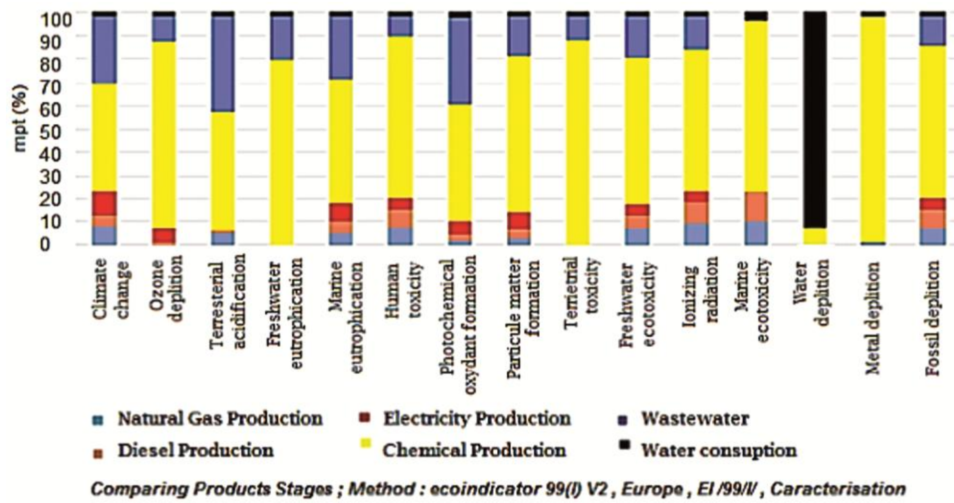

Fig. 9 — Scenario 2 Characterization –ecoindicators 99

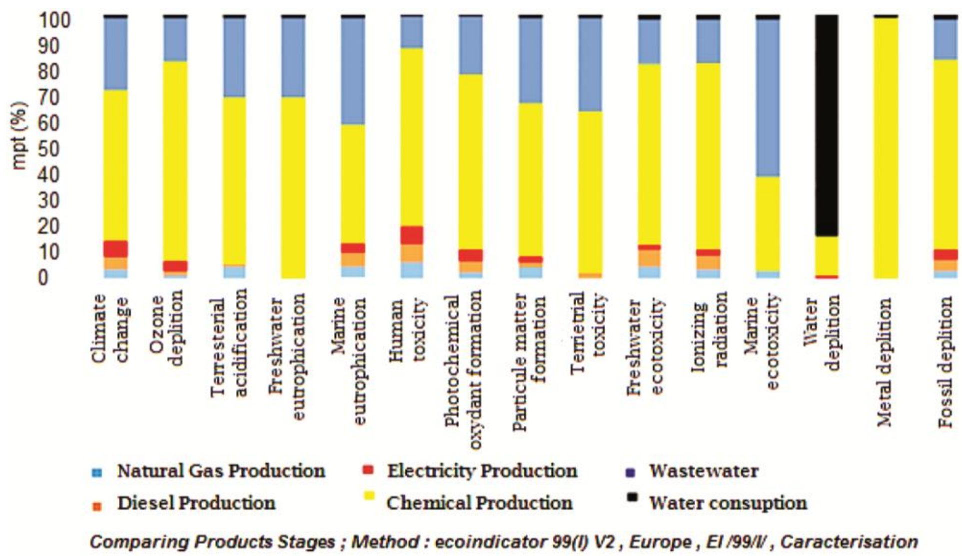

Fig. 10 — Scenario 3 Characterization –ecoindicators 99

to diesel consumed in the tannery are not significant because the diesel consumption calculated for the tanning standard is very slow. Although the environmental impact associated with natural gas are very significant (climate change, land acidification, freshwater ecotoxicity, fossil fuel depletion, etc.), it can be concluded, that diesel is more ecological than natural gas, because, in terms of quantity, the consumption of natural gas consumed is very important compared to diesel.

