Development of a Formalized Toolset for Footwear Product

Thierry PONCET [*]***, Régis LETY***

CTC, 4, rue Hermann Frenkel, 69367 Lyon Cedex 07, France

Abstract: Environmental considerations are now part of the consumer behaviour influencing their purchases. The only way to get information on the environmental impact of an article is to go through Life Cycle Assessment (LCA). In some European countries, it is also included in legislation. Environmental impact of some articles has to be labelled indicating for example the carbon footprint.

Purchasing product with a lower environmental impact is one way leading to sustainable consumption.

Footwear and leather-goods as all products causes environmental impacts throughout their lifespan (from raw materials to end of life). Impacts are wide-ranging and include global warming, acidification, smog, ozone layer depletion, toxicity, water and energy consumption, depletion of mineral and fossil fuels….

There are a number of barriers to effectively providing information to consumers and linking information to action. These barriers are related to the growing volume and complexity of environmental information today, consumer scepticism vis-à-vis the credibility of most information source.

Eco-design through Life Cycle Analysis is the methodology that quantifies the impact of an article throughout its lifespan. The eco-design toolset developed gives the opportunity to deeply understand the signification of Life Cycle Analysis and Environmental Impacts and to quantify the environmental impacts of a model in order to check that it is really environmentally friendly. In order to go further up to eco-design, the toolset provides results showing impacts related to transportation, to material production, to the footwear industry itself and to the end-of-life of the article. Demonstration and results will be proposed.

Key words: footwear; Life Cycle Analysis; Life Cycle Assessment; Environmental Impact; footwear

1 Introduction

Global warming might be one of the most serious challenges that humanity is facing today. The only way to protect health and economic well-being of current and future generation is to deeply reduce the emissions of heat-trapping gases. It is usually said that primary cause of global warming is fossil fuel to drive cars, generate electricity and operates homes and businesses. Does it mean that producing and wearing shoes has no impact on the environment? The purpose of this presentation is to assess the environment impact of one pair of shoes: Impact on global warming of course but not only. There are other possible environmental impacts.

Environmental consideration is now part of the consumer behaviour influencing their purchases. As environmental awareness increases, industries and businesses are assessing how their activities affect the environment. In some European countries, it is also included in legislations. Environmental impact of some articles has to be labelled either on the article or on its packaging. Purchasing product with a lower environmental impact is one way leading to sustainable consumption. Sustainable consumption does not only mean "lower environmental impact". It also means that one has to assess its needs and buy what it required taking into account the optimal lifespan of the article. Impacts are wide-ranging and include impact on air, on climate change, on water and resource depletion.

Many businesses have responded to this awareness by providing "greener" products and using "greener" processes. Footwear and leathergoods as all products causes environmental impacts throughout their lifespan (from raw materials to end of life). The objective of these project is to give guidelines for the development of an awareness on eco-design for the footwear industry through a dedicated simple toolset.

2 Methodology

The only way to get information on the environmental impact of an article is to go through Life Cycle Assessment (LCA).

LCA is the methodology that quantifies the impact of an article throughout its life cycle including:

[*] Corresponding author. Phone: +33(0) 4 72 76 10 05. E-mail: tponcet@ctcgroupe.com

mining and extraction of raw material, farming, energy supply, material supplier, shipping, manufacturing of the articles, distribution, end-of life of the article.

First rule of the LCA practitioner is to define the functional unit that is to say the intended application and the system boundaries. For a pair of shoes, categories have to be defined: general sports footwear, school footwear, men's town footwear, cold weather footwear, women's town, footwear, fashion footwear, infant's footwear, indoor footwear... Among other, the functional unit should include an estimation of the lifespan of the article. It can be expressed in units of time (months, years) but also kilometres.

Second step is the Life Cycle Inventory (LCI) of the footwear manufacturing including all inputs materials, (raw material, energy) and outputs (air and water emissions, solid waste) of the footwear manufacturing. Data collection and modelling of the production system give all the data required.

Impact assessment is directly proposed by the toolset. Results are proposed for the following parameters:

- Natural resources depletion and energy depletion
- Acidification and smog
- Global warming
- Eutrophication and aquatic toxicity
- Human toxicity

The eco-design toolset developed gives the opportunity to deeply understand the signification of Life Cycle Analysis and Environmental Impacts and to quantify its environmental impacts. In order to go further up to eco-design, the toolset provides graphs specifying impacts related to transportation, material production, footwear manufacturing and the end-of-life of the article.

The concept can be used to optimize the environmental performance of a single product (eco-design) or to optimize the environmental performance of a company by choosing the least burdensome solutions.

3 Presentation of the Tool

Much software does exist for Life Cycle Assessment. The use of software requires time and trainings. The toolset proposed for the footwear and the leathergood industry is easy to use and it is dedicated to these products. As it is developed under Microsoft Excel, the user does not need any specific computer sciences background. Wordings and data are specific of the footwear and leathergood industry.

4 Results of Life Cycle Assessment of a Pair of Shoes

4.1 How to Present the Results

In order to make it easier to understand, the impact of a pair of shoe is presented in a "standardisation mode" which means that all results are presented in the form for ratio compared to an average European.
Example:

Example of an article which impact would be 36 kg of $CO_{2.}$.

As the impact of an average European is 30 kg of CO_2 per day, the impact of the pair of shoes is 36/30 = 1,2 days of average European impact. Such an approach has to be assessed for all indicators.

