ISSN: 2594 - 2905

INNOVATION AND LIFE CYCLE ANALYSIS FOR SUSTAINABLE DECISION MAKING IN PRODUCT DESIGN.

[1]Lucio Guzmán Mares, [2)]Ma. Soledad Castellanos Villarruel, [3]Alfonso Moreno Salazar, [4]Alma Jessica Velázquez Gallardo, [5]Norma Bautista Rangel.

[1]Doctorate in Engineering and Innovation Projects, [2)]Doctorate in Cooperation and Social Welfare, [3]Doctorate in Project Engineering, [4)]Doctorate in Cooperation and Social Welfare, [5]Master in Information Science and Knowledge Management.

[1,2]University of Guadalajara
Centro Universitario de la Ciénega, Departamento de Negocios
Av. Universidad 1115, Col. Linda Vista, Ocotlán, Jalisco,
Mexico
[1]luciog34@hotmail.com, [(2)]solcv@hotmail.com

[3]University of Guadalajara
Centro Universitario de la Ciénega, Departamento de Ingeniería Industrial
Av. Universidad 1115, Col. Linda Vista, Ocotlán, Jalisco, México
alf.morenosalazar@gmail.com

University of Guadalajara
Centro Universitario de la Ciénega, Department of Justice and Law Av.
Universidad 1115, Col. Linda Vista, Ocotlán, Jalisco, Mexico
jvelazquez@cuci.udg.mx

University of Guadalajara
Centro Universitario de la Ciénega, Departamento de Ciencias Básicas
Av. Universidad 1115, Col. Linda Vista, Ocotlán, Jalisco, Mexico
bautistanorma@hotmail.com

Abstract -- Designing eco-friendly products has become one of the greatest challenges for companies today, since consumers are looking for quality products that do not harm the planet. That is why this article develops a case study that evaluates the environmental impacts of an eco-innovated product and compares them with another product of the same essence, commercial; in order to know most polluting stage of its life cycle of each of them, then comparing the damage they generate to determine if there was environmental improvement in the innovative product.

Innovation management allows the application of creative criteria to achieve substantial improvements that contribute to sustainability. While engineering takes importance in the detailed analysis of the parts that make up the products, constructing diagrams of the parts that make up the products, flow charts, technical data sheets, dimensional drawings, among others.

The main objective of this case study is to evaluate and compare the environmental impacts of the life cycle of the two products by applying the Life Cycle Assessment (LCA) methodology framed in the international standard ISO 14040 and using the specialized software Simapro, in order to know the sustainability that exists between them.

Finally, the main results obtained from these methodologies and the individual and comparative graphs of the environmental impacts and damages generated by each product are presented, concluding with the environmental improvement achieved in the eco-designed or eco-innovated product greater than 35% overall.

Keywords: LCA, Innovation, Product Design.

Date of Receipt: September 2019 | Date of Acceptance: December 2019

iPSUMTEC
ISSN: 2594 - 2905

Abstract -- Designing organic products becomes one of the biggest challenges for companies, nowadays, as consumers look for quality in them but they do not harm the planet. That is why this article develops a case study that evaluates the environmental impacts of an eco-innovative product and compares them with another product of the same essence, commercial; in order to know the stage of its life cycle most polluting each of them, then comparing the damage they generate to determine if there was an environmental improvement in the innovative product.

Innovation management allows to apply creative criteria in order to achieve substantial improvements that contribute to sustainability. While Engineering takes importance in the detailed analysis of the parts that make up the products, constructing flow diagrams, technical sheets, dimensional drawings, among others.

The main objective of this case study is to evaluate and compare the environmental impacts of the life cycle of the two products by applying the Life Cycle Analysis (LCA) methodology framed in the international standard ISO 14040 and using the specialized software Simapro, to know the sustainability that exists between them.

Finally, the main results obtained from these methodologies and the individual and comparative graphs of the environmental impacts and damages generated by each product are presented, concluding with the environmental improvement achieved in the ecodesigned or ecoinnovated product greater than 35% overall.

Key words: LCA, Innovation, Design of Products.

INTRODUCTION

Every product has an initial function, but once it fulfills its life cycle, it can be recycled through different systems and treatments. One of the alternatives to solve the problem pollution is through recycling, a key element of sustainable development and green growth, because it reduces environmental impacts associated with waste generation, an important strategy in integrated waste management, taking into account the impact of waste on the environment and trying to counteract it. Recycling is a process in which residues or waste materials are collected and recycled and transformed into new materials that can be used or sold as new products or raw materials [1]. If waste is properly managed, it be recycled and given a new life.

For this reason, greenhouse gas emissions will be reduced in industry and other productive sectors [2].

As described above, we have as a precedent the design and development of a product made entirely of cardboard without the use of more resources and / or materials, since this is a modular design and is assembled by a slotted system without the need for tools and consumables; providing equal or better features in its functionality than a desk made of conventional materials.

