Biblid: 1821-4487 (2013) 17; 4; p 173-175
UDK: 514.174

Original Scientific Paper
Originalni naučni rad

COMPARISON OF LIFE CYCLE ASSESSMENT FOR DIFFERENT VOLUME POLYETHYLENE PACKAGING ON THE ENVIRONMENT
POREĐENJE UTICAJA ŽIVOTNOG CIKLUSA POLIETILENSKE AMBALAŽE RAZLIČITIH ZAPREMINA NA ŽIVOTNU SREDINU

Vera LAZIĆ, Nevena KRKIĆ, Danijela ŠUPUT, Senka POPOVIĆ
University of Novi Sad, Faculty of Technology, 21000 Novi Sad, Bulevar cara Lazara 1, Serbia
e-mail: nevenakrkic@gmail.com

ABSTRACT

In this paper, environmental impact of polyethylene tubes of different volumes: 30 mL and 100 mL was assessed using the life cycle assessment. The data were collected on the types and amounts of the materials and energy consumption in the process of packaging and distribution and inserted in the software GaBi 5. Total mass life cycle inventory was considerably lower for the smaller volume packaging. Breaking the inventory to the single flows, it was found that in both life cycles (polyethylene tubes of 30 mL and 100 mL) the highest contribution had the flows of fresh water consumption, emission of inorganic elements to the air and fresh water polution with waste water flows. The highest contribution to all of these flows was shown to be production and consumption of diesel fuel. The results of this paper show that in analised case, more environmental friendly is the larger volume packaging.

Key words: *packaging, polyethylene, life cycle assessment, environment.*

REZIME

U ovom radu je ispitan uticaj polietilenskih tuba različitih zapremina: 30 mL i 100 mL na životnu sredinu,upotrebom alata za analizu uticaja životnog ciklusa. Prikupljeni su podaci o vrstama i količini materijalnih i energetskih resursa koji se koriste u procesu pakovanja i distribucije i ovi podaci su uvršteni u softver GaBi 5. Ukupni maseni inventar životnog ciklusa je bio značajno niži za ambalažu manje zapremine. Razlaganjem ukupnog inventara na pojedine tokove, uočeno je da su u oba životna ciklusa (polietilenske tube od 30 mL i 100 mL) najveći udeo u ukupnom inventaru imali tokovi potrošnje sveže vode, emisije neorganskih elemenata u vazduh i zagađenje sveže vode otpadnim vodotokovima. Najveći doprinos svim navedenim tokovima za ambalažu obe ispitivane zapremine je pokazao proces proizvodnje i potrošnje dizel goriva. Rezultati ovog rada pokazuju da,u analiziranom slučaju, manji negativni uticaj na životnu sredinu ima ambalaža veće zapremine.

Ključne reči: *pakovanje, polietilen, analiza uticaja životnog ciklusa, okolina.*

INTRODUCTION

Packaging has the basic function to recieve the product and protect it adequatly until its use. Depending on the packed product, conditions that packaging should satisfy can be different. Besides the basic condition for preservation of integrity and quality of the product, packaging should answer to many other demands, such as: technological, economical, marketing and ecological adventages. It is a practice to choose packaging as a compromise among stated demands (*Lazić and Novaković, 2010; Robertson, 1993*).

In food industry (diary, confectionery and other food products), polyethylene packaging finds broad application in the form of: cups, bottles, tubes, bags and foils for overpacking. Likewise, polyethylene is being used in considerable amount in multi-layered and combined packaging materials for food industry application (*Pringer and Baner, 2000*).

