ENVIRONMENTAL ASPECTS FROM A LIFE –CYCLE PERSPECTIVE FOR TWO LEATHER TANNING SYSTEMS. PART II: IMPACT ASSESSMENT

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The goal of this paper is to quantify the environmental impact of new pre-tanning technologies developed during the execution phase of INNOVA-LEATHER project, as well as the thereof assertion of their improved environmental performance when compared against commercial chromium (III) tanning, currently applicable for the production of eighty five per cent of the total volume of finished leathers by the tanning industry worldwide. The environmental impact assessment was made based on the LCA impact categories indicators: Global Warming Potential (GWP), Ozone depletion potential (ODP), Acidification potential (AP), Eutrophication potential (EP), Abiotic depletion potential (fossil) (ADP), and Photochemical ozone creation potential (POCP). The results indicate that significant environmental impacts were caused by chrome tanning technology; carbon footprint – GWP for Chrome tanning technology was 11,4848 kg CO_2 equiv. and for Ti-Al tanning technology was 9,7250 kg CO_2 equiv. Regarding tanning process, carbon footprint – GWP for Chrome tanning process was 3,0766 kg CO_2 equiv. and for Ti-Al tanning process was 1,1752 kg CO_2 equiv., being about three times less.

Keywords: leather, LCA, chrome tanning, Ti-Al tanning, carbon footprint

INTRODUCTION

It is recognized that at the moment the LCA – Carbon Footprint topic is primarily of interest to tanners in industrialized, especially EU countries; however it is felt that also those in BRIC and even Least Developed Countries should be aware of the current environmental impact assessment and protection trends, and be ready to apply them at appropriate time as needed. It is hoped that in the meantime better standardized methodologies and probably some blueprints will also be made available (Brugnoli *et al.*, 2012).

The goal of this paper is to quantify the environmental impact of new pre-tanning technologies developed during the execution phase of INNOVA-LEATHER project, as well as the thereof assertion of their improved environmental performance when compared against commercial chromium (III) tanning (Adiguzel Zengin *et al.*, 2012; Mutlu *et al.*, 2014; Crudu *et al.*, 2014; Deselnicu, V. *et al.*, 2012; 2014).

The LCA study is a cradle – to – gate approach, evaluating the environmental impact of the finished leather starting with the slaughtering of the cattle, preservation of the raw cattle hides (by treatment with salt), and tanning of the raw salted hides through all core processes until finished leather, taking into consideration the impact of electricity production, water, chemical substances, natural gas production etc., as well as wastes and waste water treatment, water pollutants and air emissions. The agricultural phase is not included in the system boundaries, and cattle husbandry phases are taken into consideration as bringing a zero impact.

Method

The LCA study was performed using the GaBi software 6.0. and its databases in accord with ISO 14044:2006 Standard: Environmental management - Life cycle assessment - Requirements and guidelines.

The methodology was presented in the first part of this study (Deselnicu D.C. *et al.*, 2014). The environmental impact assessment was made based on the LCA impact categories indicators, which quantify the global environmental impact of the studied technologies, and allow the technologies comparison according to their environmental performance.

Typically, the commonly used and accepted impact categories for LCA studies are the following:

Global warming potential, GWP, unit: [kg CO2-eq.] – commonly known as climate change indicator;

Ozone depletion potential, ODP, unit: [kg R11-eq.] – measuring ozone hole in higher atmosphere;

Acidification potential, AP, unit: [kg So2-eq.] - environmental effect by the acid rain/ forest dieback;

Eutrophication potential, EP, unit, [kg PO43-eq.] – measuring over-fertilization of soil and water;

Abiotic depletion potential (fossil), ADP, unit: [MJ.] – indicating non renewable resources, e.g. coal, crude oil, natural gas;

Photochemical ozone creation potential, POCP, unit: [kg C2H4-eq] – indicator for ozone creation in lower atmosphere.

All these indicators were calculated and assessed during the study, and will be further discussed.

RESULTS - LIFE CYCLE ASSESSMENT IMPACT

The quantification of the total impact categories for the two investigated technologies is presented in Tables 1 and 2, and in Figures 1 to 3.