The objective of Life Cycle Assessment or LCA is to help evaluate, quantify and understand the different impacts and damages to the environment generated by products, processes or services of any kind throughout the life cycle of their creation. Currently in Mexico the LCA methodology is little used in companies to solve problems of potential environmental impacts (for example, the use of resources and the environmental consequences of emissions) throughout the entire life cycle of a product from the acquisition of raw materials, through production, use, final treatment, recycling, to its final disposal, that is, from cradle to grave, as well as to take care of health aspects of workers as carcinogens, respirable organics, toxicity, among others. Therefore, this research has a longitudinal scope to communicate and disseminate various tools and techniques to be followed in the realization of an environmentally friendly product, based on a global need, to contribute to the reduction of massive and uncontrollable pollution of our planet, raising awareness of the impact and ecological damage that have products consumed with unprecedented speed.

DEVELOPMENT

In this section, and due to the length of the document, the main methodologies and tools used for the following are clearly described the LCA. We start with a product that was designed based on the Promise ecodesign methodology, its wheel of ecodesign strategies and the basic process of innovation (which are not included in the development in this article, as well as the technical data sheet, assembly instructions, product drawings, among other results).

Life Cycle Assessment (LCA)

Overview

ISO standards are a series of standards that can be grouped into families. ISO has developed more than 19,000 international standards on a variety of subjects and more than 1,000 new standards are published every year. Achieving greater international relevance in the last decade, these standards require documented systems to control the processes used to develop and manufacture products, through the control of certain elements of the system, in order to ensure that the products are manufactured consistently meeting the characteristics of quality and on-time delivery [3]. So standards can be classified according to the following criteria:

Standards directly related to quality.

Standards related to Environmental Quality and Sustainability.

Standards related to Safety Management.

The AENOR standard UNE-EN ISO 14040 (2006) [4]. defines LCA as "a technique for determining the environmental aspects and potential impacts associated with a product by: compiling an inventory of the relevant inputs and outputs of the system; assessing the potential impacts associated with these inputs and outputs; and interpreting the results of the inventory and impact phases in relation to the objectives of the study".

LCA applications

As indicated in the regulations, LCA can be applied to:

The identification of opportunities for improving the environmental aspects of products at various points in their life cycle.

Decision making in industry, governmental institutions, and non-governmental organizations. Decisions related to strategic planning, priority setting, product or process design or redesign, etc.

The selection of relevant environmental performance indicators, including measurement techniques.

Marketing, among others (see figure 1).

LCA Methodology: ISO 14044:2006. Environmental Management. Life Cycle Assessment. Requirements and Guidelines [5].

There are four phases in a LCA study (see Figure 1):

a) The objective and scope definition phase,

b) The inventory analysis phase,

c) The environmental impact assessment phase, and

d) The interpretation phase.

Figure 1. Phases of LCA [6].

Definition of objectives and scope

The purpose of this first phase of the LCA is to define exactly to what level of detail, how and why the study will be carried out. All this information must be detailed in a clear, concise and totally transparent manner. The rationale for the study is included, and the functional unit is also established at this stage. The functional unit describes the main function of the system under analysis. An LCA is not used to compare products with each other, but services and/or product quantities that perform the same function.

function. For example, it is not valid to compare two different kilos of paint that do not serve the same function, to cover an equivalent area with a similar duration.

Inventory analysis (ICV)

This phase involves data collection and calculation procedures to identify and quantify all adverse environmental effects associated with the functional unit. In a generic way we will call these environmental effects as "environmental load". This is defined as the output or input of matter or energy from a system causing a negative environmental effect. This definition includes emissions of polluting gases, water effluents, solid waste, consumption of natural resources, noise, radiation, odors, etc... When working with systems involving several products, in this phase we will proceed to assign the flows of matter and energy, as well as the emissions to the environment associated with each product or by-product.

Impact assessment (IVIA)

Life Cycle Impact Assessment (LCIA) is aimed at assessing the significance of potential environmental impacts using the results of the inventory analysis. In general, this process involves associating inventory data with specific environmental impacts in an attempt to assess those impacts. The level of detail, the choice of impacts assessed and the methodologies used depend on the objective and scope of the study. Considering that, in the

In practice, the LCI is a long list of emissions and resources used, the purpose of life cycle impact assessment is to determine the relative importance of each element of the inventory and aggregate the interventions into a set of indicators, or if possible, into a single global indicator. This step makes it possible to identify those processes that contribute significantly to the overall impact, or to compare products or services.

The standard defines the mandatory elements of the LCIA (see Figure 2) as follows:

Selection: in this step the impact categories and characterization methods to be considered in the study are selected.

Classification: is the assignment of inventory data to different impact categories such as global warming, ozone depletion, etc.

