Assessing the environmental profile of candles from used cooking oil

Carla Caldeira[1,*], Camillo De Camillis[2] , Pedro Serpa[1] , Dulce Boavida[3] , Filipe Duarte Santos[1]

[1]SIM-Systems, Instrumentation and Modeling, Sciences Faculty of Lisbon University, Lisboa Portugal

[2]Department of Sciences, University "G. d´Annunzio", Pescara, Italy

[3]National Laboratory of Energy and Geology, Lisboa, Portugal

*cscaldeira@fc.ul.pt

Abstract This paper presents the environmental profile of candles from used cooking oil. The environmental profile was identified by implementing and analysing results from the following methodologies: screening Life Cycle Assessment (LCA); Life Cycle-oriented methodology developed by the "Forum for the Future" and "The Natural Step" (i.e. Streamlined Life Cycle Analysis - SLCA); and audit against the Swan eco-label criteria specifically developed for candles. Normalization results of the screening LCA highlighted eutrophication, ecotoxicity, soil chronic and human toxicity as the most harmful impact categories. The SLCA showed some a good environmental performance in the early stages of packaging and distribution, use and end-of-life of the new candle. In the most of cases, the Swan eco-labelling criteria seemed to be fulfilled by the new candle. The only non-conformities might be related to the use fragrances and some missing chemical tests.

1 Introduction

Considering the significant amount of used cooking oil from households and restaurants, OON (Out Of Nature - Home Recycling Solutions SA., a Portuguese start-up company), has recently designed and developed the Candlemaker, an innovative solution to recover this waste stream. This small device, which is very similar to a coffee machine, transforms used cooking oil into candles. Each candle produced by the Candlemaker is composed of a pod - the Candlepod - and used cooking oil. The candle is placed into a recycled glass container, the Candleholder.

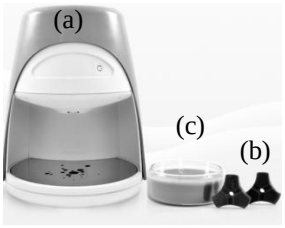

Fig.1: Candlemaker (a), candlepod (b) and candle in a candleholder (c)

Besides contributing to the reduction of impacts on ecosystems, normally generated by those households that erroneously discharge their used cooking oil in their kitchen sinks, OON aims at supporting a new concept of recycling, i.e. "do it yourself". This concept might render people more aware of the amount and value of waste streams they produce.

According the European Association of Candles Producers, the consumption of candles in Europe is circa 1.1kg a year per capita [1]. In contrast to the majority of ordinary candles generally made of paraffin (hydrocarbon obtained from petroleum cracking), candles from the Candlemaker are mainly (i.e. circa 80% composition) made of recycled used vegetable cooking oil. Besides being an option for reusing such a waste stream, new candles are almost carbon neutral because the carbon realised over their life was originally absorbed by plants. The The Candlemaker device is mostly made from recycled/recyclable materials. Although designers took care of the environment in developing this product, an environmental assessment was conducted in a later stage in order to identify the key hotspots over the product life cycle and, on this basis, keep on improving the original product. For this purpose, the following three assessment methodologies were implemented:

- Screening Life Cycle Assessment (LCA);

- Life Cycle-oriented methodology developed by the "Forum for the Future" and "The Natural Step" [2];

- audit against the Swan eco-label criteria specifically developed for candles [3], [4].

2 Screening LCA

A screening Life Cycle Assessment (LCA) was conducted given the difficulty in obtaining background data for a full LCA. The assessment was performed attempting to follow ISO 14044 requirements [5]. Some methodological choices are reported hereafter.

2.1 Goal and scope

2.1.1 Goal

This study aims at identifying the environmental performance of candles produced by Candlemakers, and to find out the key hot spots over their life cycle. A comparison with paraffin-made candles is carried out instead of comparing recovery options of used cooking oil. The study is going to be used by the manufacturer to identify the product environmental performance, and to outline improvement actions over the product life cycle.

2.1.2 Functional unit and reference flow

The study was conducted on a 125ml candle produced by the Candlemaker and able to generate up to 25 hours of light.
The product has been developed since 2007. Information used for this study come from the product launched in the market in 2010.
Although the Candlemaker is marketed all around Europe, the scope of this study was bounded to Portugal only. This choice had relevant implications on selecting the reference energy mix dataset for the use stage, and the modelling of the product end-of -life.
To relate Candlemaker production-related data to the functional unit of candles from used cooking oil, it was necessary to calculate how many candles a Candlemaker is able to produce over its life span. More specifically, this evaluation was based on: the overall quantity of used cooking oil produced per capita in Portugal [6]; an average of three people per habitation [7]; eight years as estimated Candlemaker life span; and 1600 pieces as expected production of candles over its life span.
Moreover, each glass-made Candleholder was considered to be used 100 times (i.e. for 100 candles).