Table 1. Total assessed impact of LCA impact indicators for Chrome and Ti-Al leather production technologies

	TOTAL ASSESSED IMPACT									
Catego-ries	Global Warming Potential (GWP 100 years)		Ozone Depletion Potential (ODP)		Acidification Potential (AP)		Eutrophication Potential (EP)		Photochemical Ozone Creation Potential (POCP)	
Unit	kg CO2 equiv.		kg R11 equiv.		kg SO2 equiv.		kg PO43-equiv.		kg C2H4 equiv.	
Techno-logy	Cr	Ti-Al	Cr	Ti-Al	Cr	Ti-Al	Cr	Ti-Al	Cr	Ti-Al
Quantity	11.4848	9.7250	.00001	.00000	0.0883	0.0802	0.0171	0.0176	0.1513	0.1535

The most important and commonly used impact indicator is the Global Warming Potential (GWP), known also as Carbon footprint. As can be seen from Table 1 and Figure 1, the Ti-Al tanned technology resulted in a smaller carbon footprint – Global Warming Potential (9,7250 kg CO2 equiv.) than the Chrome tanned one (11,4848 kg CO2 equiv.).

The LCA impact indicators of the two compared technologies show the higher environmental impact of the classic Chrome leather production technology as compared to the Ti-Al leather production technology.

The Ti-Al leather production technology also resulted in significantly smaller Ozone Depletion Potential (ODP), Acidification Potential (AP) and Marine Aquatic Ecotoxicity Potential (MAETP) than the classic Chrome leather production technology:

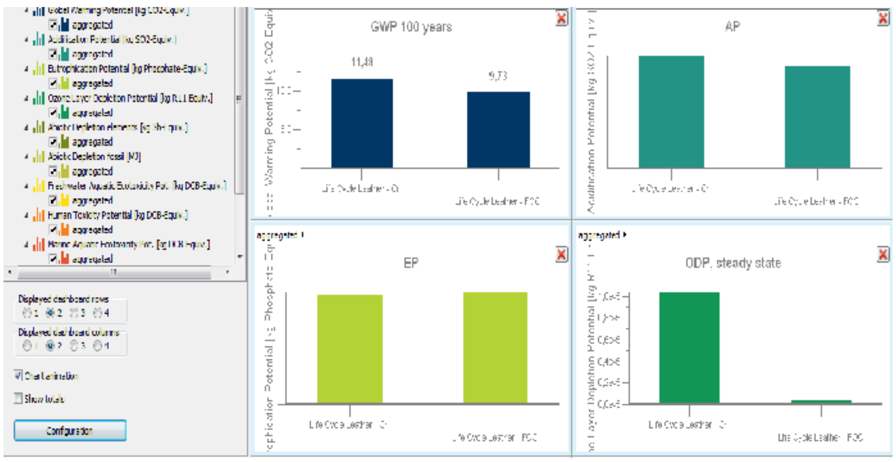

Figure 1. LCA impact indicators comparing the two technologies: Global Warming Potential (GWP), Acidification Potential (AP), Eutrophication Potential (EP) and Ozone Depletion Potential (ODP)

The Eutrophication Potential (EP) and the Photochemical Ozone Creation Potential (POCP) indicators for Ti-Al leather production technology show a slight increase as compared to the ones for Chrome leather production technology, but the values are comparable:

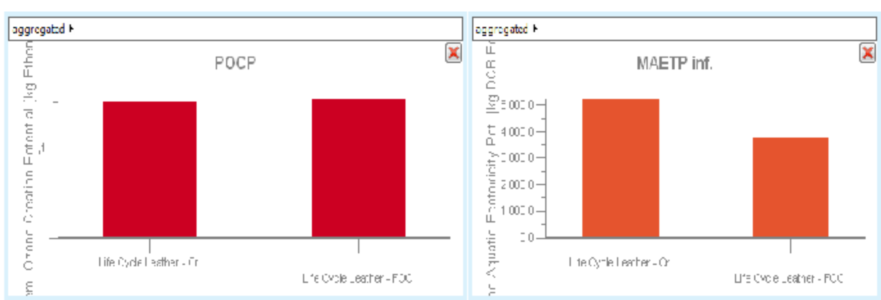

Figure 2. LCA impact indicators comparing the two technologies: Photochemical Ozone Creation Potential (POCP), Marine Aquatic Ecotoxicity Potential (MAETP)

Table 2. Total assessed impact of LCA impact category per technology phases / processes for the two compared technologies

