Environmental Evaluation of Single-Use and Reusable Cups

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Abstract

Goal, Scope and Background. The objective of the study was to determine the environmental effects of the reusable cup used during a major event (which took place in Barcelona, Universal Forum of Cultures, 2004), compared with a single-use cup of the same composition (polypropylene) but with different physical characteristics such as mass, shape and capacity.

Methods. To perform the environmental evaluations and the comparison of both types of cups, the SimaPro software developed and marketed by Pré Consultants was used. The environmental evaluation of the reusable cup was compared with that of a single-use cup using the LCA methodology [6]. The functional unit used was: 'Serving 1000 liters of draught beverages'. The objective of the study was to find the minimum number of cycles the reusable cup has to do so that its environmental impact is smaller than that of the single-use cup.

Results and Conclusions. Taking into account all the hypotheses put forward, the study drew the conclusion that the minimum number of uses of the reusable cup necessary for it to have a smaller environmental impact than the single-use cup is 10.

In this paper the environmental evaluation of the reusable cup is performed and it is compared with a single-use cup, using the Life Cycle Assessment (LCA) methodology [6]. The contribution of each process taking part in the entire life cycle of the cups was also studied in detail. In the case of the single-use cup, the most important contribution to all the impact categories is due to the production of polypropylene and the fabrication of the cup, except for the heavy metals category where it is due to the management of the waste coming from the cup’s use.

In the case of the reusable cup being used 10 times, the contribution to the different impact categories of the waste generated by the cup’s use is negligible compared to the contribution of the fabrication and washing processes. In addition, the washing process is the one which contributes most to the ozone layer depletion, heavy metals and carcinogens categories.

As the number of uses of the reusable cup increases, the contribution to all the environmental impact categories decreases. However, this reduction is not as significant for the ozone layer depletion, heavy metals and carcinogens categories. This is due to the washing process and the fact that the electrical consumption associated with it increases with the number of washing and, consequently, of uses.

Recommendations and Perspectives. From the environmental point of view, the reusable cup must be used at least 10 times to have less impact than the single-use cup. This is mainly due to the higher weight of the reusable cup and, therefore, the greater amount of raw material needed for its fabrication. If the LCA methodology had been introduced during the design of the reusable cup, its weight would have been lower. This modification would have resulted in a reduction of the environmental impact associated with the use of the reusable cup and, consequently, a smaller number of uses would have been necessary to attain the same level of impact as the single-use cup.

Introduction

One of the most important challenges brought by the new sustainability culture is to develop production and consumption habits more respectful of the environment and, by doing so, to move towards a more responsible consumption model based on efficient use of natural resources during their extraction, transport, processing, use and disposal phases. Among the types of waste that have increased most over the last years, containers and container waste require major attention because of their weight, volume and the aspects associated with their fabrication and disposal. One possible way to reduce waste creation is to use reusable cups in large events.

In this paper the environmental evaluation of the reusable cup is performed and it is compared with a single-use cup, using the Life Cycle Assessment (LCA) methodology [6].

Using LCA methodology, some authors compare or analyze different packaging materials used for distribution of consumer goods [4,11,13]. Other studies assess the reuse and recycling environmental advantages of the plastic packaging materials [10], or the environmental advantages of the reuse versus one-way glass packages [12].

It is difficult to find studies that analyze the environmental benefits of a product like the Forum cup. This kind of cup is only used for a short time period, that is only used during a specific event.

A project funded by the European Commission under the Life Program called ‘Smash events’ recommends supplying the drinks and food with reusable crockery in order to significantly reduce the amount of waste created during the event. On this project there is not any LCA study in which we can observe the real environmental benefit of this action [3].
1. Description of the Systems and Limits

The system of study for the single-use cup is, practically, of a linear type, which means it does not contain internal loops. The system's steps are: extraction of raw material and its processing, fabrication of the product, delivery, use and elimination. It must be taken into consideration, since they are cups intended for food consumption, that it is impossible to use recycled polypropylene for their fabrication.

The system on study for the reusable cup has an internal loop located at the use step, where the possibility of reusing the previously cleaned cups is considered.

Different scenarios will be considered depending on the work hypotheses that will be seen in section 2 of this paper.

