Developing the environmental label criteria for the Turkish Environmental Labelling System for powder and liquid laundry detergents using a life cycle assessment approach

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Keywords: life cycle assessment, laundry detergent, environmental impacts, eco-labelling
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1. Introduction

Laundry detergents have a crucial role in many aspects of life, from the home to the workplace, due to their diverse capabilities. Depending on individual preferences, washing habits, and machine type, the quantity of resources required to do laundry with a washing machine might vary significantly. Variability in the consumer behavior can significantly impact the environmental performance of laundry detergent. Customers have the ability to affect environmental impacts not only through the products they purchase, but also through the consumption patterns they adopt (Järvi and Paloviita, 2007). For instance, water hardness has a significant impact on the usage of detergents, however the majority of consumers are unaware of the proper laundry detergent dose and use twice or more than what is required (Sudheshna and Srivastava, 2022). Laundry detergents are complex mixtures composed of over as 25 compounds, including surfactants, enzymes, sequestering agents, polymers, and fragrances (Gaubert et al, 2016). The production of laundry detergent has various environmental impacts resulting from these compounds. Besides, the use and end-of-life phases of laundry detergent may cause detrimental environmental impacts over their entire life cycle. Thus, both the producers and customers of laundry detergent must consider the environmental impacts of their production and consumption. In this regard, life cycle assessment (LCA) is one of the widely used tools for assessing the environmental performance of a product or service throughout the entire life cycle.

The purpose of the Turkish Environmental Labeling System which has been developed with the Environmental Label Regulation that came into force in 2018, is to promote the production and use of greener products. All environmental labels promote sustainable products, but each is based on a unique set of criteria which might lead to customers receiving conflicting information. Increasing market shares for products with environmental labels indicate the need for clear and prominent product environmental information. The criteria development method is based on measuring and communicating the life cycle environmental performance of products and organizations, which is a crucial step toward a more coherent and standardized method of measuring the environmental performance of products and organizations using a life cycle assessment approach (Saouter et al, 2018). The Turkish Environmental Labelling System covers a wide range of product groups and the criteria have been developed for textile, ceramic covering, tissue paper, touristic accommodation, hand dishwashing, personal care cosmetic, glass, laundry and dishwasher detergent products groups. Each product group has its own set of criteria and the full description of those can be consulted on the Turkish Environmental Labelling System website (https://cevreetiketi.csb.gov.tr/en). For detergents, Turkish Environmental Labelling criteria were published in 2022 for the laundry and dishwasher detergent product groups. The aim of this study is to evaluate the environmental performance of powdered and liquid forms of laundry detergent throughout all life cycle phases from raw material extraction to end of life phase by using LCA methodology, within the scope of the studies on the determination of environmental label criteria of laundry detergent products within the Turkish Environmental Label system.

2. Materials and methods

The cradle-to-grave methodology was used to conduct this study, and the functional unit was defined as g of detergent/kg of laundry. The LCA study was conducted in compliance with TS EN ISO 14024, TS EN ISO 14040/44 standards. The primary inventory data was provided by Turkish laundry detergent manufacturers while secondary data were retrieved from the literature. The IMPACT2000+ method and the Ecoinvent v3.7 database provided in SimaPro v9.3 software were used for LCA analyzes. The system boundaries of powder laundry detergent cover the spray tower process, mixing, packaging, use and end of life phase as shown in Figure 1. The system boundaries of liquid laundry detergent are the same in terms of life cycle phases except spray tower process (Figure 2). The sulfonation process, transportation to central stores and retail point of sale were excluded for both powder and liquid laundry detergent.