2.1.3 Systems boundaries and allocation

The system studied is shown in Figure 2. No allocation was carried out.

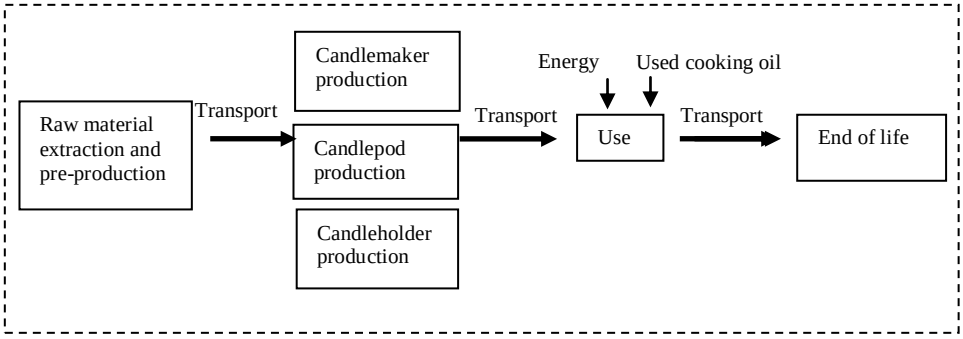

Fig.2: Product system

2.2 Inventory analysis

Product specific data (origin of materials, weight and transport) were mainly provided by OON. The inventory was mainly set up by using generic data from Simapro databases. More specifically, key data features in terms of sources, assumptions, and simplifications are illustrated in Table 1.

Tab.1: Key data features per life cycle stage.

Life cycle stage	Data features
Raw material extraction and production	As data were not available for some materials and process units, a comparison by type of material and production was made in order to replace the missing data with similar products and/or production processes.
Candlemaker production	A Candlemaker is made of several components coming from several Countries, and then assembled in Portugal. 95% w/w of the product materials was considered. Concerning the production process of components, only the production of plastic parts (85 % w/w) was considered in the study. Assembly process was not included in this study; only the materials used were assessed.
Candlepod production	A Candlepod is made of a mix of four reagents, colour and scent. Production processes of the latter two elements were left out the study due to a lack of data. Although these elements represent only 0.96% (w/w) of the final candle weight, the use phase of colour and scent was modelled on the base of data from the safety sheets of these products. Secondary data were used for the production of reagents.
Candleholder production	Only (recycled) glass production data were included in the system.
Transport	Component types and their origin were used as key data to model transport processes. Distance (in Km) was obtained by using a journey calculator available in the Internet.
Use	As used oil is a waste stream, all the upstream process were not considered. Burning of candles was excluded because gaseous emissions were not measured and a significant uncertainty is expected due to the wide range of used cooking oil mixes. The Portuguese energy mix was chosen as reference energy production mix.
Final Disposal	The end of life was modelled on the basis of the current situation in Lisbon (i.e. incineration of candle residues; recycling of candleholder-glass; recovery of Candlemakers by waste management companies specialised in material recycling (plastic, metals and packing materials where considered).

2.3 Impact assessment

The EDIP methodology was applied for the impact assessment phase [8].
According to this methodology, normalisation was carried out per person equivalent.. Normalised results of the impact assessment shown in Figure 3 indicate eutrophication, ecotoxicity soil chronic and human toxicity as the most harmful impact categories. In particular, most emissions related to the latter two categories come from the production of reagent A (used in the Candlepod production), whilst eutrophication-related burden mostly come from the production of the component B, used in the Candlemaker.

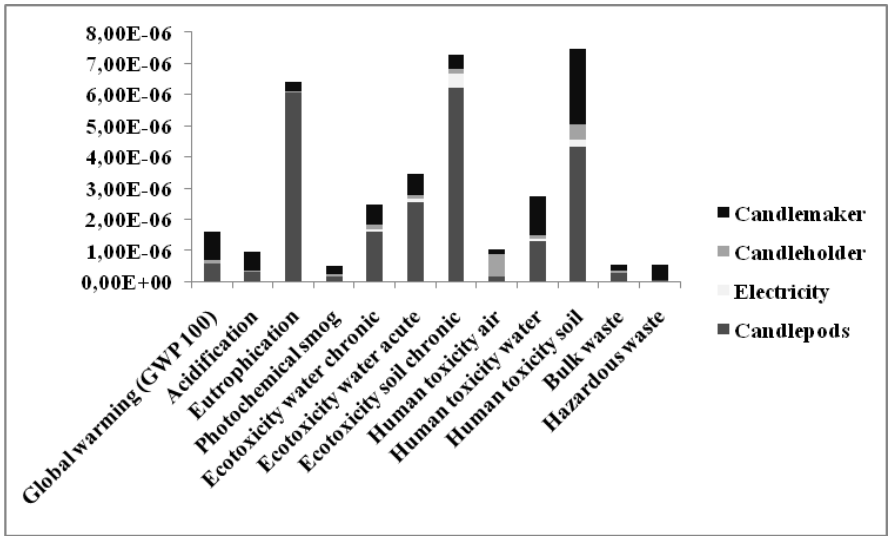

Fig.3: Candles from used cooking oil: normalization results in person equivalent.