Categories/ Unit	Global Warming Potential (GWP 100 years) – kg CO2 equiv.		Ozone Depletion Potential (ODP) kg R11 equiv.		Acidification Potential (AP) kg SO2 equiv.		Eutrophication Potential (EP) kg PO4 equiv.		Photochemical Ozone Creation Potential (POCP) kg C2H4 equiv.	
Technology	Cr	Ti-Al	Cr	Ti-Al	Cr	Ti-Al	Cr	Ti-Al	Cr	Ti-Al
Slaughter-house	1.5706	1.5706	.00000	0.0	.0114	0.0114	0.0005	0.0005	0.0006	0.0006
Beamhouse	0.9357	0.8835	.00000	0.0	.0273	0.0247	0.0020	0.0020	0.0013	0.0012
Tanning	3.0766	1.1752	.00000	0.0	.0200	0.0112	0.0035	0.0018	0.0014	0.0008
Post-tanning	1.1805	1.3278	.00001	0.0	.0135	0.0162	0.0027	0.0032	0.0014	0.0018
Finishing	1.0204	1.0341	.00000	0.0	.0109	0.0109	0.0008	0.0008	0.1464	0.1490
Wastewater treatment	0.2458	0.2458	.00000	0.0	.0040	0.0040	0.0036	0.0056	0.0002	0.0002

Figure 3 shows the LCA impact indicators comparing the two technologies on human toxicity: Human tox (cancer) indicator is zero for the new production technology, and Human tox (noncancer) indicator is smaller than the one of the Chrome leather production technology.

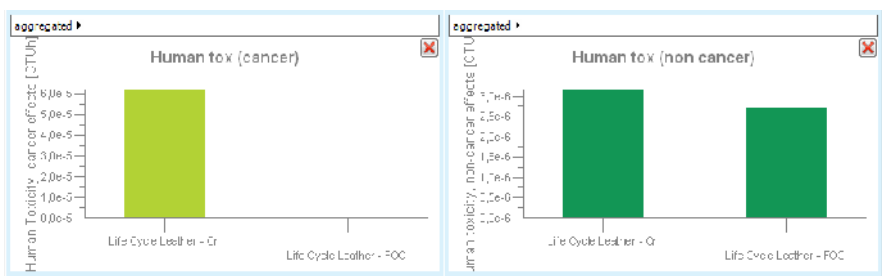

Figure 3. LCA impact indicators comparing the two technologies Human tox (cancer) and Human tox (noncancer)

If we analyses the impact indicators of the main processes for leather production (Table 2), the *Chrome technology has a higher environmental impact than the Titanium – Aluminum technology in almost all the processing phases*, except for the Post-tanning and Finishing phase.

In the Tanning phase, where the two leather production technologies differ – one is using the classical Chrome based tanning agents, and the other is using the newly developed Ti-Al tanning agents, there is the most significant difference in terms of Carbon footprint: the new INNOVA – LEATHER leather production technology *is generating three times less environmental impact* than the classical Cr-based tanning technology.

CONCLUSIONS

The goal of this study was to quantify the environmental impact of new tanning agents and related technologies for leather production, developed during the execution phase of INNOVA-LEATHER project, as well as the assertion of their improved environmental performance when compared against chromium (III) tanning.

The LCA study was performed with GaBi software 6.0. and databases in accord with Standard ISO 14044:2006: Environmental management - Life cycle assessment - Requirements and guidelines.

The main conclusion of the study is that the new overall tanning technology developed in INNOVA-LEATHER project generates a 15% lower environmental impact measured as Carbon footprint (Global Warming Potential indicator) than the chrome tanning technology. The other calculated impact indicators have comparable values between the two technologies.

In terms of the investigated Life Cycle process phases, the Tanning phase brings the most significant difference in terms of Carbon footprint: the new INNOVA – LEATHER technology is generating almost three times lower environmental impact than the Cr-based tanning technology in the tanning phase.

Out of the five main LCA impact indicators that were investigated in this study, three of them (namely Global Warming Potential – GWP, Ozone Depletion Potential – ODP and Acidification Potential – AP) have significantly lower total values for the new Ti-Al based technology than the classic Chrome leather production technology. Other three secondary impact indicators (Human toxicity cancer effects and non-cancer effects – Human tox cancer and Human tox non-cancer, and Marine Aquatic Ecotoxicity Potential - MAETP) also remarkably low values (sometimes negligible) for the new technology.

This demonstrates that the new tanning agents based on Ti-Al developed in the INNNOVA – LEATHER Project generate a significantly smaller environmental impact than chrome tanning agents and related technologies, recommending it for increased industrial use for a more sustainable and eco-efficient leather production, as new and innovative low carbon technologies help to reduce greenhouse gas emissions and create new employment and growth.

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