4.2 Example of a Women's Town Pair of Shoes

An example of the impact of a women town's pair of shoes is presented in Fig. 1. Depending on the indicator, the impact varies from 0.04 days of the average European impact for eutrophication to 0.6 days for acidification.

Fig. 1 Example of the impact of a pair of women's town pair of shoe (standardisation)

5 Eco-design

5.1 Impact of Materials

The purpose of Life Cycle Assessment is to produce less impacting articles. Fig. 3 doesn't give any assistance for the reduction of any impacts. In order to have better environmental performances, more detailed data are required. Fig. 2 indicates the impacting steps of the life being of that pair of shoes.

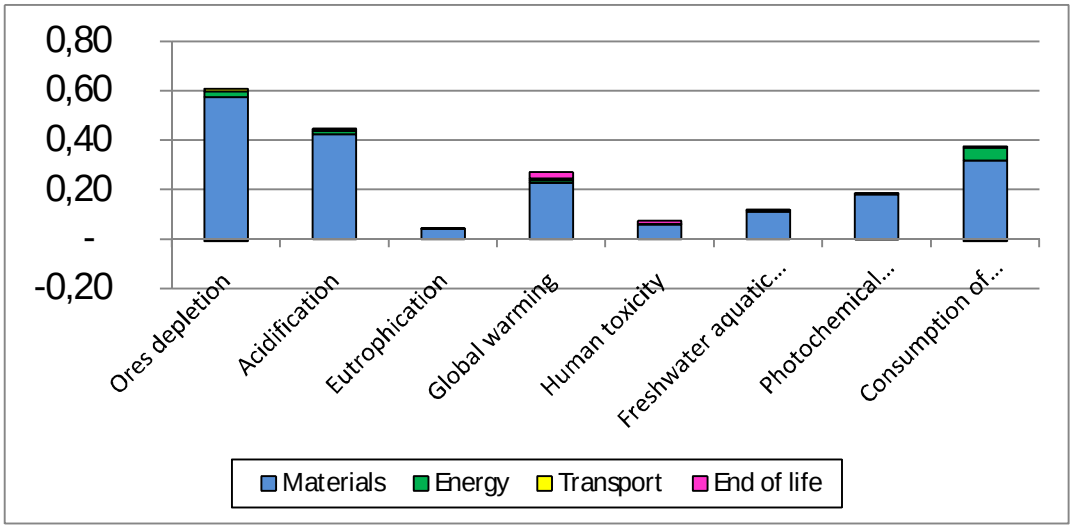


Fig. 2 Example of the impact of a pair of women's town pair of shoe (standardization) with the allocation "materials", "energy", "transportation" and "end of life"

Whatever the indicators, most impact of a pair of shoes is generated by "materials" that is to say the impact of suppliers.

Next step consists in checking how to reduce the impact of these materials, therefore to identify what are the impacting materials. This is shown on figure.

To reduce most of the impact due to material, one has to be aware of the impact of the potential alternative materials. Fig. 4 is a comparison of the impact of 1 square meter of different types of materials.

