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Introducing life cycle thinking to define best available techniques for products: Application to the anchovy canning industry

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ABSTRACT

This study presents a method based on life cycle assessment to reduce and simplify the decision-making process and to identify the best available techniques of a product. This procedure facilitates the selection of a technical alternative from an environmental point of view and the reduction of emission levels and the consumption of energy and primary resources. This method comprises the following four steps: (i) the identification of the current techniques of a specific product, (ii) the application of a life cycle assessment to determine the hot spots, (iii) the proposal of the best available techniques and (iv) the development of a best available techniques reference document (step not implemented in our case study). The Cantabrian anchovy canning industry is selected as a case study due to the importance of this sector from economic, social and touristic points of view. An entire life cycle assessment of one can of anchovies in extra virgin olive oil is conducted. The results indicated that the hot spots of the life cycle were the production of aluminium cans (for packaging) and extra virgin olive oil and the management of the packaging waste. According to these results, the study proposes several improvements, such as packaging recycling and several best available techniques for the canned anchovy product.

1. Introduction

One of the main challenges of production systems is industrial environmental sustainability and the ability to reduce the consumption of resources and the generation of pollutants and minimise environmental impacts. In the European context, the Integrated Product Policy (IPP) (Commission of the European Communities, 2003) and the Integrated Prevention Pollution and Control (IPPC) Directive (European Commission, 2008) represent a significant shift in the basis of environmental regulations in Europe.

The IPP Directive considers that products cause environmental degradation from their manufacturing, use or disposal. The IPP seeks to minimise these impacts by evaluating all phases of a product's life cycle and taking action where it is most effective. The IPPC Directive, which was derogated by the Industrial Emissions Directive (IED) (European Commission, 2010), is based on an integrated approach, flexibility and public participation and proposes the use of best available techniques (BATs) for the industrial installations that are covered by Annex I of this regulation. To identify BATs for these industrial sectors, the European Commission has prepared BAT reference documents, which are referred to as BREFs (Ibañez-Forés et al., 2013). The selection of BATs is based on technical feasibility, environmental benefits and economic profitability (Bello et al., 2013). However, according to the IPP Directive, a life cycle oriented approach that considers offsite impacts provides a complete environmental overview of the techniques. Life cycle assessment (LCA) is ideally suited to the type of integrated and holistic assessment that is required by the IPPC Directive to assess the different techniques that are being considered as BATs and identify which technique has the lowest 'cradle-to-grave' impacts based on emissions, energy and resource use (Nicholas et al., 2000).

Abbreviations: BAT, Best Available Techniques; BREF, Best Available Techniques reference document; Cr, Ga; Cradle to Gate, EB; Environmental Burdens, EBS; Environmental Burden Sustainability, EoL; End of Life, E-PRTR; European Pollutant and Transfer Register, EVOO; extra virgin olive oil, FU; functional unit, Ga; Ga, Gate to Gate; Ga-Gr, Gate to Grave; LCA, Life Cycle Assessment; LCI, Life Cycle Inventory; LCIA, Life Cycle Impact Assessment; IED, Industrial Emissions Directive; IPP, Integrated Product Policy; IPPC, Integrated Prevention Pollution and Control; NR, Natural Resources; NRS, Natural Resource Sustainability; TWG, Technical Working Group.

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BATs must protect the environment as a "whole" but the IED does not require the use of a full LCA to assess their environmental performance from "cradle-to-grave". This fact means that all life cycle emissions and impacts are not considered, although BATs aim to reduce certain direct and indirect emissions that are related to an installation. Therefore, the identification of environmentally sustainable options among different BAT alternatives is not possible as some impacts may be either missed or underestimated (Ibañez-Forés et al., 2013). LCAs have been successfully applied to identify environmentally sustainable options among different BAT alternatives for several industrial sectors, such as the cement sector (Valderrama et al., 2012), pig meat production industry (González-García et al., 2015) or metal industry (Yilmaz et al., 2015). BATs are applied to processes, and the BREF documents are only available to the processes of the industrial sectors that are included in the IPPC Directive.

For this reason, the use of LCA can aid in the establishment of several improvement measures and the development of a BREF document that includes the entire life cycle of a product (raw materials extraction, production, use and end of life (EoL)).