The production of electricity required in the tannery also contributes significantly to environmental impact: climate change, ozone depletion, human toxicity, depletion of fossil resources, etc., it can be concluded that diesel is more environmentally friendly than natural gas, because amount of natural gas consumed is very large compared to the amount of diesel.

The production of electricity needed in the tannery also contributes significantly to environmental impacts: climate change, depletion of the ozone layer, human toxicity, depletion of fossil resources etc. It appears from this study, that the environmental impacts linked to the wastewater treatment for the three scenarios are mainly generated by the use of chemical reagents, the qualities of raw and treated water and the electrical consumption of the agitation and transfer pumps (25.56% impact). Scenario 1 is distinguished by its contribution to the eutrophication and ecotoxicity impact categories and depends on the quality of the effluents. In particular, tanning activities use a lot of water and play a major role in the appearance of environmental impact, during the life cycle of the leathers studied. The assessment shows that the production system (scenario 2) has a higher environmental impact than that of scenarios 2 and 3. According to the estimate, scenario 2 reject 210L/m^2 in total, while scenarios 1 and 3 reject 200.39 L/m^2, 96.45 L/m^2, of course from wastewater from recycling, neutralization and retanning. The quantity of chemical product used per m2 of leather (scenario 2) is 3.23 kg and (scenario 3) 5.42 kg.

Normalization and weighting

The characterization step is to standardize data, aggregated by category of impact depending, on the actual extent, of impacts, within this category, in a limited geographical area, in order to compare the values of different categories of impact, L normalized cumulative impact is to determine a score in a number of categories. The different impact categories are weighted to be compared and evaluated.

The weighted impact is added to determine a single score or 'indicator'. In principle, the results of a weighted assessment reflect social values and preferences; it consists of converting and possibly to aggregate indicator results between impact categories using numerical factors based on[64-65]. Normalization is the calculation of the magnitude of the results of the category indicators against the reference information[66,67].

Damage assessment

The characterization framework illustrates the impact categories for the ecoindicator 99 software methodology is presented in Fig. 11; the damages are classified to three areas of protection: ecosystem quality human health and resources.

All eco-Indicators except aquatic acidification and aquatic eutrophication, have been grouped into three damage categories namely, human health, ecosystem quality and resources (Fig. 12).

Ecosystem quality

The protection zone of the quality of ecosystems deals with damage caused by intrinsic value of natural ecosystems. Most models currently used are based only on the structural features of biodiversity such as species richness[68,69]. This damage category is the sum of the eco-indicators: aquatic eco-toxicity, terrestrial ecotoxicity, terrestrial acidification / nitrification and land use ([. M². An / kg of triethylene glycol.] this is scenario 2, which respectively has values of 1.65 and 0.12 * m2 * year, this process contributes to more than 10 times more impact categories and depends, above all, on the quality of the liquids waste..

Human health

Human health is expressed as DALY (disability-adjusted life years). In this DALYs method, it is crucial to have a common metric. In this regard, the human health impact categories are generally based on a well-established and widely adopted metric of the disability adjusted life year (DALY)[70,71], caused by carcinogenic substances can be added to DALYs caused by climate change.

The human health category is the sum of the carcinogenic and non-carcinogenic median categories, organic and inorganic respiratory substances, ionizing radiation, and depletion of ozone layer. This damage category is slightly dominated by the pre-tanned aluminum process. According to Figure No 10, the