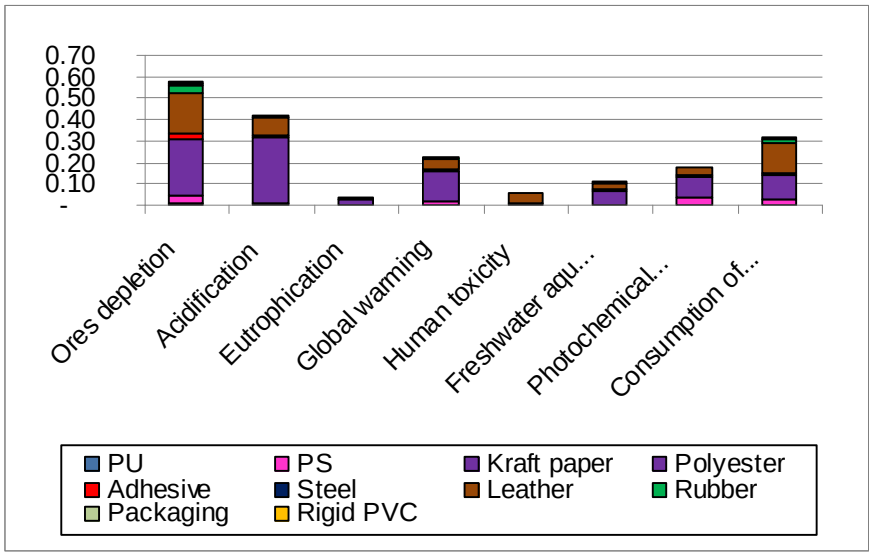
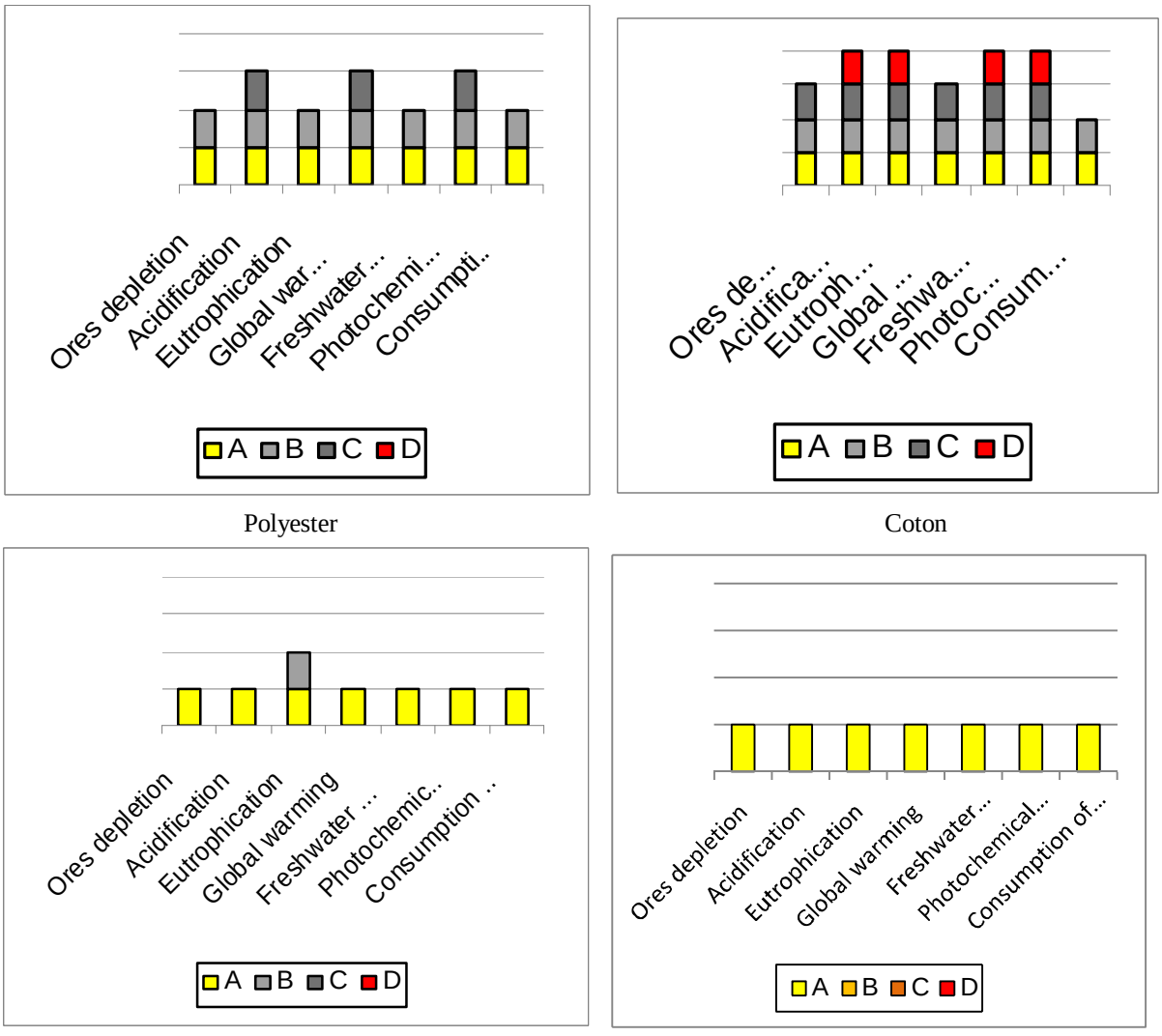


Fig. 3 Impact of the different materials



Polyester

Coton

Jute

Hemp

Fig. 4 Environmental impact of 1 m^2 of polyester, cotton, jute and hemp

5.2 Impact of Energy

Depending on the country in which the footwear is manufactured, the impact of energy might vary. As a matter of fact, producing energy in a country with 88% of its electricity produced with nuclear energy, 8% from hydroelectrical sources and 4% from thermal processes produces less carbon dioxide that countries producing electricity from fuel, gas and coal. By producing most of its energy with nuclear power and hydroelectrical plant, a pair of shoes produced in France has a lower impact on global warming and acidification than countries using fuel, gas and coal. This is show on Fig. 5.

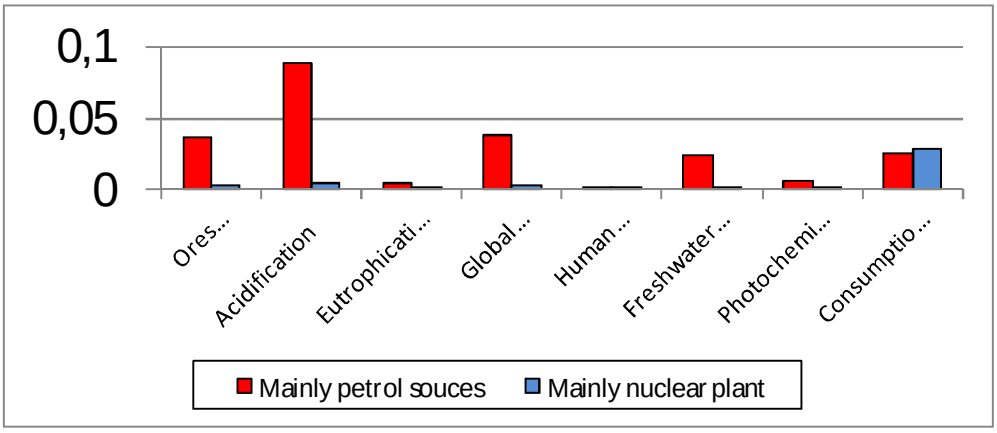


Fig. 5 Comparative impact of 1 KWh of Asian and European (France) electricity

5.3 Transportation

Asia produces more than 10 billion pairs of shoes every year. This is more than 75% of shoes manufactured every year in the world. Most of these pairs have to be shipped to Europe or to the United-States. Depending on the shipment mode, the impact will considerably vary. This is shown in Fig. 6.