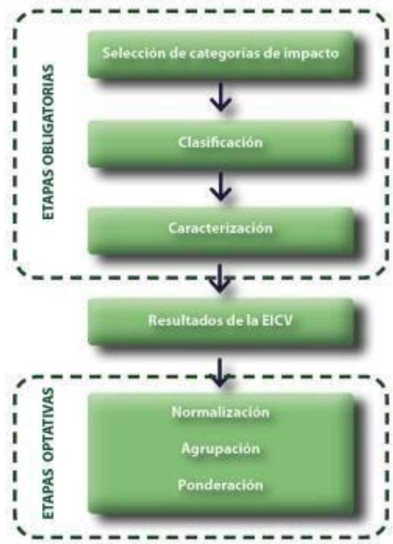


Figure 2. Mandatory and voluntary elements of the EICV [6].

Characterization: refers to the calculation of the impact indicator for each of the selected impact categories, using characterization factors, which are estimated using characterization models.

The optional elements of the LCIA are also defined by the standard, which states the following:

Normalization: is the calculation of the magnitude of the impact indicator. For this, reference information is used, such as emissions in a given area, previously characterized by the same characterization method.

Clustering: is the process of classifying impact categories by groups of similar impact or by categories in a given hierarchy, e.g. high, medium or low priority.

Weighting: consists of establishing factors that give a relative importance to the different

IPSUMTEC
ISSN: 2594 - 2905

impact categories and then sum them to obtain a weighted result in the form of a single overall environmental index for the system.

It should be borne in mind that the steps of grouping and weighting are based on the creation of damage that involve the establishment of hypotheses and the creation of scenarios involving value judgments with no scientific basis.

Interpretation

In the last stage of the LCA, the results obtained in both the inventory and the impact assessment are interpreted and recommendations aimed at reducing the environmental impacts caused by the system under analysis are extracted (ISO14040:2006, 2018).

Computer Tools for LCA

There are different methods, tools, techniques and/or software to perform a life cycle analysis, some of which such as: SimaPro, Eco-it, Pems, LCAiT, EcoPro, GaBi, and OpenLCA greatly facilitate the study.

Criteria for the selection of LCA tools

Before we start looking at the different databases and software available on the market, it is important to know what information is important selecting one or another software. Not only the quality of the database and the user-friendliness of the tools should be taken into account, but also qualities such as data-importance features and the capacity of the graphical environment, among others, are also very important and decisive for the choice of one tool or another. Figure 3 summarizes the most important criteria for the evaluation of databases and software [7].

SOFTWARE ACV	**BASE DE DATOS**	**Criterios** • Extensión • Transparencia • Calidad de los datos • Subrutina de entrada de datos • Prestaciones para la importancia de datos
	PROGRAMAS	**Criterios** • Facilidad de uso • Ayuda online • Capacidad del entorno grafico • Realización de diagramas de flujo • Análisis de sensibilidad • Diferentes métodos de evolución de datos • Preparado para ser utilizado en red.

Figure 3. Criteria for the selection of LCA software [7].

According to these criteria, the GABI 3 program and TEAM are the ones that would offer the best evaluation since they meet all of them with the sole exception of the graphic device, followed by SIMAPRO. The , except for not having a graphical interface and the impossibility to perform an uncertainty analysis, is quite complete [8]. However, because of the knowledge in the use, benefits and counting are the Simapro software, it is the tool that was used to carry out the LCA. Furthermore, this tool is designed and/or structured based on the ISO 14040 and 14044 standards.

SimaPro

SimaPro is a program developed by the Dutch company PRé Consultants, which allows to carry out LCA, through the use of own inventory databases (created by the user) and bibliographic databases (Ecoinvent, BUWAL, IDEMAT, ETH, IVAM). With this
tool facilitates the analysis and graphical representation of complex cycles in a systematic and transparent way. The program helps you effectively apply your LCA expertise to help you empower sound decision making, improve your product life cycles and enhance your company's positive impact. SimaPro is the leading LCA software package with a 25-year reputation in industry and academia in more than 80 countries.

The software is designed to be a science-based source of information, providing full transparency and avoiding black box processes. To be able to make conscious decisions throughout the analysis to ensure the accuracy of the results. It is the professional tool for collecting, analyzing and monitoring sustainability performance data of company products and services. The software can be used for a variety of applications, such as sustainability, carbon and water footprint reporting, product design, generation of environmental product declarations and determination of key performance indicators, and especially for conducting LCA, generating compelling results through graphs and tables [9].

IPSUMTEC
ISSN: 2594 - 2905

DISCUSSION AND ANALYSIS OF RESULTS

The analysis of results follows the order of the four phases of the LCA methodology described above. Of course, this section presents the main products obtained in each of the phases.

Case Study: LCA of an Innovative Product and/or Process

Phase I: Definition of objective and scope

In this phase, the objective, motive, functional unit and reference flow of the product system as a whole are determined (see figure 4).

