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GP: Comparative LCA of alternative packaging materials for beverage

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Introduction

Packaging makes an important contribution to the impact of the final product on the environment. What's more: often the life cycle of packaging is even longer than the product itself and exhibits greater environmental impacts than the product.

Therefore, packaging is one of the more intensively studied areas of life cycle assessment (LCA). These analyses can be used to evaluate the environmental impacts of packaging throughout the life of the packaging, from the extraction of raw materials through the processing of materials, production, distribution, use, repair and maintenance, to possible disposal or recovery.

With LCA analysis, we can determine which are the key process stages of a product that have the greatest impact on the environment. Because the analysis focuses on the entire life cycle, this prevents the burden of the environment from shifting from one phase of the life cycle to another (e.g. from production to production of raw materials).

Introduction

LCA analysis is increasingly recognized as a tool for improvement and innovation and a way to reduce environmental impacts. In line with trends, we expect that the use and thinking about LCA in leading Slovenian companies will intensify in the coming years. Those companies that have already set out to carry out an LCA analysis often face a number of practical issues regarding the implementation itself. Therefore, with this study, we want to promote LCA analysis as currently the best method for assessing environmental impacts and mitigate the complex image of such analysis.

The purpose of this practice is to assess the potential environmental impact of disposable beverage packaging available on the Slovenian market.

Goal

The goal of this practice (Krajnc *et al.*, Faculty of Chemistry and Chemical Engineering, University of Maribor, 2019) is to present assessment of the potential environmental impact of the following packaging systems:

- polyethylene terephthalate (PET) bottles,
- glass bottles (GL) and
- aluminium cans (ALU).

The functional unit of the study was defined as the packaging, necessary for filling and distribution of 1000 L of filled beverage.

The reference flow of a product system included the actual beverage packaging, labels and closures, transport packaging (reusable bottle boxes, corrugated trays, shrink-wrap for disposable containers, pallets).

Six indicators of potential environmental impacts were considered in the analysis: global warming potential, ozone depletion, photochemical oxidation, acidification, eutrophication and non-renewable energies.

Source: D. Krajnc, Z. Novak Pintarič, Z. Kravanja, 2nd Int. Conf. „Technologies & Business Models for Circular Economy“, Proceedings, 16 pp., 2019.

System boundaries of the assessed system

The geographical boundary of the study is within the typically used production processes and waste management within the EU. The study assesses the potential environmental impacts for the entire life cycle of each packaging system, often referred to as the “cradle to grave” approach. This means that the packaging systems included all stages from the extraction of raw materials to the final processing of the waste.

The evaluated waste management processes were disposal, recycling and incineration (heat treatment).

System boundaries of the assessed system

The system boundary of the study includes the following stages of the life cycle:
• production of primary packaging, including bottles, aluminum sheets, PET bottles, aluminum and polymer caps (HDPE), kraft paper and polypropylene (PP) labels; manufacture of secondary packaging materials, including corrugated board, kraft paper, low density polyethylene (LDPE) and wooden pallets;
• waste management: recycling and waste disposal;
• transport of raw materials, packaging material and transport of beverages to the retailer along the life cycle.

It is important to distinguish between the packaging and the product that the packaging includes. In this analysis, the production of the product itself, i.e. beverages were not included in the analysis. This means that the process of filling of beverages has not been studied either.

Resources needed

Data have been sourced from Ecoinvent 3.2 and ILCD databases as well as beverage manufacturers and literature. OpenLCA software tool have been used for LCA modelling.

The environmental impacts have been estimated according to the CML 2001 method.

The study has been carried out following the ISO 14040/44 life cycle assessment (LCA) methodology.