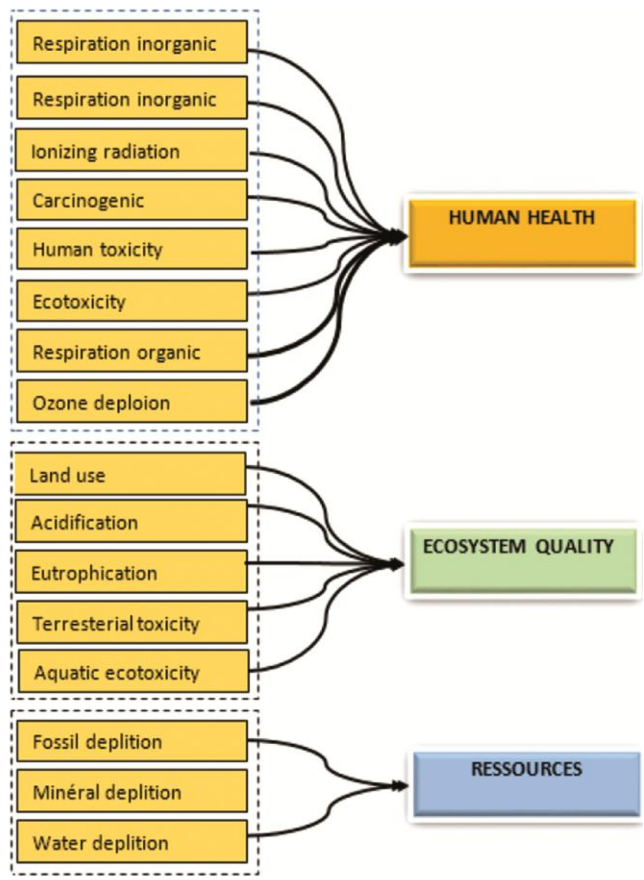

Fig. 11 — List of impact categories for characterization at midpoint and endpoint level

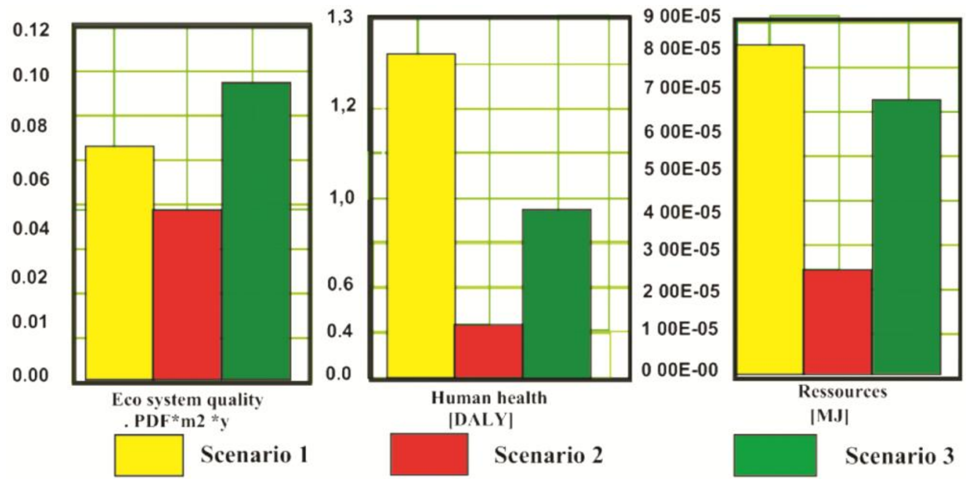

Fig. 12 — Impact assessment (normalized values) at midpoint and endpoint level of the three Scenarios with contribution from the different life cycle processes

contribution of scenario processes (1 and 3) 1.26 and 0.96 respectively are the most dominant.

1. PDF•m^2 •y (Potentially Disappeared Fraction of species disappeared on 1 m^2 of earth surface during one year) is the unit to measure the impacts on ecosystems.
2. DALY (Disability-Adjusted Life Years) characterizes the disease severity, accounting for both mortality years of life lost due to premature death.
3. MJ: Surplus energy per kg mineral.

Resources

Several impact analysis methods were tested[49.72]. Human activity gives priority to the best resources first, leaving inferior resources for future use. Future generations will have to redouble their efforts to eliminate remaining resources and suffer significant damage, this additional effort being expressed as excess energy [MJ] needed for the future extraction of minerals and fossil fuels. This category is significantly dominated by ecotoxicity (8.00E-5 [Primary MJ] for Scenario 1 and 6.00E-5 [Primary MJ] for Scenario 3.