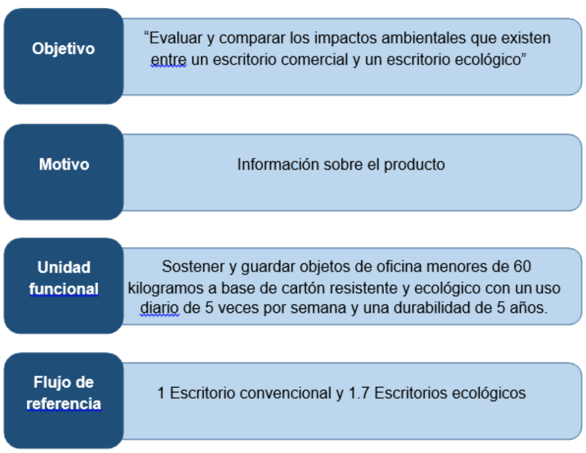


Figure 4. Phase I_ Objective and Scope (own elaboration).

Phase II: Inventory analysis

This section only presents an initial analysis of each product, including data collection and calculation procedures to quantify the relevant inputs and outputs of a product system. Multifunctional Desk see table 1) and the Conventional Desk (see table 2), and thus to know and evaluate the environmental impacts of both products.

Tables 1 and 2 are based on the materials used in the manufacturing process of each of these products. In phase 3 of the methodology, these inputs and outputs are introduced into Simapro to obtain the environmental damages and impacts they have on the environment.

Table 1. Inventory of the Multifunctional Desk.

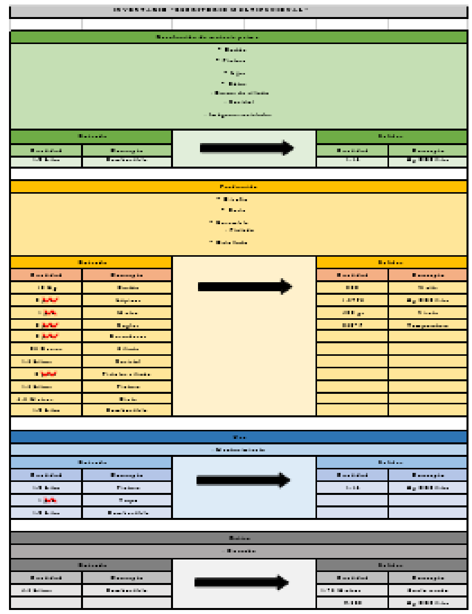
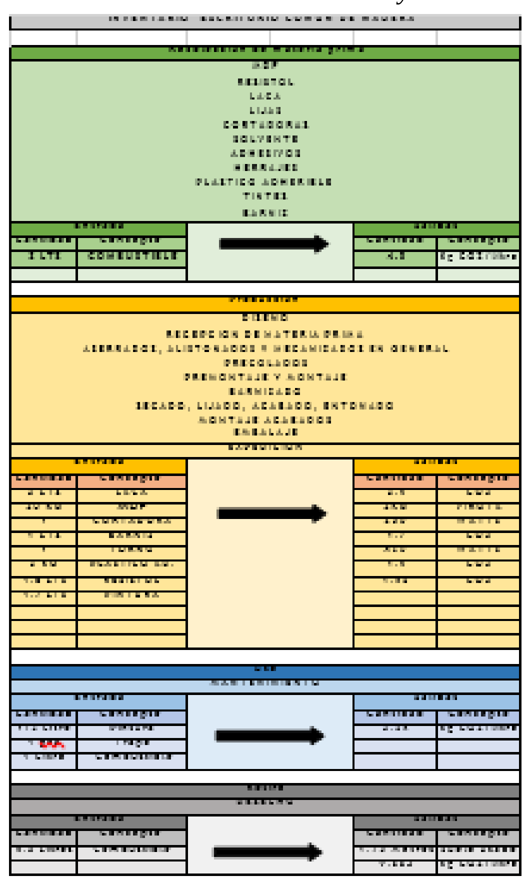


Table 2: Conventional Desk Inventory.



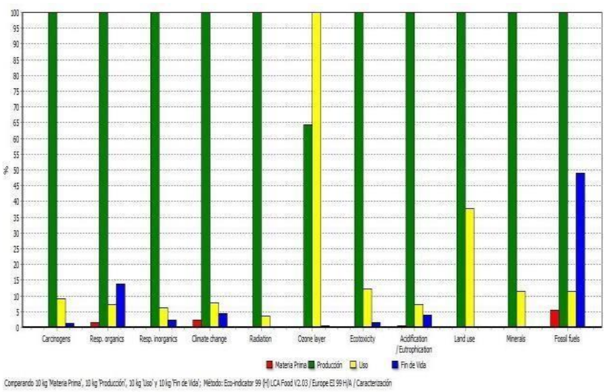
Phase III and IV: Evaluation of impacts and interpretation of results.