After consuming the product, its packaging becomes packaging waste. Industrialization, high technology and consumer demand for safe products led to the problem of large quantities of used, discarded packaging (*Lazić et al., 2010*). Besides the packaging waste, packaging affects the environment in all the phases of its life cycle. The life cycle of packaging includes many phases, starting from the raw materials production and delivery, packaging material production, packaging preform formation and processing, delivery of the packaging material or packaging, packaging formation, filling and closing, storage, distribution and delivery to retail and in the end of the cycle, processes of separation, recycling and disposal (*Kirwan and Strawbridge, 2003*). Using the method for life cycle assessment (LCA) it is possible to evaluate the impact of packaging production, use and disposal on the environment. Apart from the possibility of evaluating the environmental impact, LCA analysis method allows the comparison of similar packaging, which makes it even more important. This comparison is possible between systems of similar packaging, such as the original packaging and reduced weight packaging or packaging of different volumes. In such cases, life-cycle assessment is used to quantify the effects of these differences (*Sonneman et al., 2004*). In this paper, environmental impact of polyethylene tubes of different volumes: 30 mL and 100 mL was assessed using the life cycle assessment. The results of this paper shows that in analised case, more environmental friendly is the larger volume packaging.

MATERIAL AND METHOD

In this study, 30 mL polyethylene tube (PE 30) and 100 mL polyethylene tube (PE 100) were supplied from the distance of 100 km. Masses of empty tubes were: 7.6 g for PE 30 and 16.0 g for PE 100. The process of packaging in polyethylene tubes of different volume: 30 mL and 100 mL is shown in the fig. 1. The process starts with filling of the product into the tubes, using the filler machine with the power of 8.5 kW. The filing speed depends of the packaging volume. For the PE 30 filling speed was 56 pieces/min, while for the PE 100 this speed was 28 pieces/min. Following step was packing of filled tubes into the polyethylene bags. Tubes were packed 6 pieces per bag, but bag dimensions and mass depended on the tube volume. For PE 30 bag dimensions were 165x330x0.03 mm, while for PE 100 they were 240x330x0.03 mm. Polyethylene bags were sealed using sealing machine with the power of 5 kW. Polyethylene bags were supplied from a local supplier (transport was not included in the study). After being sealed in the polyethylene bags, PE 30 and PE 100 were packed in cardboard boxes, supplied from a local supplier (transport was not included in the study). Cardboard boxes for packing of PE 30 and PE 100 had dimensions of 307x186x144 mm and 335x235x170 mm, respectively. PE 30 and PE 100 were then transported to the supermarkets which are located 150 km away. Transport was done by the vehicle running on Euro diesel with the fuel consumption of 6 L /100 km.

Based on all the collected data, three elements of life cycle assessment were calculated:

1. Functional unit was chosen to be monthly sales of the packed product for the two biggest consumers. Mean value of the sales for three months was taken and it was 52 500 mL of the product.
2. Reference flow was determined as the number of PE 30 or PE 100 which was needed to deliver the quantity of the product described by the functional unit to the consumer. For PE 30 and PE 100 reference flows were 1750 and 525, respectively.
3. Product system and system boundaries were determined (shown in the fig. 1).

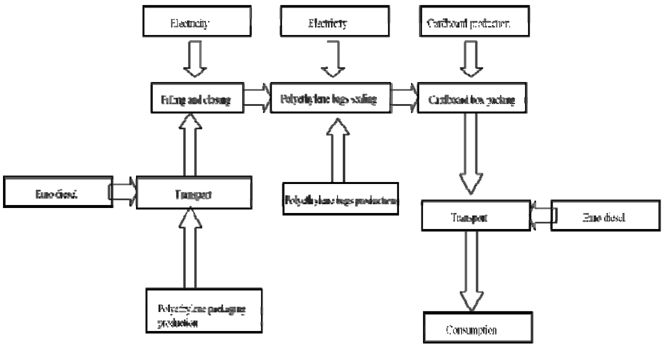

Fig. 1. Lifecycle scheme for PE 30 and PE 100

For the LCA analysis, software GaBi 5 was used. For the life cycle processes: electricity production, polyethylene packaging production, Euro diesel production, polyethylene bags production and cardboard production, the data were used from the software program GABI 5.