The subsystems being studied are:
- The polypropylene's (PP) production processes.
- The cups' fabrication processes, including facilities' consumption for producing the cups.
- Transport from the factory to the store located in the village of Sant Esteve Sesrovires.
- The use of the cup, taking into consideration different scenarios concerning the reuse of the reusable cup.
- Waste management.

In the case of reusable cups, the acid engraving phase was not taken into consideration because no data were available. If we would have considered this phase, a larger environmental impact associated with the fabrication of reusable cups would be obtained. This fact would imply a greater number of reusable cup uses to have less impact than the single use cup.

A priori, the number of uses or cycles of the reusable cup are not known. That is why different scenarios will be studied. The objective of this study is to determine at which number of cycles of the reusable cup it starts to have a lesser environmental impact than the single-use cup.

1.2. Definition of the system's function and functional unit

The only function developed by the system is to contain beverages. The basic difference between the two types of cups studied is the reusable character of the cup used at Forum 2004.

The functional unit has to be the same for both systems in order to be able to compare them. The functional unit is 'serving 1,000 l of beverage' and this means a different number of cups for each specific type of cup.

In Table 1, the physical characteristics of the two PP cups are shown.

2. Methodology of the Study

The impact of the two types of cups will be studied, with different numbers of cycles for the reusable cup. In Table 2, the studied scenarios are shown.

Next, the data associated with the fabrication subsystem for the cups needed to distribute 1,000 l of draught beverages (5,000 cups = 5,000 uses), as well as the data associated with the fabrication of the reusable cups needed to serve 1,000 l of draught beverages (3,333 uses) are shown (Table 3).

Table 1: Physical characteristics of the cups

<table>
<thead>
<tr>
<th>Physical characteristics</th>
<th>Single-use cup</th>
<th>Forum cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (ml)</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Weight of a cup (g)</td>
<td>3.20</td>
<td>44.89</td>
</tr>
<tr>
<td>Number of cups needed to serve 1,000 liters of draught beverages</td>
<td>5,000</td>
<td>3,333</td>
</tr>
<tr>
<td>Weight of cups (kg) equivalent to 1,000 l beverage distribution</td>
<td>16.00</td>
<td>149.63</td>
</tr>
</tbody>
</table>

Table 2: Scenarios studied for the Forum cup

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 uses (1 cleaning)</td>
<td>9 uses (8 cleanings)</td>
<td>10 uses (9 cleanings)</td>
<td>14 uses (13 cleanings)</td>
</tr>
</tbody>
</table>

Table 3: Inventory table associated with the fabrication of the cups to distribute 1000 l of beverage assuming one use by cup

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Single-use cup</th>
<th>Forum cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kWh)</td>
<td>21.03</td>
<td>97.2</td>
</tr>
<tr>
<td>Water (l)</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Raw material (kg)</td>
<td>16.50</td>
<td>166.67</td>
</tr>
<tr>
<td>Cardboard boxes</td>
<td>1.45</td>
<td>7.00</td>
</tr>
<tr>
<td>PP sheet</td>
<td>0.31</td>
<td>0.00</td>
</tr>
<tr>
<td>Colorant</td>
<td>0.00</td>
<td>2.67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outputs</th>
<th>Single-use cup</th>
<th>Forum cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product (kg)</td>
<td>16.00</td>
<td>149.63</td>
</tr>
<tr>
<td>Emissions into the air (kg C)</td>
<td>0.63</td>
<td>5.95</td>
</tr>
<tr>
<td>VOC</td>
<td>Not being considered</td>
<td>0.00</td>
</tr>
<tr>
<td>Emissions into the water (mg)</td>
<td>Paper/cardboard</td>
<td>0.023</td>
</tr>
<tr>
<td>PP</td>
<td>0.010</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Since there is a great variety of models for this type of cup, one of the most standard was taken. Cardboard boxes with dimensions (cm): 35.9 x 28.8 x 58.5 (length x width x height) and with a delivery capacity for the boxes of 2000 units of cups.**

**Since there is no value of VOC emission for the Forum cup, it was estimated from data of the single-use cup.**

**There is no water consumption during the fabrication and the only waste waters are the sanitary ones. Since the volume of that type of water depends basically on the number of workers, i.e. the size of the company, it was assumed that both cups are fabricated by companies with an equal number of workers.**