Impact assessment. The significance potential environmental impacts is assessed using the results of the life cycle inventory analysis.

Interpretation of results. Conclusions and recommendations for decision making, consistent with the defined objective and scope.

Multifunctional desk

The following are some of the graphs provided by this software tool, which show the environmental impacts obtained throughout the life cycle of a multifunctional desk made of resistant and ecological cardboard. The evaluation was carried out with the help of Simapro software and the Eco-indicator 99 method.



Graph 1. Characterization of the Multifunctional Desk.

According to Graph 1 of the characterization of the multifunctional desk, it can be seen that within the category of damage to human health, which only includes the first 6 elements of the graph, the greatest environmental impact is caused by the production process of the product, the percentages of each element are established as follows:

Carcinogens: Production process affects about 100%, use process 9% and both raw material and end-of-life processes are irrelevant.

Respirable organics: Production process affects about 100%, use process 7%, end-of-life process 13%, raw material 2%.

Respirable inorganics: Production process affects about 100%, use process 6%, end-of-life process 3%.

Climate change: Production process affects about 100%, use process 13%, end-of-life process 4%, raw material process 3%.

Radiation: Production process affects about 100%, use process 3%.

Ozone layer: Production process affects about 64%, use process 100%.

On the other hand, within the category of Ecosystem damage, which includes the following three elements (acidification, ecotoxicity, land use), the one with the greatest environmental impact is also caused by the production process of the product, the percentages of each element are established as follows:

Ecotoxicity: Production process affects 100%, use process 12%, end-of-life process 1%.

Acidification: Production process affects about 100%, use process 7%, end-of-life process 4%.

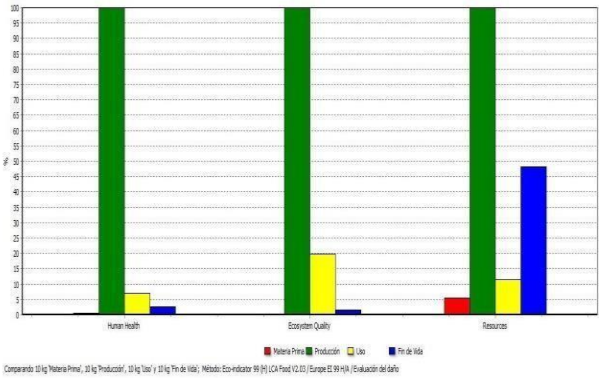
Land use: Production process affects about 100%, use process 37%.

Finally, within the Resource damage category, which comprises the last two elements (minerals and fossil fuels) in Graph 1, the greatest environmental impact is also caused by the product production process, the percentages of each element are established as follows:

Minerals: Production process affects about 100%, use process 11% and both raw material and end-of-life processes are irrelevant.

Fossil fuels: Production process affects about 100%, use process 11%, end-of-life process 49% and raw material 5%.

ISSN: 2594 - 2905



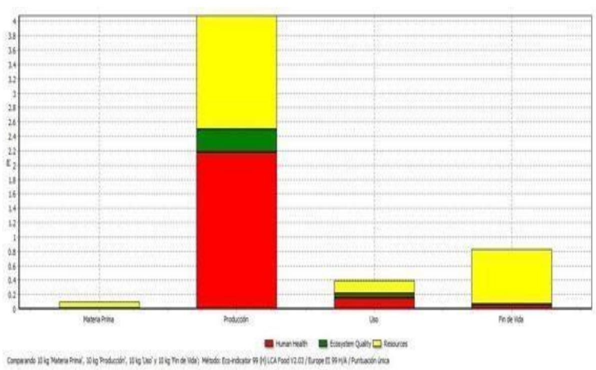
Damage Assessment Multifunctional Desk.

Graph 2 shows that, in the three categories of damage, the process that has the greatest environmental impact is production, followed by use, end of life and raw material. The approximate percentages affecting each category of damage are as follows:

Human health: Production process affects about 100%, use process 7% and end-of-life process 2%.

Ecosystems: Production process affects about 100%, use process 20% and end-of-life process 1%.

Resources: Production process affects about 100%, use process 11%, end-of-life process 48% and raw material process 5.5%.



Graph 3. Single score of the Multifunctional CV_Desk.

Finally, Graph 3, single score or ecopoints, clearly shows that the main problem to be addressed in order to minimize pollution and thus the damage caused, mainly to human health and resources; it is the production process stage, followed by the end-of-life and use stages, note that the raw materials stage is not significant in this product, proving that the use of low-energy impact materials is a good design option.

Conventional Desk

The following are some of the graphs provided by this software tool, which show the environmental impacts obtained throughout the life cycle of a conventional desk, the main source of raw material being wood. The evaluation was carried out with the help of Simapro software and the Eco-indicator 99 method.