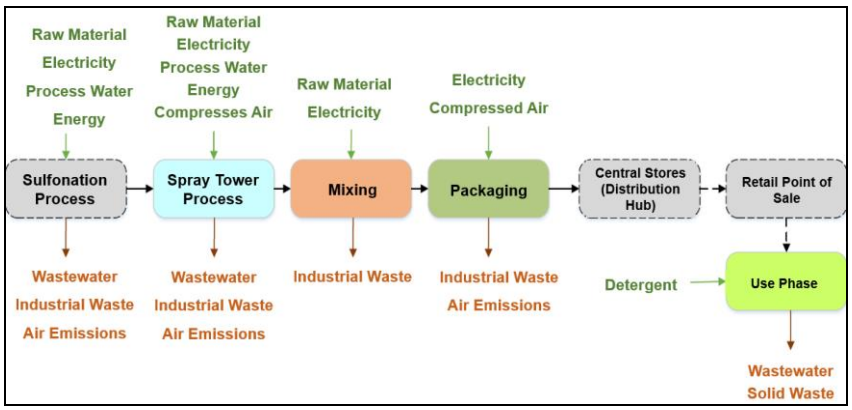

Figure 1. The system boundaries of powder laundry detergent used in LCA studies

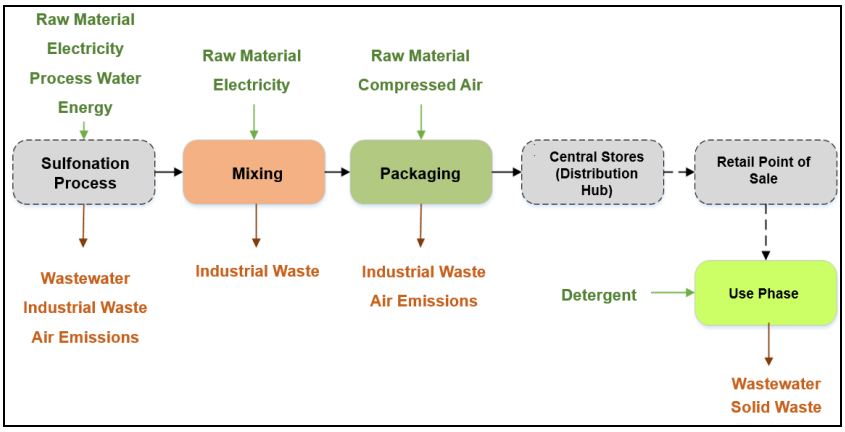

Figure 2. The system boundaries of liquid laundry detergent used in LCA studies

3. Results and discussion

The environmental impacts of liquid laundry detergent throughout its entire life cycle are shown in Figure 3. The key environmental impact categories and the impacts of life cycle stages in different categories were analyzed while evaluating the environmental impacts of liquid laundry detergent through LCA analysis. As shown in Figure 3, most of the environmental impacts occur during the use phase (37-97%) and the end-of-life phase (1-62%) of the entire life cycle of liquid laundry detergent. While the contribution of the mixing phase varies between 1% and 24% to the total environmental impacts of liquid laundry detergent, the packaging phase has a negligible impact (less than 1%). In addition, LCA analysis showed that the main contributor to the use phase is electricity consumption which is the mostly used fossil-based energy source in Türkiye.

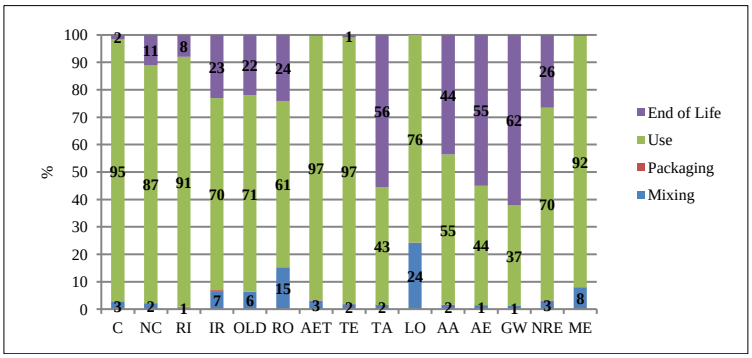

Figure 3. The distribution of the environmental impacts for liquid laundry detergent based on IMPACT2000+ method: IMPACT2000+ V2.15/characterization. C: Carcinogens, NC: Non-carcinogens, RI: Respiratory inorganics, IR: Ionizing radiation, OLD: Ozone layer depletion, RO: Respiratory organics, AET: Aquatic ecotoxicity, TE: Terrestrial ecotoxicity, TA: Terrestrial acid/nutrition, LO: Land occupation, AA: Aquatic acidification, AE: Aquatic eutrophication, GW: Global warming, NRE: Non-renewable energy, ME: Mineral extraction