RESULTS AND DISCUSSION

In this paper, environmental impact of polyethylene tubes of different volumes: 30 mL and 100 mL was assessed using the life cycle assessment software GaBi 5. Total mass life cycle inventory was considerably lower for the larger volume packaging, compared to the smaller volume packaging. Breaking the inventory to the single flows, it was found that in the both life cycles (PE 30 and PE 100) the highest contribution had the flows of fresh water consumption, emission of inorganic elements to the air and fresh water polution with waste water flows (*fig 1*). It can be seen in *fig 1* that for all the flow categories presented, PE 100 had

lower values of mass inventory.

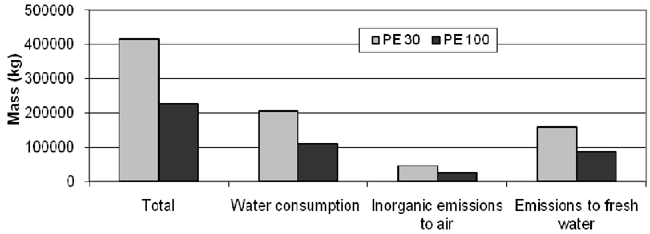

Fig. 1. Mass life cycle inventory (kg), total and individual flows for water consumption, inorganic emissions to air and emissions to fresh water

For both PE 30 and PE 100, the highest contribution to all of the flows presented in fig 1. was shown to be consumption of diesel fuel (*fig 2.* and *fig 3.*), that is used for transport of empty packaging to the plant and for the transport of packed product to the market.

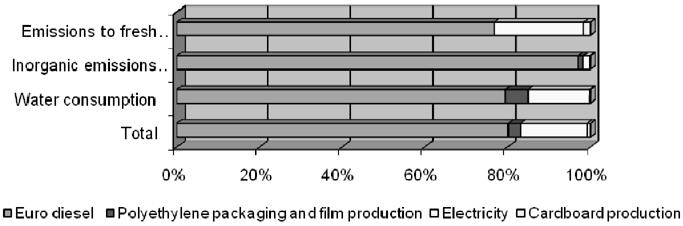

Fig. 2. Contribution of Euro diesel consumption, polyethylene packaging and film production, electricity consumption and cardboard production (%) to the mass life cycle inventory flows: total, water consumption, inorganic emissions to air and emissions to fresh water for the PE 30.

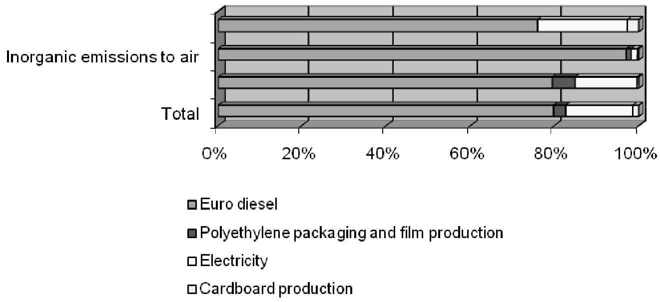

Fig. 3. Contribution of Euro diesel consumption, polyethylene packaging and film production, electricity consumption and cardboard production (%) to the mass life cycle inventory flows: total, water consumption, inorganic emissions to air and emissions to fresh water for the PE 100

After the contribution of diesel fuel consumption, the following highest contribution was showen to be electricity consumpsion and then the polyethylene packaging and film production.

Regarding the life cycle impact assessment, in the accordance with the life cycle inventory data, the folowing impact indicators were chosen: climate change, freshwater eutrofication, freshwater eco-toxicity and water depletion (*fig. 4, fig. 5, fig. 6, fig. 7*).