Environmental impacts or stage of the life cycle Single Score: for the three scenarios

The different indicators are assembled to form a single bar or partition. Figure 13 shows the distribution of the impact of the three scenarios on the different indicators of the Eco-Indicator 99 method. It integrates the impact of leather tanning and its manufacturing process. The most relevant indicators are:

The indicator "ecotoxicity" corresponds to the emission of inorganic particles in the air harmful to human health, so scenarios 2 and 3 are predominant and with equal impact and to a lesser degree scenario 1, where aluminum is not very mobile alone.

The indicator "climate change» is the impact related to the emission of greenhouse gases. Scenarios 2 and 3 are very much higher than Scenarios 1, the tannins seem to be responsible for this impact for the possible degradation gases from the organic substances of the vegetal tannin and these substitution products following lactic and acetic fermentation's.

The minerals indicator, mineral extraction and non-renewable energy, which eventually contribute to damage categories of human health. Scenarios 1 and 3 characterize it and the mineral tannin "aluminum" is the first responsible.

The last indicators "acidification -eutrophication", indicate that the Processing chemicals and vegetal tannin have a dominant role for increased eutrophication and acidification. scenario 2 seems to have the most impact.

Comparison of materials used to make leather (tanning)

The deviation from the environmental impact of the plant fiber used for scenario 2 are approximately three times higher than those for scenario 1 and 3 (X2>X1). This differentiation is due to the transport and use of process water and wastewater generated. The impacts of the aluminum / vegetable tannin mixture are approximately four times greater than those of scenarios 1 and 3 combined (X1>X2). This difference is due mainly as before transportation to the materials used and the wastewater generated.

It can be seen in Figure 14, that the difference X3-X1 has no importance as an environmental constraint, because this difference generated by "land use" is due to the use of vegetable tannin, cultivated