By comparing the environmental performance of candles from used cooking oil with those from paraffin, both produced by the Candlemaker, it emerged that the first ones are less polluting over the most environmental impacts with the global warming performance being roughly half the one produced by paraffin made candles (see Figure 4).

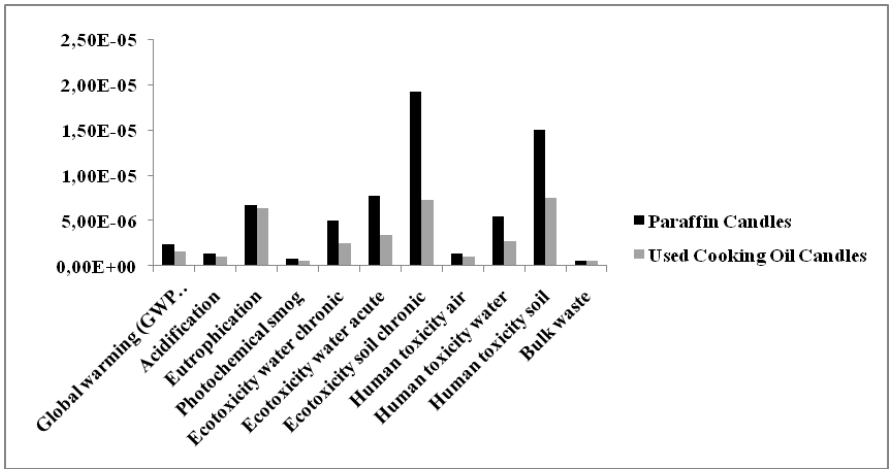

Fig.4: Candles from used cooking oil vs paraffin made candles: normalization results in person equivalent.

2.4 Interpretation

A screening LCA was run in order to have a preliminary overview of the environmental performance of candles from used cooking oil.
A more detailed LCA study might be advisable to study in detail specific aspects that have been left out the study so far. These aspects, such as e.g. gaseous emissions of candles during their use phase and environmental credits from used cooking oil recovery, might affect the study results significantly.

3 Life cycle-oriented methodology

In order to compare the environmental performance results from the screening LCA with those from a simpler methodology, a Life Cycle-oriented methodology was also applied to the product system. For this purpose, we used a tool called Streamlined Life Cycle Analysis (SLCA) and developed by the "Forum for the Future" and "The Natural Step". Such a tool is based on a set of system conditions (SC) claimed to ensure sustainable choices over the product life cycle [2].
These SCs focus on the following environmental issues:

- SC1, natural resource depletion;
- SC2, eco-toxicity;
- SC3, other impacts on eco-systems (e.g. desertification, deforestation, landscape disruption);
- SC4, inability of people to meet their own needs [2].

To apply this methodology a detailed analysis of the product system was carried out. This implementation implied, inter alia, a survey whose results formed the baseline of a matrix concerning the environmental performance of candles from used cooking oil (see Figure 5). This matrix enables to identify possible week points of the system.

	Raw materials	Production	Packaging and distribution	Use and related processes	End of life
SC1					
SC2					
SC3					
SC4					

LEGEND

Good System condition met	Quite good System condition mostly met	Ok System condition on the way to be met	Quite bad System condition mostly not met	Bad System condition not met	Unknown Insufficient knowledge to draw conclusions

Fig.5: SLCA Matrix

The SLCA matrix shows new candles to be characterised by a good environmental performance in the early stages of packaging and distribution, use and end-of-life. Available information are not sufficient to draw any conclusion about raw material supply and candle production. Further aspects need to be investigated, especially those related to the energy mix and material recovery in the production phase.

4 Swan ecolabel

Swan eco-label criteria were developed for candles in 2007 by the Nordic ecolabelling. The main goals of this label is to reduce the emission and effect of substance harmful to users health and the reduction of gases having and impact on climate change [3]. According to this scheme, 19 out of 28 are environmental requirements [4]. A screening audit was run against environmental requirements to find out where candles from used cooking oil stand in relation to such an excellence eco-labelling scheme (see Table 2).

Tab.2: Findings from the audit report.