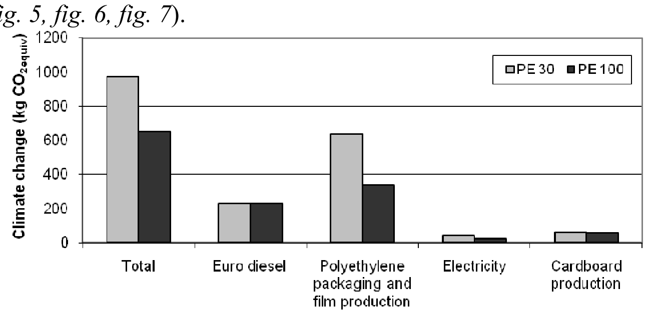

Fig. 4. Climate change (kg CO_{2equiv}) impact indicator: total, Euro diesel consumption, polyethylene packaging and film production, electricity consumption and cardboard production

For the climate change indicator, the highest influence had the polyethylene packaging production process, and then the diesel fuel consumption (*fig 4*). These results are comparable to the results obtained for PP and PET disposable cups, where about 60 % of CO_2 emission originated from material production (*van der Harst and José Potting, 2013*). Also, for different packaging options for juice, water and beer:1.0 L aseptic carton 1.5 L PET and 330 mL aluminium can, highest contribution to the global warming potential showed packaging manufacturing (*Pasqualino et al., 2011*).

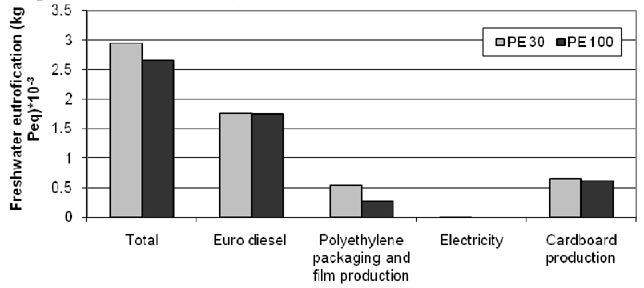

Fig. 5. Freshwater eutrofication ((kg Peq)10^{-3}) impact indicator: total, Euro diesel consumption, polyethylene packaging and film production, electricity consumption and cardboard production*

For the fresh water eutrofication, the most important was contribution of diesel fuel consumption, then the cardboard boxes production process and the polyethylene packaging production (*fig 5.*).

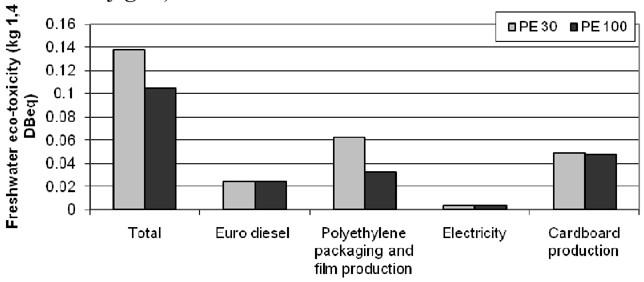

Fig. 6. Freshwater eco-toxicity ((kg 1,4DBeq) impact indicator: total, Euro diesel consumption, polyethylene packaging and film production, electricity consumption and cardboard production

For the freshwater eco-toxicity, contributions of the processes: polyethylene packaging and cardboard boxes production and the diesel fuel consumption were the most important (*fig 6.*).

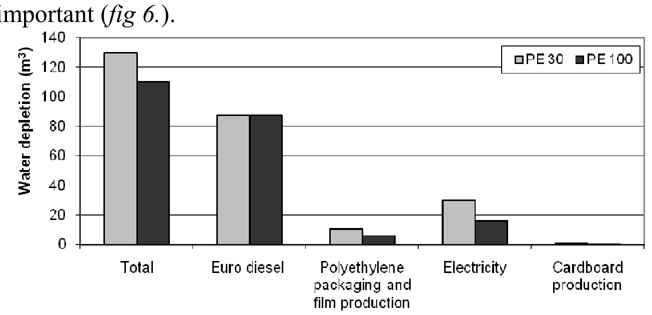

Fig. 7. Water depletion (m^3) impact indicator: total, Euro diesel consumption, polyethylene packaging and film production, electricity consumption and cardboard production