The distribution of environmental impacts of powder laundry detergent over its life-cycle stages is depicted in Figure 4. When assessing the environmental impacts of powder laundry detergent, LCA analyses were used to evaluate the impacts of various phases of the product's life cycle on the environment. As illustrated in Figure 4, the majority of environmental

impacts occur during the usage phase (37-88%) and end-of-life phase (1-59%) of powder laundry detergent's entire life cycle for all environmental impact categories, except for respiratory organics. While the post-add phase contributes between 1% and 26% to the overall environmental impacts of powder laundry detergent, the tower powder production has the highest impact (93% for respiratory organics) due to the high occurrence of particulate matter. The obtained results are coherent with the previous studies in the literature. Saouter and Hoof (2002) applied LCA for laundry detergents produced in Belgium collecting life cycle inventory data from the detergent manufacturers. Their life cycle impact assessment results revealed that the contributions of the use and disposal phases to the total environmental impacts of the laundry detergent are 17.7-71.5% and 1-74.9%, respectively. Our LCA research also demonstrated that electricity consumption that is associated with the utilization of fossil fuels is the primary contributor to the use phase impacts.

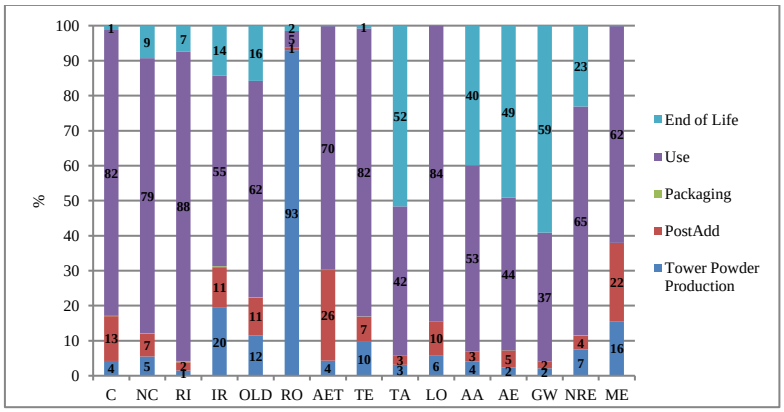

Figure 4. The distribution of the environmental impacts for powder laundry detergent based on IMPACT2000+ method: IMPACT2000+ V2.15/characterisation. C: Carcinogens, NC: Non-carcinogens, RI: Respiratory inorganics, IR: Ionizing radiation, OLD: Ozone layer depletion, RO: Respiratory organics, AET: Aquatic ecotoxicity, TE: Terrestrial ecotoxicity, TA: Terrestrial acid/nutrition, LO: Land occupation, AA: Aquatic acidification, AE: Aquatic eutrophication, GW: Global warming, NRE: Non-renewable energy, ME: Mineral extraction

4. Conclusions

In conclusion, the LCA results for both powder and liquid detergents revealed that the use phase and end-of-life phases have a major contribution in most of the environmental impact categories. This study revealed that the primary contributor to the environmental impacts of laundry detergents is the electricity required during the use phase. Therefore, electricity generation from renewable energy sources should be preferred to minimize the environmental impacts of laundry detergents over their life cycle.

5. References

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Acknowledgment - The authors would like to thank the Turkish Ministry of Environment, Urbanization and Climate Change for their support under "The Development of the Turkish Environmental Labelling System" Project.