Based on what is observed in graph 4 of the conventional desktop characterization, it can be seen that within the category of damage to human health, which only includes the first 6 elements of graph 4, the greatest environmental impact is caused by the production process of the product in 4 of the 6 elements and the rest are dominated by the process of use, the percentages of each element are established as follows:

Carcinogens: Production process affects about 100%, use process 37%, end-of-life process 4% and raw material process 9%.

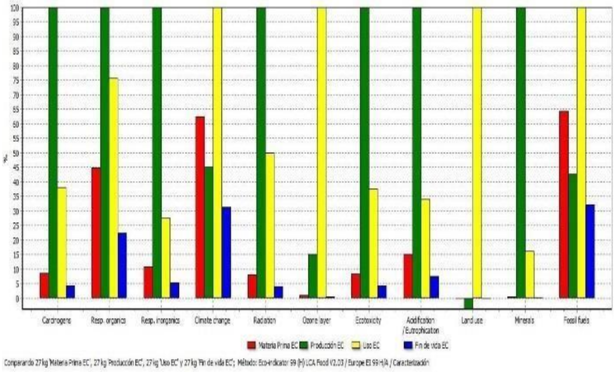
Respirable organics: Production process affects about 100%, use process 75%, end-of-life process 22%, raw material 45%.

Respirable inorganics: Production process affects about 100%, use process 27%, end-of-life process 5% and raw material process 11%.

Climate change: Production process affects about 45%, use process 100%, end-of-life process 31%, raw material process 63%.

Radiation: Production process affects about 100%, use process 50%, end-of-life process 4% and raw material process 8%.

Ozone layer: Production process affects about 15%, use process 100%.



Graph 4. Characterization of the Conventional Desktop

On the other hand, within the category of Ecosystem damage, which includes the following three elements (acidification, ecotoxicity, land use) in graph 4, the greatest environmental impact is also caused by the production process of the product, the percentages of each element are established as follows:

Ecotoxicity: Production process affects about 100%, use process 37%, end-of-life process 4% and raw material process 8%.

Acidification: Production process affects about 100%, use process 34%, end-of-life process 7% and raw material process 15%.

Land use: Land use process affects about 100% of the land use.

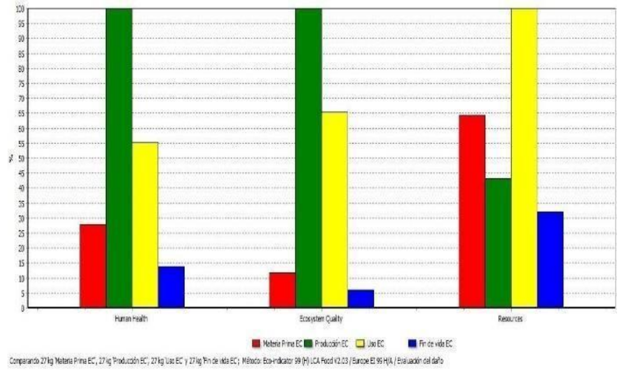
Finally, within the Resource damage category, which includes the last two elements (minerals and fossil fuels) in Graph 4, the greatest environmental impact is caused by the production process and use of the product, the percentages of each element are established as follows:

Minerals: Production process affects about 100% and use process 16%.

Fossil fuels: Production process affects about 43%, use process 100%, end-of-life process 32% and raw material 64%.

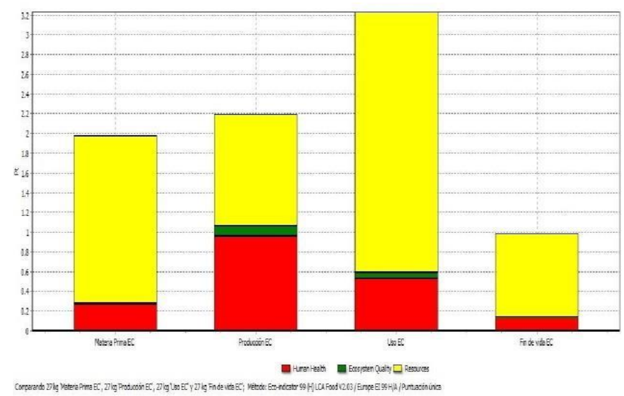
However, in both the Human Health and Ecosystems categories, the VC stage with the greatest environmental impact is production, followed by use, end of life and, finally, raw material. On the other hand

By far the process that has the greatest effect on resource contamination is the CV stage of the application.



Graph 5. Damage Assessment_Conventional Desk.

Finally, Graph 6, single score or ecopoints, shows how each stage of the VC generates significant environmental impacts where the main problem to be addressed to minimize pollution and thus the damage caused to human health and resources is the desktop use stage.



Graph 6. Single score of the CV_Conventional Writing.