Transportation by transoceanic ship is the only reasonable way to ship shoes to their final destination. Transportation by plane is just a non-sens.

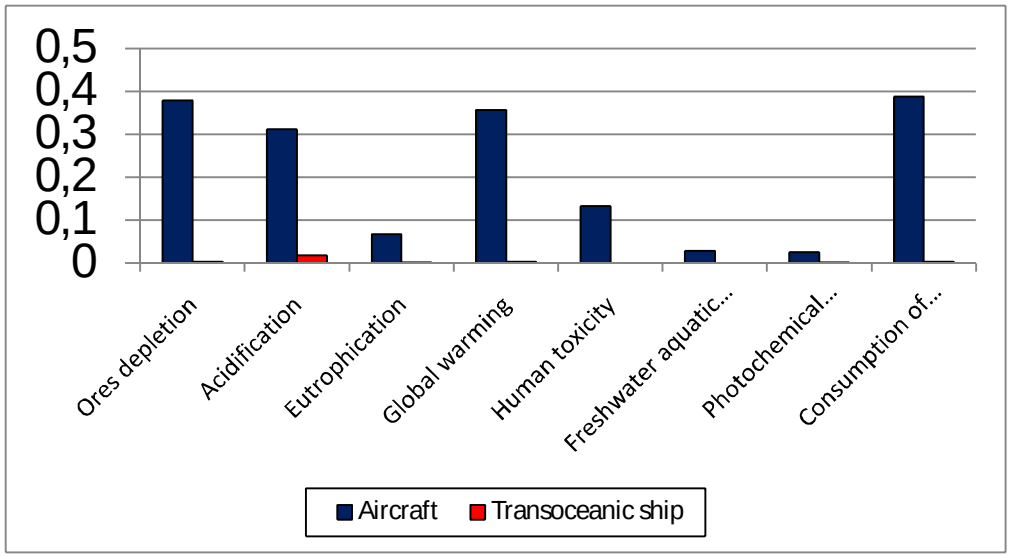


Fig. 6 Comparative impact of 10 000 km by plane or by transoceanic ship

For short distance transportation, the traveling by train, truck or barge will have an incidence on the environmental performance of the article. This is shown in Fig. 7.

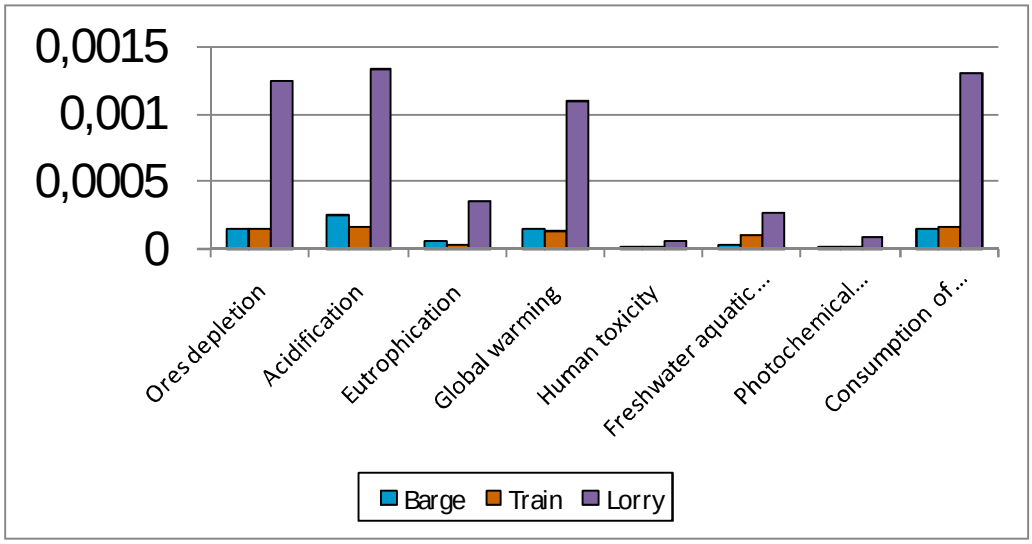


Fig. 7 Comparative impact of 100 k m by barge, train or lorry

6 Sustainable Footwear

The most important to check the environmental impact of an article might be the lifespan of the article. It is not fare to compare disposable articles with articles that could last for years or for hundreds of kilometres. Therefore, a methodology is being developed to estimates that lifespan. Through a bench laboratory tests, it should be possible to estimate a range of lifespan categories for footwear:

- Whole shoe: Determination adhesion between outsole and upper.
- Sol: flex resistance, abrasion resistance
- Upper: Resistance to tear strength, flexion resistance (dry and wet), abrasion resistance,
- Lining : Resistance to tear strength, abrasion resistance

By defining a range of results for each tests and by allowing a coefficient to each result, it is possible to estimates the lifespan of the pair of shoes. Lifespan of the article has to optimized be to its use.