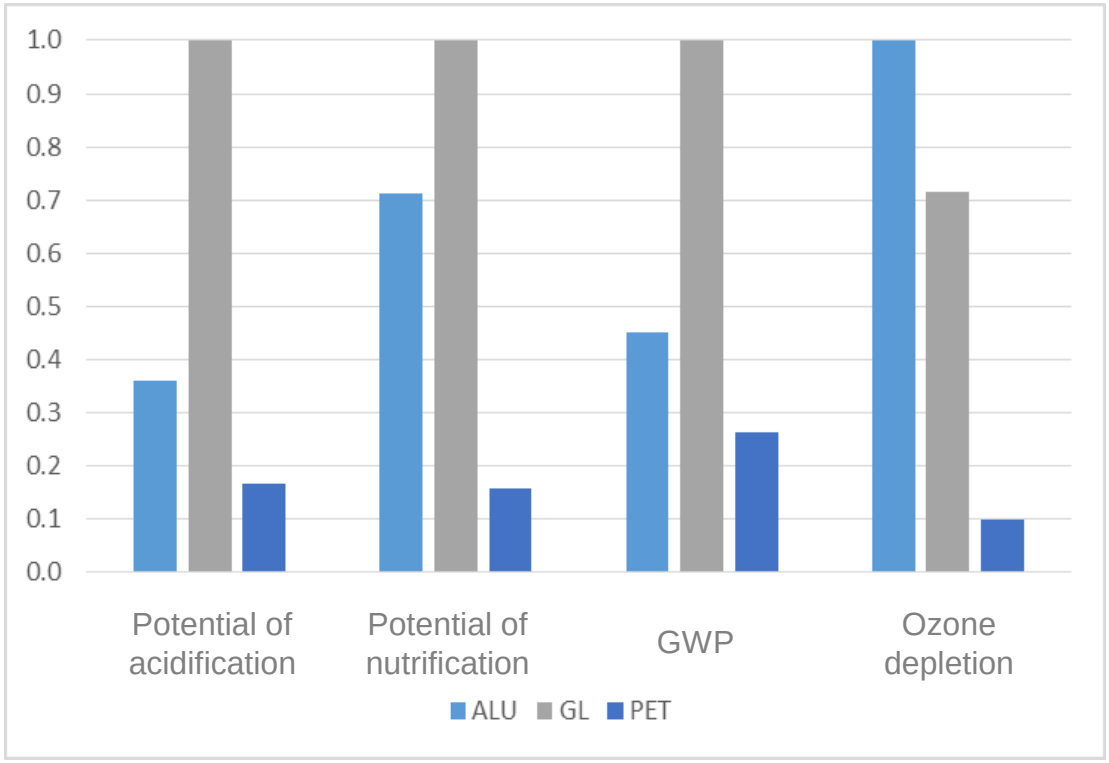
Results

In this example of good practice, the effects of three packaging systems for the distribution of 1000 L filled beverages (used cans, bottles and bottles with a single 0.5 L filled unit) were evaluated.

The study shows that the production phase is the one that contributes the most to the overall environmental impacts of the global warming potential (around 90 %), so it is necessary to pay the most attention to this phase and plan packaging in accordance with eco-design guidelines. The main factors of this result are the type and amount of material used. There is a likely link between bottle weight and environmental impact. However, this connection is not true for aluminum cans, which are the lightest in terms of weight, but still show a greater environmental impact than PET bottles. It should be noted that the single-use system has been assessed as one of the most common practices in the world. If the returnable bottle system were taken into account, the bottles would probably show lower environmental impacts, but the returnable bottle system should take into account additional bottle cleaning processes, return transport, etc.

The performed analysis shows that PET bottles are the least stressful among the evaluated systems, followed by aluminum cans and finally non-returnable bottles. Also, it can be observed that the end-of-life and transport phases affect the final values of the indicators less than expected.