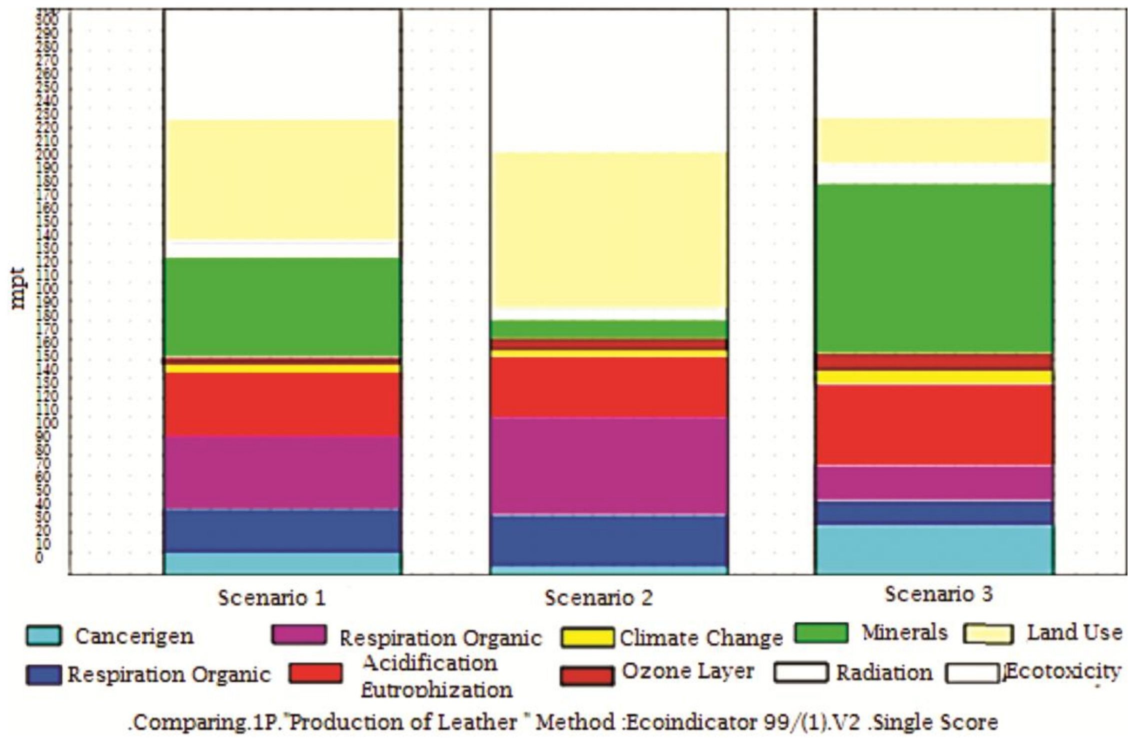

Fig.13 — Representation environmental impacts or stage of the life cycle Single Score: for the three scenarios.

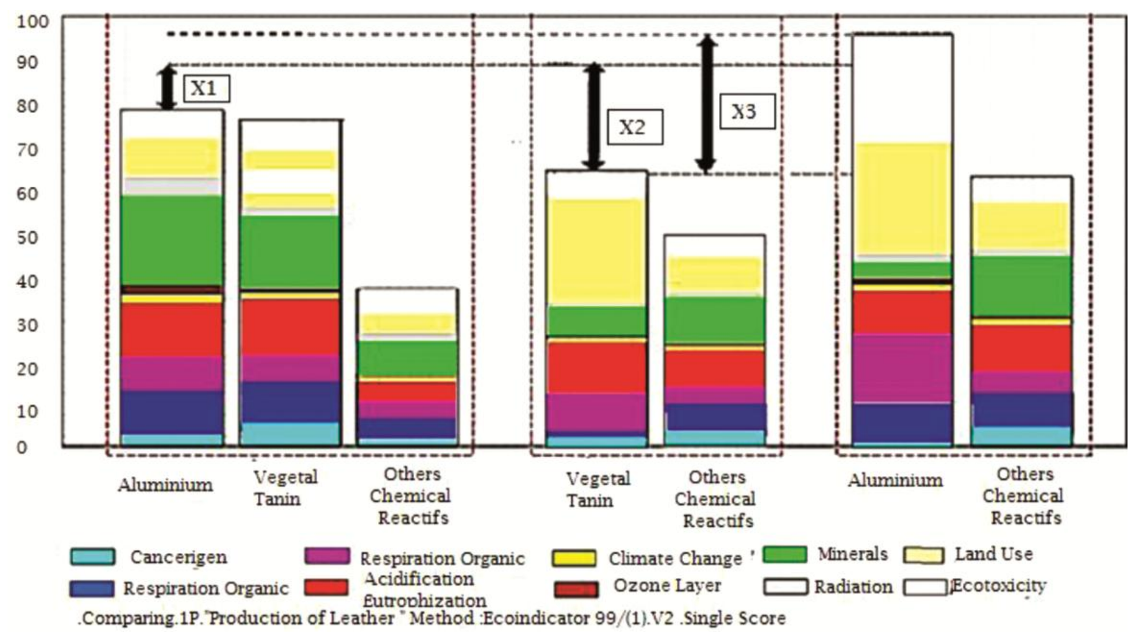

Fig. 14 — Comparison products stages of the three scenarios studied for leather tanning with single score

on soils. , without harming it, on the contrary, cultivated, this soil remains an element that conserves biotopes and protects biodiversity.

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Conclusion

The industries of processing rawhide into finished leather goods are insignificant in Algeria and tanneries are involved in the production of finished leather from rawhide using the chrome tanning process. Therefore, the life cycle analysis presented in this document is very beneficial for the leather industry and its development in an environmentally friendly framework.