Development of a Formalized Toolset for Footwear Product

Thierry PONCET [*]***, Régis LETY***

CTC, 4, rue Hermann Frenkel, 69367 Lyon Cedex 07, France

Abstract: Environmental considerations are now part of the consumer behaviour influencing their purchases. The only way to get information on the environmental impact of an article is to go through Life Cycle Assessment (LCA). In some European countries, it is also included in legislation. Environmental impact of some articles has to be labelled indicating for example the carbon footprint.

Purchasing product with a lower environmental impact is one way leading to sustainable consumption.

Footwear and leather-goods as all products causes environmental impacts throughout their lifespan (from raw materials to end of life). Impacts are wide-ranging and include global warming, acidification, smog, ozone layer depletion, toxicity, water and energy consumption, depletion of mineral and fossil fuels….

There are a number of barriers to effectively providing information to consumers and linking information to action. These barriers are related to the growing volume and complexity of environmental information today, consumer scepticism vis-à-vis the credibility of most information source.

Eco-design through Life Cycle Analysis is the methodology that quantifies the impact of an article throughout its lifespan. The eco-design toolset developed gives the opportunity to deeply understand the signification of Life Cycle Analysis and Environmental Impacts and to quantify the environmental impacts of a model in order to check that it is really environmentally friendly. In order to go further up to eco-design, the toolset provides results showing impacts related to transportation, to material production, to the footwear industry itself and to the end-of-life of the article. Demonstration and results will be proposed.

Key words: footwear; Life Cycle Analysis; Life Cycle Assessment; Environmental Impact; footwear

1 Introduction

Global warming might be one of the most serious challenges that humanity is facing today. The only way to protect health and economic well-being of current and future generation is to deeply reduce the emissions of heat-trapping gases. It is usually said that primary cause of global warming is fossil fuel to drive cars, generate electricity and operates homes and businesses. Does it mean that producing and wearing shoes has no impact on the environment? The purpose of this presentation is to assess the environment impact of one pair of shoes: Impact on global warming of course but not only. There are other possible environmental impacts.

Environmental consideration is now part of the consumer behaviour influencing their purchases. As environmental awareness increases, industries and businesses are assessing how their activities affect the environment. In some European countries, it is also included in legislations. Environmental impact of some articles has to be labelled either on the article or on its packaging. Purchasing product with a lower environmental impact is one way leading to sustainable consumption. Sustainable consumption does not only mean "lower environmental impact". It also means that one has to assess its needs and buy what it required taking into account the optimal lifespan of the article. Impacts are wide-ranging and include impact on air, on climate change, on water and resource depletion.

Many businesses have responded to this awareness by providing "greener" products and using "greener" processes. Footwear and leathergoods as all products causes environmental impacts throughout their lifespan (from raw materials to end of life). The objective of these project is to give guidelines for the development of an awareness on eco-design for the footwear industry through a dedicated simple toolset.

2 Methodology

The only way to get information on the environmental impact of an article is to go through Life Cycle Assessment (LCA).

LCA is the methodology that quantifies the impact of an article throughout its life cycle including:

[*] Corresponding author. Phone: +33(0) 4 72 76 10 05. E-mail: tponcet@ctcgroupe.com

mining and extraction of raw material, farming, energy supply, material supplier, shipping, manufacturing of the articles, distribution, end-of life of the article.

First rule of the LCA practitioner is to define the functional unit that is to say the intended application and the system boundaries. For a pair of shoes, categories have to be defined: general sports footwear, school footwear, men's town footwear, cold weather footwear, women's town, footwear, fashion footwear, infant's footwear, indoor footwear... Among other, the functional unit should include an estimation of the lifespan of the article. It can be expressed in units of time (months, years) but also kilometres.

Second step is the Life Cycle Inventory (LCI) of the footwear manufacturing including all inputs materials, (raw material, energy) and outputs (air and water emissions, solid waste) of the footwear manufacturing. Data collection and modelling of the production system give all the data required.

Impact assessment is directly proposed by the toolset. Results are proposed for the following parameters:

- Natural resources depletion and energy depletion
- Acidification and smog
- Global warming
- Eutrophication and aquatic toxicity
- Human toxicity

The eco-design toolset developed gives the opportunity to deeply understand the signification of Life Cycle Analysis and Environmental Impacts and to quantify its environmental impacts. In order to go further up to eco-design, the toolset provides graphs specifying impacts related to transportation, material production, footwear manufacturing and the end-of-life of the article.

The concept can be used to optimize the environmental performance of a single product (eco-design) or to optimize the environmental performance of a company by choosing the least burdensome solutions.

3 Presentation of the Tool

Much software does exist for Life Cycle Assessment. The use of software requires time and trainings. The toolset proposed for the footwear and the leathergood industry is easy to use and it is dedicated to these products. As it is developed under Microsoft Excel, the user does not need any specific computer sciences background. Wordings and data are specific of the footwear and leathergood industry.

4 Results of Life Cycle Assessment of a Pair of Shoes

4.1 How to Present the Results

In order to make it easier to understand, the impact of a pair of shoe is presented in a "standardisation mode" which means that all results are presented in the form for ratio compared to an average European.
Example:

Example of an article which impact would be 36 kg of $CO_{2.}$.

As the impact of an average European is 30 kg of CO_2 per day, the impact of the pair of shoes is 36/30 = 1,2 days of average European impact. Such an approach has to be assessed for all indicators.