Comparison: Multifunctional Desk / Conventional Desk

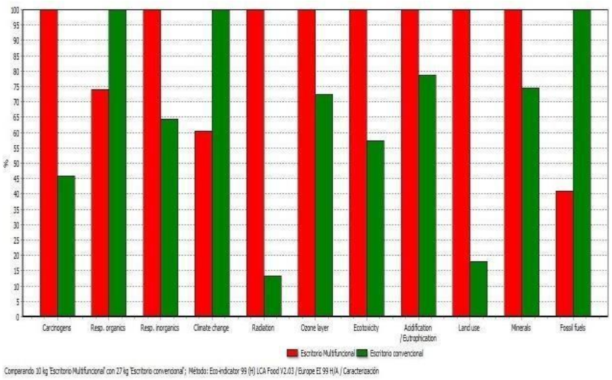
Finally, part of the graphs provided by this computer tool are presented, showing the environmental impacts obtained throughout the life cycle of both desks in order to compare the four processes and, based on the analysis performed, to determine the most polluting product. The evaluation was carried out with the help of Simapro software and the Eco-indicator 99 method.

IPSUMTEC
ISSN: 2594 - 2905

Graph 7, of characterization, shows that the desk with the greatest environmental impact, within each element of the three categories of damages and impacts, is the multifunctional desk; it occupies the highest percentage in 8 elements compared to the conventional desk, which only has the highest percentage of damages caused to the environment in 3 elements. The percentages are as follows:

Carcinogenic: The multifunctional desk encompasses 100% of this effect and the conventional desk only 46%.

Breathable organics: The multifunctional desk covers 74% while the conventional desk covers 100%.



Graph 7. Product Comparison Characterization.

Breathable inorganics: The multifunctional desk covers 100% of this effect and the conventional desk only 64%.

Climate change: The multifunctional desk covers 60% while the conventional desk covers 100%.

Radiation: The multifunctional desk encompasses 100% of this effect and the conventional desk only 13%.

Ozone layer: The multifunctional desk covers 100% of this effect and the conventional desk only 73%.

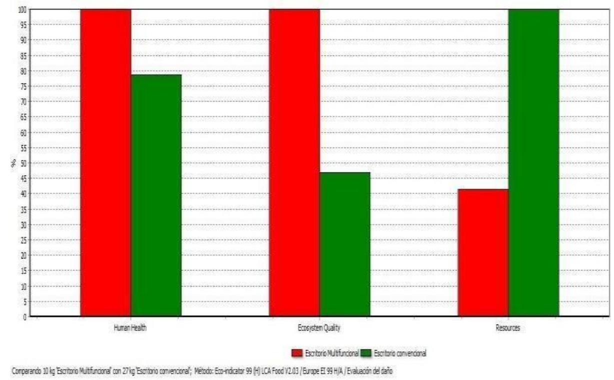
Ecotoxicity: The multifunctional desk covers 100% of this effect and the conventional desk only 53%.

Acidification: The multifunctional desk encompasses 100% of this effect and the conventional desk only 84%.

Floor use: The multifunctional desk accounts for 100% of this effect and the conventional desk only 23%.

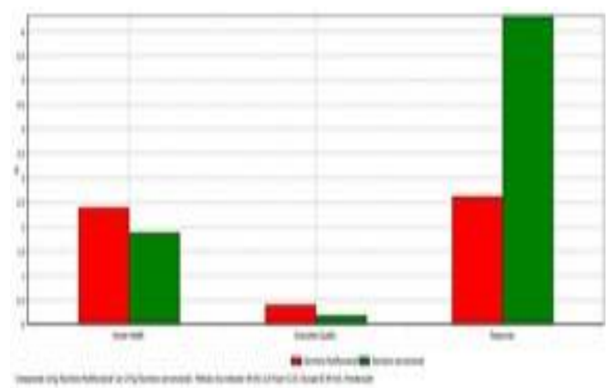
Minerals: The multifunctional desk covers 100% of this effect and the conventional desk only 75%.

Fossil fuels: The multifunctional desk covers 40% while the conventional desk covers 100%.



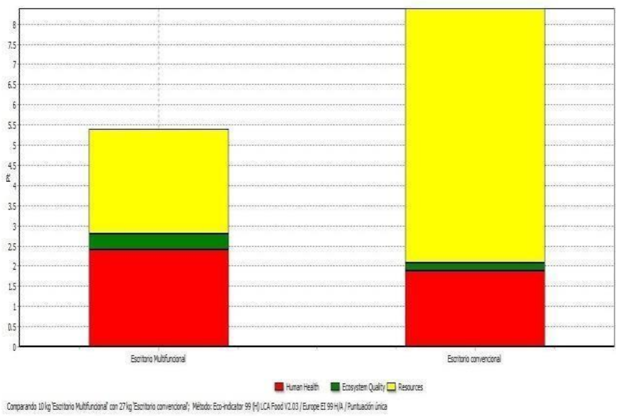
Damage Assessment Product Comparison.