The goal of this study is to compare the environmental performance of three leather manufacturing processes (three scenarios), in order to understand which approach is the most environmentally sustainable. The accounting environmental analysis (LCA), with SimaPro 8, has clearly shows and estimate each contribution of all impact categories , however, that the contribution of scenario 2 (vegetal tannin) is at least 20-50% lowers, than the two others processes , This differentiation is due to the combination of tanning products which requires lot of interactive chemicals, probably with the vegetal tanin, whose degradation biochemically causes the formation of by very complex products, often with varying working conditions.

The impact caused by the enormous water quantity used for vegetable tannin process, are approximately three times higher than those of "scenarios 1 and 3". This difference is due to the quantity and quality of the wastewater rejected, however, The advantages of scenario 1 are mainly because the process uses natural reagents (vegetable tannin) available in nature and renewable, moreover scenarios 2 and 3 are the most impactants (resources and human health).

As a result, the assumptions made on energy consumption could affect the results, but not the overall conclusions because the difference between the three scenarios is not significant enough. Analyzing more closely we see that scenario1 consumes a lot of water. Whereas electricity generation governed the impact categories of mineral extraction, carcinogenic and respiration organic. Finally, a possible reuse of treated wastewater could be an option for washing processes in production phases. Installing an effluent treatment plant will significantly reduce environmental burden in the different damage categories.

Finally, for an effective sustainable development, the vegetable tanning process must be conceived as the only way, followed of course by a reuse of wastewater after treatment, which must be an option to considerably reduce the environmental burden in the different categories of damage.

References

1 Dennison F J, Azapagic A, Clift R & Colbourae J S, *Water Sci Technol*, 38 (1998) 23.

2 Ogedengbe K & Akinbile C O, *Niger J Technolog Dev*, 4 (2004) 139.

3 Wang X, Liu J, Ren N Q & Duan Z, *Bioresour Technol*, 126 (2012) 31.

4 Abdel-Raouf N, Ibraheem I B M & Hammouda O, Eutrophication of River Nile as indicator of pollution. *In Al-Azhar Bull. Sci., Proceeding of 5th Int. Sci. Conf,* March (2003).

5 Abel P D, *Water pollution biology*. (CRC Press. Ellis Horwood Ltd) (1996).

6 Sreeram K J & Ramasami T, *Conserv Recy*, 38 (2003) 185.

7 Dargo H & Ayalew A, *Int Emerg Trends Sci Technol*, 1 (2014) 1488.

8 Ogbonna J O, Lawal F A, Owoeye L D & Udeh M U, Chemical characteristics and fertilizing value of primary sludge from tannery effluent treatment plant. *In 16th annual national conference of the Nigerian institute of science and technology* (University of Ibadan), November (1998).

9 Covington A D, *Tanning chemistry: the science of leather*. (Royal Society of Chemistry) (2009).

10 Luken R & Stares R, *Bus Strategy Environ*, 14 (2005) 38

11 Boshoff G, Duncan J & Rose P D, *Water Res*, 38 (2004) 2651.

12 Farenzena M, Ferreira L D S, Trierweiler J O & Aquim P M D, *Braz Arch Biol Technol*, 48 (2005) 281.

13 Chowdhury M, Mostafa M G, Biswas T K & Saha A K, *Water Resour Indus*, 3 (2013) 11.

14 Akan J C, Moses E A, Ogugbuaja V O & Abah I, *J Appl Sci*, 7 (2007) 2788.

15 Khan S, Khan A M & Khan M N, *J Ap Sci*, 2 (2002) 457.

16 Khan S R, Khwaja M A, Khan A M, Ghani H & Kazmi S, *Environ Dev Eco*, 6 (1999) 383.

17 Cooman K, Gajardo M, Nieto J, Bornhardt C & Vidal G, *Environ Toxicol An Int J*, 18 (2003) 45.

18 Verheijen L A H M, Wiersema D, Hulshoff Pol L W & De Wit J, Management of waste *The Netherlands: J. De Wit International Agriculture Centre*, (1996).