The diesel fuel consumption as well as the electric energy used in the packaging processes contribute the most to the water depletion (*fig. 7*). For all four impact indicators, impact of polyethylene tubes of 30 mL was higher in total than the impact of polyethylene tubes of 100 mL. These results are different than results obtained in our previous work with PP jars of different volume, where jars of 200 mL showed lower environmental impact, compared to jars of 350 mL (*Krkić, et al., 2012*). This is probably because volume has important impact to the mass of the packaging and amount of packaging material neded for the packaging production. This was shown for the case of different disposal cups where the global warming potential increased nearly proportional to the weight of the cups (*Franklin Associates, 2011; Vercalsteren et al., 2006*). The weight of the packaging also partly depends on the packaging material and other properties of the packaging. Different properties of the packaging, e.g., lining material or waste processing options, therefore also affect environmental impact of the product (*van der Harst and José Potting, 2013*).

CONCLUSION

The highest influence to the life cycle inventory in the analysed systems had the flows of fresh water consumption, emission of inorganic elements to the air and emissions to fresh water. All off these flows, including the total material flow had lower mass inventory values for the larger volume packaging. For both PE 30 and PE 100, the highest contribution to all of these flows showed consumption of diesel fuel. For all four impact indicators, climate change, freshwater eutrofication, freshwater eco-toxicity and water depletion, impact of polyethylene tubes of 30 mL was higher in total than the impact of polyethylene tubes of 100 mL. The results of this paper show that in analised case, more environmental friendly is the larger volume packaging.

ACKNOWLEDGMENT: This study was supported by the Ministry of Science and Technological Development of the Republic of Serbia, Project No. III 46009.

REFERENCES

Franklin Associates, a division of erg (2011). Life cycle inventory of foam polystyrene, paper-based, and PLA foodservice products. Prairie Village: Eastern Research Group, Inc.

GaBi software system, v.5.0. (2011). PE International GmbH Leinfelden-Echterdingen, Germany (www.gabi-software.com)

Kirwan, M.J., Strawbridge, J.W. (2003). Plastics in Food Packaging, in Food Packaging Technology. Eds. Coles, R., McDowell, D., Kirwan, M.J., Blackwell Publishing, San Francisco, USA, 233-237.

Krkić, Nevena, Lazić, Vera, Šuput, Danijela (2012). Comparison of life cycle assessment for different volume polypropylene jars. Acta periodica technologica, 43, 159-167.

Lazić, Vera, Novaković, D. (2010). Ambalaža i životna sredina. Univerzitet u Novom Sadu, Tehnološki fakultet, Novi Sad, Srbija.

Lazić, Vera, Krkić, Nevena, Gvozdenović, Jasna, Novaković, D. (2010). Packaging Life Cycle Assessment. Journal on Processing and Energy in Agriculture, 14 (1), 61-64.

Pasqualino, Jorgelina, Meneses, M., Castells, F. (2011). The carbon footprint and energy consumption of beverage packaging selection and disposal. Journal of Food Engineering, 103, 357–365.

Pringer, O.G., Baner, A.L. (2000). Plastric Packaging Materials for Food. WILEY-VCH, Weinheim, Germany.

Robertson, L. G. (1993). Food Packaging: Principles And Practice. Massey University, Palmerston North, New Zealand.

Sonnemann, G., Castells, F., Schuhmacher, M. (2004). Integrated Life Cycle and Risk Assessment for Industrial Processes. Lewis Publishers, Boca Raton, USA.

van der Harst, E., Potting, J. (2013). A critical comparison of ten disposable cup LCAs. Environmental Impact Assessment Review, 43, 86–96.

Vercalsteren, A., Spirinckx, C., Geerkens, T., Claeys P. (2006). Comparative LCA of 4 types of drinking cups at events. OVAM, Public Waste Agency for the Flemish Region, 390.

Received: 01.03.2013. Accepted: 06.09.2013.