According to Graph 8, evaluation of damages, it can be concluded that in both the Human Health and Ecosystems categories, the product that causes the most contamination is the multifunctional desk, with 100% in both categories. In the Resources category, the desk that causes the most damage is the conventional desk.



Graph 9. Weighting_Product Comparison.

In the weighting graph 9, it can be concluded that in both the Human Health and Ecosystems categories, the product causing the most contamination is the multifunctional desk with scores not exceeding 2.5, while in the Resources category, the desk causing the most damage is the conventional desk with a score of more than 6.



Graph 10. Single score_Product Comparison.

Finally, the data observed in graph 10 of the single score clearly shows that the product that has the greatest impact on the planet, due to the different environmental damages and impacts it causes, is the conventional desk with a score of more than 8, while the multifunctional desk also presents the three categories of damage, but at a lower level with a score of 5.4. Therefore, there is an environmental improvement in the design of the multifunctional desk greater than 35%.

CONCLUSIONS

Once the relevant LCA results have been shown, it can be concluded, based on the comparison made, that in most of the elements analyzed, the conventional desk affects or involves greater impacts and damage, i.e., it represents a greater risk of environmental pollution. However, in the single score, graph 10, which is considered of greater importance and where the level of damage of each category of the two desks evaluated is presented, it can be observed how the category of damage to Resources represents the highest score in both products (50% in the The multifunctional desk and 75% in the conventional desk), followed by the category of damage to Human Health (45% in the multifunctional desk and 27% in the conventional desk) and finally the category of damage to Ecosystem Quality shows about 5% and 3% respectively. Achieving an overall environmental improvement, in the multifunctional desk, greater than 35%.

The main problem to be solved to minimize pollution and thus reduce the damage caused to human health, with 65% overall, and to resources with 30% overall, is the use stage, followed by the production, raw materials and end-of-life stages of the conventional desktop. While for the multifunctional desk, the main problem to be solved to minimize pollution and thus reduce the damage caused, mainly to Human Health with 50% overall, to Resources with 45% overall and to Ecosystem Quality with 5% overall, is the production process stage, followed the end-of-life and use stages, where the raw material impact is not significant.

In the case of the conventional desk, it is more practical to purchase because of its useful life, and it may seem a little strange at first glance because of the purchase of wood, but wood has a longer life cycle than cardboard. Where their reference flow says that for every commercial desk, approximately two cardboard-based eco-friendly multifunctional desks have to be used.

On the other hand, the price is a very important index in the choice of people and the economy of each person in a materialistic world. A commercial desk has a higher cost due to all the manufacturing process it has before going to the market, so the value is about 70% higher versus the ecological desk that is of lower cost. It can be said that it is an interesting game between the price and the life cycle of each one of them.

Finally, we that environmental impacts and their analysis is an extensive subject to be dealt with, that there are different computer tools for their analysis, and that it is necessary to make an inventory of the material that enters and leaves the system-product. Where the Simapro is a excellent tool that allows us to understand the relationship between environmental damages and impacts, costs, material qualities, among other benefits; which are the basis for decision making in the design of products and processes to achieve the desired sustainability.

BIBLIOGRAPHY .

[1] Escobar, A. Quintero, D. & Serradas D. (2006). Recycling as an instrument for Environmental Conservation Awareness. Unpublished thesis. Andrés Bello University. Venezuela.

[2] Parellada, R. (2012). Recycling, no laws are needed to promote it. Siglo XXI del 23 de agosto. Guatemala.

[3] Yánez, J. Y. (2012). Audits, Continuous Improvement and ISO Standards: key factors for the evolution of organizations. Actualidad y Nuevas Tendencias, 83- 92.

[4] AENOR. UNE-EN ISO 14040. 2006. Management Environmental. Life Cycle Assessment. Principles and Reference Framework. AENOR. Madrid, Spain. 32 p.

[5] ISO 14044:2006. Environmental management - Life cycle assessment - Requirements and guidelines. Retrieved from https://www.iso.org/obp/ui/es/#iso:std:iso:14040:ed-2:v1:en

[6] AENOR. UNE-EN ISO 14044. 2006. Management Environmental. Life Cycle Assessment. Requirements and Guidelines. AENOR. Madrid, Spain. 29 p.

[7] Capuz, R. S. & Gómez, N. T. (2003). Ecodesign Life Cycle Engineering for Sustainable Product Development. Mexico: Alfa Omega.

[8] Vivancos, J. L., Viñoles, C, R., Ferrer, G, P. & Capuz, R, S. (2008). ResearchGate. Retrieved from ResearchGate: https://www.researchgate.net/publication/312539292_ ANALYSIS_OF_DIFFERENT_HERRAMENTAL_INFORMATICS_ FOR_CYCLE_ANALYSIS. LIFE

[9] PRÉ CONSULTANTS BV. (2018). SimaPro. Retrieved from SimaPro: https://simapro.com/about/