19 Favazzi A, Study of the impact of the main policies and environment protection measures in Africa's leather industry. (Principal: Assomac Servizi Srl for UNIDO) (2002).

20 Gupta P K, Achieving production effectiveness and increasing business competitiveness through cleaner production. *Retrieved from: Acesso em*, 10 (2013).

21 Júnior H M, Da Silva J, Arenzon A, Portela C S, de S Ferreira I C F & Henriques J A P, *Chemosphere*, 67 (2007) 1211.

22 Bajza Z & Vrcek I V, *Ecotoxicol Environ Saf*, 50 (2001) 15.

23 Verma T, Ramteke P W & Garg S K, *Environ Monito Assess*, 145 (2008) 243.

24 Dhungana T P & Yadav P N, *J Nepal Chem Soc*, 23 (2009) 101.

25 Tabesh M, Azadi B & Roozbahani A, *Int J Environ Res*, 5 (2011) 321.

26 UNEP, Tanneries and the Environment: a technical guide to reducing the environmental impact of tannery operations. United Nations Environment Programme, Industry and Environment, Programme Activity Centre (UNIDO, IE/PAC), Paris, (1991).

27 Tünay O, Kabdasli I, Orhon D & Ates E, *Water Sci Technol*, 32 (1995) 1.

28 Naumczyk J & Rusiniak M, *Polish J Environ Stud*, 14 (2005) 789.
29 Mohanta M K, Salam M A, Saha A K & Hasan A, *Asian J Exp Biol Sci*, 1 (2010) 294.
30 Adewoye R O & Bangaruswamy S, *J Soc Leather Technol Chem*, 73 (2000) 141.
31 Mahdi H, Palmina K, Gurshi A & Covington T, *Vegetable and aluminium combination tannage: aboon alternative to chromium in the leather industry*, (2008).
32 Haron M A, Khirstova P, Gasmelseed G A & Covington A, *Suranaree J Sci Technol*, 19 (2012) 31.
33 Ramteke P W, Awasthi S, Srinath T & Joseph B, *Environ Monito Assess*, 169 (2010) 125.
34 Ding K, Taylor M M & Brown E M, *Tanning effects of aluminum-genipin or-vegetable tannin combinations*, (2008).
35 Vitolo S, Seggiani M, D'aquino A, Barbani N, Naviglio B & Tomaselli M, Tara-*aluminum tanning as an alternative to traditional chrome tanning: development of a pilot-scale process for high-quality bovine upper leather*, (2003).
36 Madhan B, Gunasekaran S, Narasimman R, Rao J R & Sadulla S, *J Am Leather Chem Assoc*, 100 (2005) 373.
37 Sathiyamoorthy M, Selvi V, Mekonnen D & Habtamu S, *J Eng Comput Appl Sci*, 2 (2013) 17.
38 King-Thom C , Tit Yee W , Cheng-I W , Yao-Wen H & Yuan L, *Crit Rev Food Sci Nutr*, 38 (2010) Please tell me paper pages number.
39 Choudhury S D, Das Gupta S & Norris G E, *Int J Biolog Macromol*, 40 (2007) 351.
40 Eckelman M J & Chertow M R, *Int J Life Cycle Assess*, 18 (2013) 1524.
41 Mattila T, Lehtoranta S, Sokka L, Melanen M & Nissinen A, *J Indus Ecol*, 16 (2012) 51.
42 Sokka L, Lehtoranta S, Nissinen A & Melanen M, *J Indus Ecol*, 15 (2011) 137.
43 Yu F, Han F & Cui Z, *Environ Sci Pollut Res*, 22 (2015) 5511.
44 Scheepens A E, Vogtländer J G & Brezet J C, *J Clean Prod*, 114 (2016) 257.
45 Zhou Z, Chi Y, Dong J, Tang Y & Ni M, Model development of sustainability assessment from a life cycle perspective: A case study on waste management systems in.
46 International Organization for Standardization (ISO). *Environmental management—life cycle assessment*. (European standard EN ISO 14040): Geneva, Switzerland, (2019).