Environmental requirement	Conformity
R1 Description of the candle	Yes
R2 Description of chemical additives and coatings	Yes
R3 Amount of raw material from renewable resources More than 90% of the total weight of candles shall be attributable to materials from renewable resources	Yes
R4 Renewable resources Wax from renewable resources (e.g. palm tree oil) shall have no implication in any forest environment meriting protection due to high biological and/or social value	Yes
R5 Carbon dioxide balance related to vegetable raw materials Production of vegetable raw materials shall have either a positive or a neutral carbon balance	Analysis to be performed
R6 Soot index The soot index mean of 3 tests shall be less than 1.0 per hour. No individual sample shall exceed 2.0 per hour	Tests to be performed
R7 Chemicals, substances, preparations, additives, lacquers and dyes The use of chemicals, substances, preparations, additives, lacquers and dyes that are assigned or may be assigned at the time of application to any of risk phrases established, containing more than 0.01% by weight of substances , are prohibited.	Yes

Tab.2 : Findings from the audit report (continued)

R8 Azo dyes and azo lacquers Azo dyes and azo lacquers that may belong to any of a table of the aromatic amines exceeding a concentration of 30ppm shall not be used	Analysis to be performed
R9 Heavy metals None of the following heavy metals must be added to any part of the candle: Mercury (Hg), Lead (Pb),Cadmium (Cd), Zink (Zn), Copper (Cu), l Nickel (Ni), Cobalt (Co), Antimony (Sb) and Chrome (Cr)	Yes
R10 Aromatic solvents Aromatic solvents must not be used in the production of candles	Yes
R11 Halogenated solvents Halogenated solvents must not be used in the production of the candle	Yes
R12 Total amount of organic solvents The content of organic solvents must not exceed 1% by weight of the candle	Analysis to be performed
R13 Fragrance Any kind of fragrance or aroma shall not be added in candles in order to attribute a certain scent	No
R14 Phthalates The candle must not contain any kind of phthalates	Yes
R15 Other parts All other parts like cups and containers encircling the candle and sold together with the candle shall be biodegradable	Yes
R16 Wick The wick shall not contain any kind of metal, and the cotton must be öko-tex 100 certified	Yes
R17 Product and packaging Products and packages (including labels) containing PVC or other plastic containing chlorinated material must not be used. Product package must not exceed 5% of the candles weight	Yes
R18 Information to the consumer The consumer must be informed about the burning time of one candle. Either written information on the packaging or with a text placed nearby the candles where they are sold. Companies shall follow EN 15494 for product safety labels and warnings	To be implemented
R19 Fire safety Companies must follow the EN 15493 standard for fire safety. If other materials (see R15) are connected to the candle it must be documented that such materials do not pose a risk on fire safety	To be implemented

The Swan eco-labelling requirements seem to be met by the new candle in the most of cases. The only non-conformities are related with the requirement on the fragrance use. Some requirements require further chemical tests to draw any conclusion, and other requirements are to be implemented (R18 and R19).

5 Conclusions

Normalization results of the screening LCA have highlighted eutrophication, ecotoxicity soil chronic and human toxicity as most harmful impact categories. In particular, most emissions related to the latter two categories come from the production of reagent A (used in the Candlepod production), whilst eutrophication-related burden mostly come come from the production of the component B, used in the Candlemaker. By comparing the environmental performance of the candles from used cooking oil with those from paraffin, both produced in the Candlemaker, it emerged that the first ones are less polluting over the most environmental impacts with the global warming performance being circa half the one produced by paraffin candles.

The SLCA matrix indicates that the new candle has a good environmental performance in the early stages of packaging and distribution, use and end-of-life. However, no conclusion can be drawn on raw material supply and candle production due to a lack of information.

Most Swan eco-labeling requirements seem to be fulfilled by the new candle. The sole non-conformities might be reported on the fragrance use and those criteria requiring additional tests.

6 References

[1] Association of European Candles Manufacturers, <www.europecandles.com>, (Accessed 02.09.2010).

[2] Streamlined Life Cycle Analysis Tool (SLCA)- Assessing the Sustainability of Products, <http://www.naturalstep.org/>, (Accessed 26.11.2010).

[3] Nordic Ecolabelling, "About Swan Labelling of Candles" September 2007.

[4] Nordic Ecolabelling "Swan-labelling of Candles Nordic Ecolabelling" Version1.0 December 2007 –December 2011.

[5] ISO 14044:2006 International Organization for Standardization, "Environmental management – Life Cycle Assessment – Requirements and Guidelines".

[6] Inovação e Projetos em Ambiente, IPA, "Actualização da Situação de Base para o Sector de Gestão e Valorização dos Óleos Alimentares Usados ", Portugal, 2006.

[7] National Statistics Institute Portugal, <www.ine.pt>, (Accessed 15.09.2010).

[8] Wenzel, H.,Hauschild, M. and Alting, L., "Environmental Assessment of products", Volume 1, Kluwer Academic Publishers, 1997