4.2 Example of a Women's Town Pair of Shoes

An example of the impact of a women town's pair of shoes is presented in Fig. 1. Depending on the indicator, the impact varies from 0.04 days of the average European impact for eutrophication to 0.6 days for acidification.

Fig. 1 Example of the impact of a pair of women's town pair of shoe (standardisation)

5 Eco-design

5.1 Impact of Materials

The purpose of Life Cycle Assessment is to produce less impacting articles. Fig. 3 doesn't give any assistance for the reduction of any impacts. In order to have better environmental performances, more detailed data are required. Fig. 2 indicates the impacting steps of the life being of that pair of shoes.

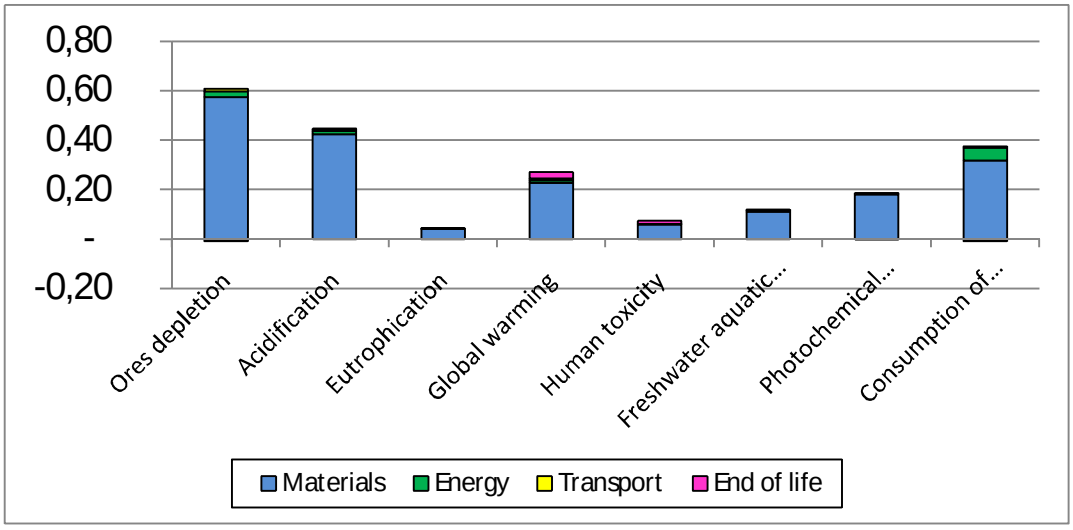


Fig. 2 Example of the impact of a pair of women's town pair of shoe (standardization) with the allocation "materials", "energy", "transportation" and "end of life"

Whatever the indicators, most impact of a pair of shoes is generated by "materials" that is to say the impact of suppliers.

Next step consists in checking how to reduce the impact of these materials, therefore to identify what are the impacting materials. This is shown on figure.

To reduce most of the impact due to material, one has to be aware of the impact of the potential alternative materials. Fig. 4 is a comparison of the impact of 1 square meter of different types of materials.