47 Tascione V & Raggi A, *Sust*, 4 (2012) 2430.
48 EC-JRC-IES, International Reference Life Cycle Data System (ILCD) Handbook - Recommendations for Life Cycle Impact Assessment in the European context. (First edition) November (2011).
49 Goedkoop M, Heijungs R, Huijbregts M, De Schryver A, Struijs J & Van Zelm R, ReCiPe 2008 *First Edition (Version 1.08) Report I: Characterisation. Ministry of foreign Affairs: Rijnstraat*, (Netherlands) (2013).
50 Negelah S, A *Life Cycle Assessment of Sewage Sludge Treatment Options (Doctoral dissertation*, Msc, thesis, (Aalborg University, Denmark), (2008).
51 PRé Consultants. *Software LCA SimaPro 8*, Netherlands (www.pre.nl), 2013.
52 Rolf F & Niels J, *Implementation of Life Cycle Assessment Methods*. (Swiss Centre for Life Cycle Inventories. Accessed) April, (2007).
53 Buyukkamaci N & Koken E, *Sci Total Environ*, 408 (2010) 6070.
54 Pati A, Chaudhary R & Subramani S, *Environ Sci Pollut Res*, 21(2014) 11266.
55 Hernández-Sancho F, Molinos-Senante M & Sala-Garrido R, *Sci Total Environ*, 409 (2011) 2693.
56 Tao X C, (2014). *Energy consumption in wastewater treatment plants in China*. Conference paper in conference World Congress on Water, Climate and Energy at Dublin, (Ireland) Agustus, (2017).
57 El Boushy A R, Van der Poel A F B, Koene J I A & Dieleman S H, *Bioresour Technol*, 35 (1991) 321.
58 Huggins T, Fallgren P H, Jin S & Ren Z J, *J Microb Biochem Technol*, 6 (2013) 12.
59 Baumann H & Tillman A M, *The Hitch Hiker's Guide to LCA: An orientation in life cycle assessment methodology and application. Lund*, (Sweden: Student litteratur AB) (2004).
60 Humbert S, De Schryver A, Bengoa X, Margni M & Jolliet O, Impact 2002+: user guide. Draft for version Q,Feb, (2014).
61 Bayus J A, *Environmental Life Cycle Comparison of Aluminum-based High Barrier Flexible Packaging Laminates*, (2015).
62 Guo H C & Sun Y F, *Prog Geog*, 21 (2002) 500.
63 Howarth R W, Sharpley A & Walker D, *Estuaries*, 25 (2002) 656.
64 Huppes G, van Oers L, Pretato U & Pennington D W, *Int J Life Cycle Assess*, 17 (2012) 876.
65 Cortés-Borda D, Guillén-Gosálbez G & Esteller L J, *Int J Life Cycle Assess*, 18 (2013) 948.
66 Curran M A, Life cycle assessment student handbook. John Wiley & Sons, (2015).
67 Castellani V, Sala S & Benini L, *J Clean Prod*, 140 (2017) 556.
68 Guinée J B & Lindeijer E, (Eds.). *Handbook on life cycle assessment: operational guide to the ISO standards*, (Springer Science & Business Media) (2002).
69 Goedkoop M, Heijungs R, Huijbregts M, De Schryver A, Struijs J V Z R & Van Zelm R, *A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level*. The Hague, Ministry of VROM. ReCiPe, (2009).
70 Crettaz P, Pennington D, Rhomberg L, Brand K & Jolliet O, *An Int J*, 22 (2002) 931.
71 De Hollander A E, Melse J M, Lebret E & Kramers P G, *Epidemiol*, Please tell me volume numer (1999) 606.
72 Jolliet O, Margni M, Charles R, Humbert S, Payet J, Rebitzer G & Rosenbaum R, *Int J Life Cycle Assess*, 8 (2003) 324.