In recent years, several studies of the use of LCAs for products (Cooper et al., 2005) such as household refrigerators sector (Luglietti et al., 2016) and aluminium windows (Werner (2005)) have been published. Similarly, LCAs analysis for process such as urea process plant (Khan et al., 2002) and coal based power plant (Khan et al., 2004) evaluation and selection are collected in the literature. These methods have been employed in process design and environmental decision-making. The proposed method employs a systematic approach to estimate the environmental impacts that are associated with the life cycle of products and processes and to identify and evaluate opportunities that affect environmental improvements. In this study, we propose a complementary tool for evaluating environmental impacts and proposing BATs for products. This procedure proposes a set of environmental metrics that are stackable; that is, they can be combined (or stacked) to calculate the environmental impact per product unit over a series of processes that comprise a supply chain. The construction of BREF documents for all processes involved in the supply chain of a product is possible (Schwarz et al., 2002).

This procedure is applied to canned anchovies from the Cantabrian Sea (northern Spain). The quality of fresh raw materials and the handmade and traditional manufacture of the semi-preserved product in Santoña (Cantabria, Spain) is world-renowned. The life cycle of one can of Cantabrian canned anchovies has several environmental problems, such as the management of a large amount of solid residues (approximately 60% of anchovy weight is lost) and liquid waste (primarily water and oils) and the high-energy demand of the manufacture of the cans. Some studies have discussed the anchovy canning industry. A Nordic report on the fish processing industry (Tomczak-Wandzel et al., 2015) developed a case study regarding anchovies; this report is based on an inventory of the fish processing industry, which is oriented to a process (industry) instead of a product. Vázquez-Rowe et al. (2012) reviewed the current state-of-the-art of the LCA development in fishery based seafood production systems and concluded that the literature about canned seafood product is limited. Only canned tuna from Galicia (North of Spain) (Hospido et al., 2006) and Ecuador (Avadí et al., 2015) and canned sardines from Portugal (Almeida et al., 2015) have undergone a complete life cycle assessment.

Regarding anchovies, LCAs have been performed by Fréon et al. (2014) in which the Peruvian anchovy fishing is analysed and Avadí et al. (2014b) in which the eco-efficiency of the Peruvian anchovy fleet is measured using LCA + DEA. Moreover, Avadí et al. (2014a) analyse various anchovy products processed in Peru. However, despite the social and economic value of the canned anchovies in the Cantabria Region, no study has collected information about the entire life cycle of this product in order to design and implement local strategies for the sustainable production and consumption of this food product. This paper considers the life cycle thinking by considering all life-cycle stages of Cantabrian canned anchovies (anchovy fishing, production in the caning industry, packaging, distribution, use and end of life). An integrated approach that is based on the LCA method is proposed. In the published BREF documents, the reported LCA results are rare. Instead, data on mass and energy flows are considered (Kropp and Scheffran (2007)). For many products, several BREF documents (fish production, olive oil production, and waste management) are needed to consider all life cycle steps. A review of these documents is especially important for the Cantabrian anchovy canning sector, which is a handmade industry composed of several small and medium enterprises. Therefore, the objective of this study is the selection of BATs for the Cantabrian canned anchovy industry that encompass the life cycle steps for the entire product to provide producers with a simple tool for decision-making.

2. Methods

Fig. 1 shows the proposed method for the development of a BREF document for a product based on the interaction between IPP and IPPC policies. The procedure includes the following four main steps:

1. Identification of current techniques for raw material extraction, manufacture, use and EoL of a specific product.
2. Application of the LCA procedure to determine the environmental impacts and hot spots for the different phases of a product's life cycle.
3. Proposal of BATs for a product life cycle to develop a BREF. The use of BATs enables a reduction in the environmental impact and the selection of the most environmentally friendly alternative.
4. According to previous results, the development of a BREF document for a product.

In this paper, only steps 1–3 were developed. The application of this method to the canned anchovy product will be conducted in a future study to elaborate a BREF document (step 4) for anchovy canning products. Therefore, this paper only proposes some recommendations about BAT for the anchovy canning industry of Cantabria.

2.1. Identification of the current techniques and estimation of the environmental impacts

The first stage comprises the state of the art of the main techniques that are applied in the manufacture, use and EoL of a product. A rigorous review of the current situation of the industrial sector is required.

With this information, the input and output data of the system are collected to conduct the LCA. This method determines the environmental metrics for the entire life cycle of the product using an integrated approach. The metrics of the processes in the "cradle-to-gate" (Cr–Ga), "gate-to-gate" (Ga–Ga) and "gate-to-grave" (Ga-Gr) stages are obtained. These metrics are stacked to obtain a set of environmental indicators for a product. The use of stackable units enhances the versatility and usefulness of the method as a decision-making tool to reduce the LCA complexity. The metrics for the entire supply chain of a product can be compared and evaluated (Schwarz et al., 2002).

The environmental metrics that are proposed for the life cycle