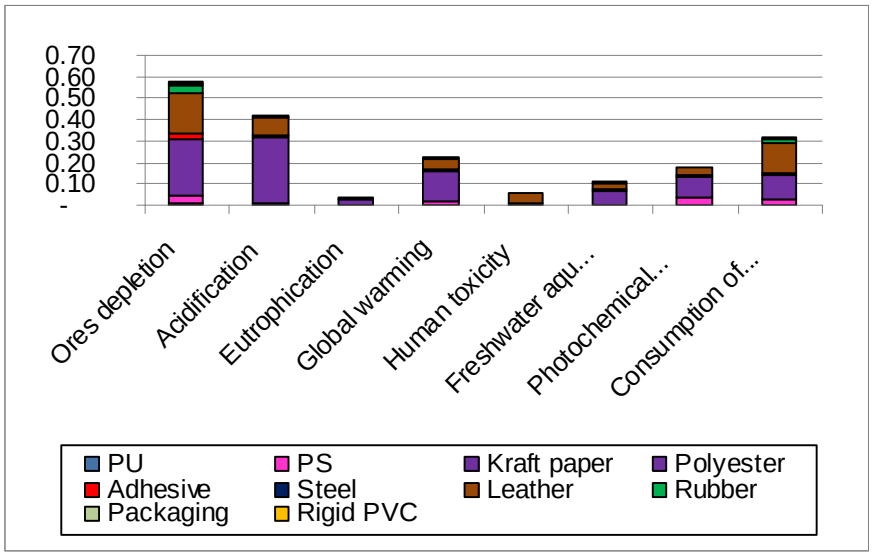
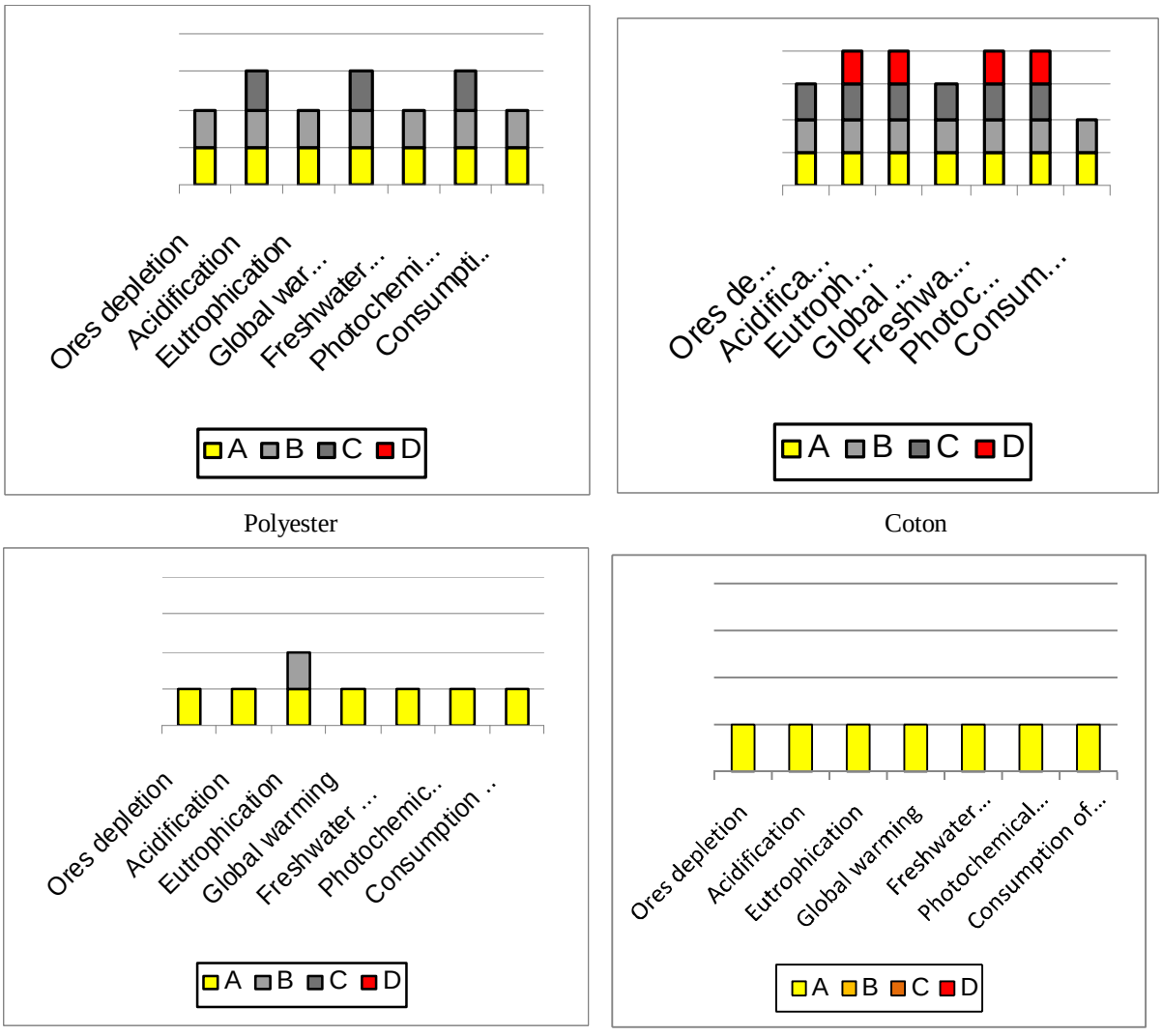


Fig. 3 Impact of the different materials



Polyester

Coton

Jute

Hemp

Fig. 4 Environmental impact of 1 m^2 of polyester, cotton, jute and hemp

5.2 Impact of Energy

Depending on the country in which the footwear is manufactured, the impact of energy might vary. As a matter of fact, producing energy in a country with 88% of its electricity produced with nuclear energy, 8% from hydroelectrical sources and 4% from thermal processes produces less carbon dioxide that countries producing electricity from fuel, gas and coal. By producing most of its energy with nuclear power and hydroelectrical plant, a pair of shoes produced in France has a lower impact on global warming and acidification than countries using fuel, gas and coal. This is show on Fig. 5.

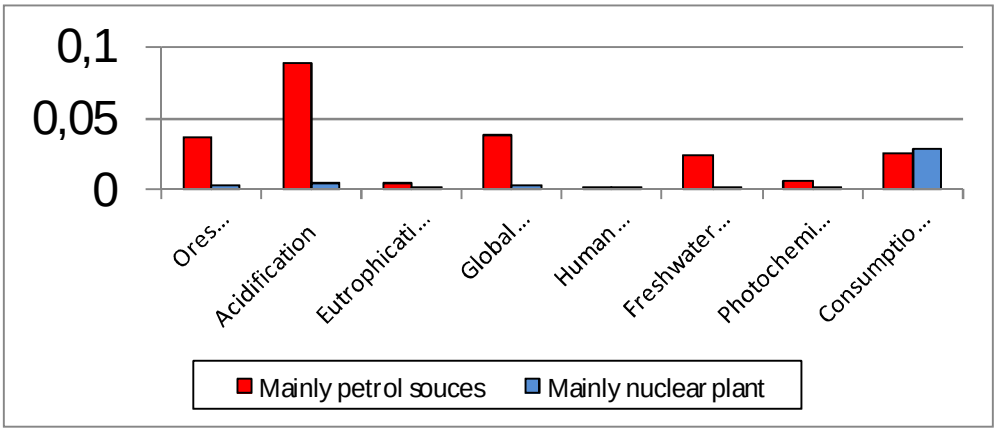


Fig. 5 Comparative impact of 1 KWh of Asian and European (France) electricity

5.3 Transportation

Asia produces more than 10 billion pairs of shoes every year. This is more than 75% of shoes manufactured every year in the world. Most of these pairs have to be shipped to Europe or to the United-States. Depending on the shipment mode, the impact will considerably vary. This is shown in Fig. 6.