Results

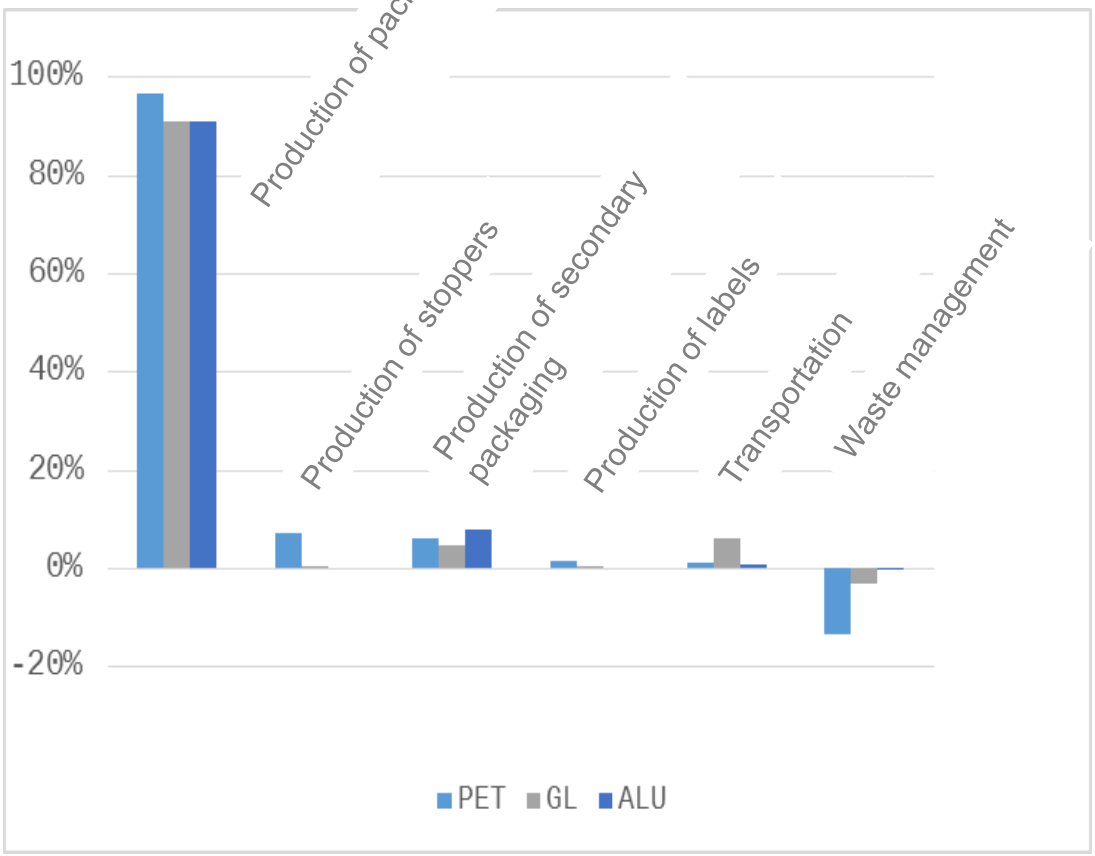


Comparison of analyzed packaging systems for individual environmental categories (relativized results).

Bottle production contributes most to impacts in almost all of the impact categories assessed (except in the ozone depletion category, where can production has a greater impact). This is due to the large mass of the bottles and the energy-intensive process of maintaining the high temperatures required in the kilns. Bauxite used as a source of canned aluminum, is a major source of the ozone depletion indicator. PET bottles show the lowest environmental impact in all categories. Their smaller influences can be attributed to the smaller influences of material and manufacturing and their mass. This also reduces the effects of end-of-life transport and disposal.

Based on these results, it can be concluded that the process of making glass bottles has the greatest impact on the environment, as it contributes the most to almost all categories of environmental impacts. They are followed by the production of aluminum cans.

Results



Contributions of individual process phases to global warming potential (GWP).

This figure shows the contributions of individual process phases to the global warming potential (GWP). The individual phases are divided into the production of packaging, stoppers, secondary packaging, labels, transport and waste management.

Extraction of raw materials and their processing into primary packaging contributes the most to the environmental profile of beverage packaging systems. It follows that in the environmental planning of packaging, great attention must be paid to the choice of packaging material. Nevertheless, the production of secondary packaging is also important. Furthermore, it can be observed that the end of life and the transport phase affect the final values of the indicators less than would be expected.

Challenges encountered

The following were excluded from the system boundaries due to lack of data: ink used and printing process, impacts in the home use phase and losses through the supply chain.

Furthermore, the following activities were excluded from the system boundary due to lack of data:

- production and packaging of beverages and their ingredients,
- mass flows contributing less than 1 % to total mass flows,
- transportation of consumers to buy a drink and any storage at the consumer.

Therefore, lack of above-described data has presented challenges to fully perform the presented study.

Potential for learning or transfer

This GP demonstrates a good example how the principles of LCA methodologies can be implemented regarding an impact of drink packaging on the environment. Therefore, by following the outcome of this research the public authorities could encourage companies and citizens of requesting from them to preferentially use environmentally friendly PET bottles, which would in turn minimize the environmental burden.

In the research cooperation of the Faculty of Chemistry and Chemical Engineering, University of Maribor, with Slovenian companies an increasing interest was noticed in conducting a life cycle assessment (LCA) of a selected product or the entire company.

The value of the contribution was not only in the obtained results of the analysis, but also to contribute supporting information for easier and more intensive use of LCA analysis. This will provide companies with an instrument to support packaging policy decisions and make it easier to choose between different packaging options with comparable properties.

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Thank you!

Questions welcome

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