Transportation by transoceanic ship is the only reasonable way to ship shoes to their final destination. Transportation by plane is just a non-sens.

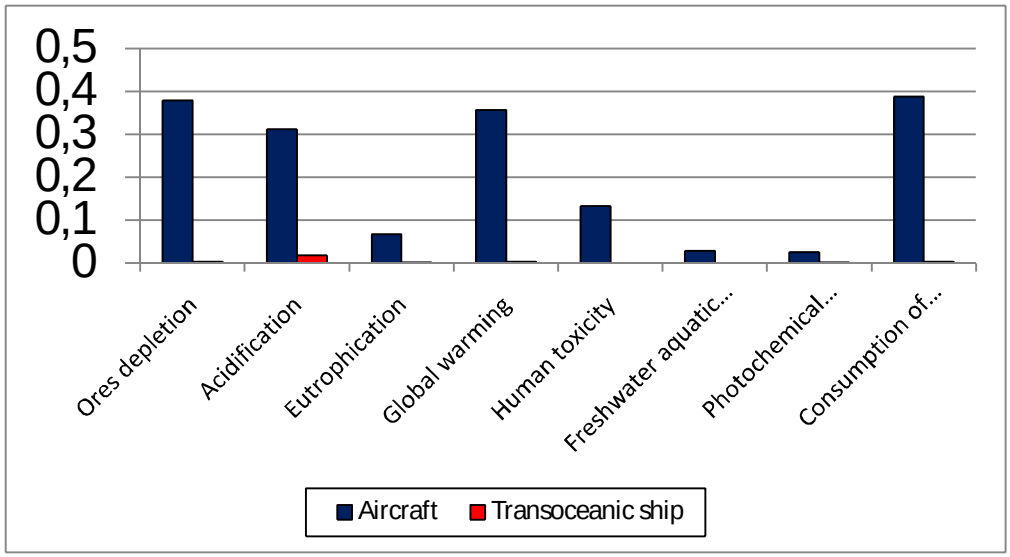


Fig. 6 Comparative impact of 10 000 km by plane or by transoceanic ship

For short distance transportation, the traveling by train, truck or barge will have an incidence on the environmental performance of the article. This is shown in Fig. 7.

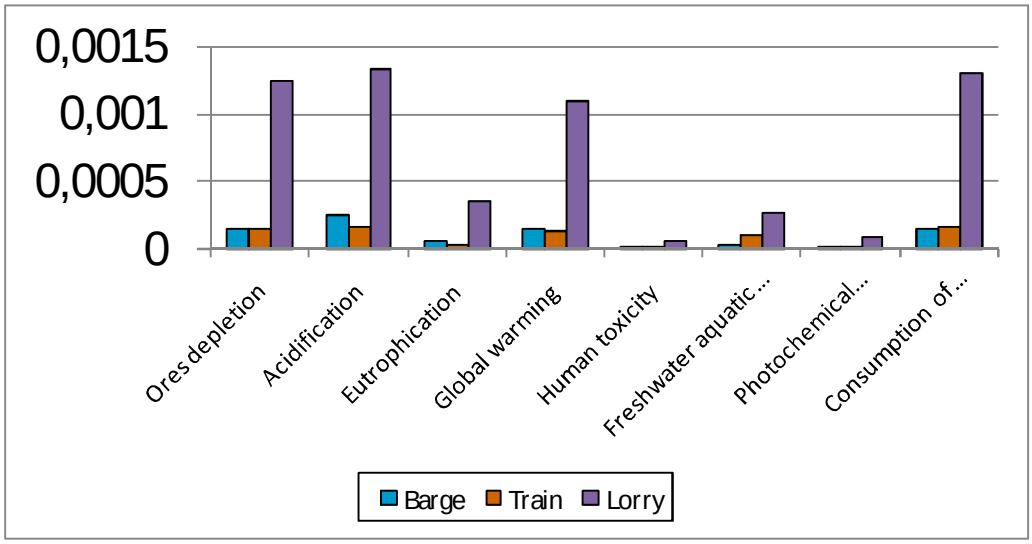


Fig. 7 Comparative impact of 100 k m by barge, train or lorry

6 Sustainable Footwear

The most important to check the environmental impact of an article might be the lifespan of the article. It is not fare to compare disposable articles with articles that could last for years or for hundreds of kilometres. Therefore, a methodology is being developed to estimates that lifespan. Through a bench laboratory tests, it should be possible to estimate a range of lifespan categories for footwear:

- Whole shoe: Determination adhesion between outsole and upper.
- Sol: flex resistance, abrasion resistance
- Upper: Resistance to tear strength, flexion resistance (dry and wet), abrasion resistance,
- Lining : Resistance to tear strength, abrasion resistance

By defining a range of results for each tests and by allowing a coefficient to each result, it is possible to estimates the lifespan of the pair of shoes. Lifespan of the article has to optimized be to its use.