PROPOSAL FOR A COLLABORATIVE LCA DATA MANAGEMENT METHODOLOGICAL APROACH FOR CREATING "NODES" IN THE BRAZILIAN NATIONAL INVENTORY DATABASE (SICV) BRASIL

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ABSTRACT:

Global Guidance proposes mechanisms for LCA studies and data management for improving interoperability, data exchange, accessibility and credibility of LCA databases. The PBACV (CONMETRO, 2010) has among its objectives to implement in Brazil a system capable of organizing, storing and disseminating information of LCIs. The Brazilian government responded to this demand through IBICT, which developed the SICV Brazil. For a LCI database to succeed, it is necessary to have primary data provided by the productive sector. The availability of data contributes to the growth of the country while benefiting the primary data providers, as society is increasingly attentive to the transparency and environmental awareness of companies. The management of LCA data is not a concern of national LCI databases alone. Other institutions also need to manage their LCA data independently of proprietary software, ensuring autonomy and sustainability for their operations. Keeping data on someone's own infrastructure favors autonomy, but multiplies infrastructure investment and impairs interoperability. This research proposes a procedure for shared management of LCA data through the creation "nodes", an instance of SICV Brazil for storing LCI data from private and public institutions. This procedure for shared management promoted the Brazilian National Inventory Database (SICV Brazil) and offered advanced information resources to institutions, such as Embrapa, without additional infrastructure and facilitating interoperability with other institutions. Authors believe that the creation of other instances of the SICV could contribute to the advance of LCA in Brazil.

Keywords:
LCA Databases, data management, LCA network.

1| INTRODUCTION

Life cycle assessment (LCA) data management is a task traditionally reserved for LCA software companies (FRISCHKNECHT; REBITZER, 2005). It was up to these software, such as SimaPro and GaBi, to manage the entire process of information flow in LCA, from its creation through analysis, distribution and storage. Such an approach was common during the gestational period of LCA, understood here to be the beginning of the discussions of ISO 14.040 (ABNT, 2014) in the early 1990s and in the first half of the 2000s.

The use of software as a tool for the management of the information cycle in LCA, although efficient in understanding the entire evaluation process, from data collection to impact analysis and information storage, also presented some difficulties. Among them, it is possible to mention the lack of tools focused on multi-user teams, technical flaws in data conversion between different software, and inefficient mechanisms to search and make available inventories (FRISCHKNECHT; REBITZER, 2005; NARITA et al., 2004; PROC SAF PR , 1999).

Such difficulties and the need to use LCA data on an integrated manner amongst distinct actors, both in national and international contexts, have led to several initiatives for the creation of networks of LCA. One of the first examples was the creation of the database ecoinvent, which aimed to integrate Swiss data production related to LCA, reflecting the situation of the year 2000 (FRISCHKNECHT; REBITZER, 2005). In 1998, Japan started its LCA network Project, with the creation of the Japanese national database (IDEA). This database was published in a first version with 100 inventories made available voluntarily. The Japanese project believed that "compatibility with reliability and openness was important in LCA's data management system" (Nakano; Sugimoto; Tahara, 2014, p. 165, authors translation). Like the Swiss and Japanese examples, other countries such as the United States, France, Italy, Australia and Brazil have also started national database projects. These initiatives aimed to allow the sharing of LCA information specific to the national context of each country, creating information networks in LCA. More recently initiatives, strived at the creation of international networks, have emerged with the European Commission (EC) through the Life Cycle Data Network (LCDN) and the United Nations Environment Program (UNEP) through the Global LCA Data Access (GLAD).

The understanding that this worldwide movement to standardize LCA data management needed uniform guidelines has led UNEP to take action in order to unify efforts. One of these actions was the workshop promoted in Shonan, Japan, which resulted in the publication of the Global Guidance Principles for Life Cycle Assessment Databases (UNEP, 2011). In the same vein, the Brazilian government officialized its efforts to promote LCA in 2010, with the creation of the Brazilian LCA Program (CONMETRO, 2010), which, among other objectives, aims to "implement a recognized international system capable of organize, store and disseminate standardized information on the

life cycle inventories of Brazilian industrial production "(CONMETRO, 2010, p.3). This initiative of the Brazilian government has been promoting the LCA in the country.
Although the actions of the Brazilian government make official the effort to create the National Life Cycle Inventory (SICV Brasil), there are numerous reports of companies that still find it difficult to carry out LCA studies. These difficulties are due to technical reasons, such as those mentioned above, such as difficulties in maintaining LCA software or hiring professionals, or because there is no Brazilian data to serve as a basis for deriving new studies. Thus, the question that moves this research is: how to create a network of LCA databases that allows to increase the number of datasets in the SICV Brasil and at the same time allow institutions to have autonomy to manage their inventory data? In order to answer it, the Brazilian Institute of Science, Technology and Information (IBICT) and the Brazilian Agricultural Research Corporation (Embrapa), two Brazilian institutions that participate in the subject of LCA and which respectively coordinate the technical commissions of Database and Of PBACV inventories, act together in carrying out this research. The objective is to establish procedures for the creation of "nodes" in SICV Brasil, being the first "node" of Embrapa, while defining strategies to increase the number of life cycle inventories made available by the Brazilian database.

2| METHODOLOGY

The methodology for node creation in SICV Brazil and implementation of the first Embrapa "node" is based on the analysis of PBACV documents and scientific articles related to the management of LCA databases, data collection with representatives of PBACV technical committees associated with the thematic and situation analysis from discussions between researchers from the field of LCA and Information Science.
As a consequence, the procedures and strategies that resulted in the three phases described during the presentation of results were defined.

3| RESULTS AND DISCUSSION

In order to achieve the proposed objectives for this research, IBICT and Embrapa jointly made efforts to establish the "Embrapa Node" of SICV Brasil, covering three phases:

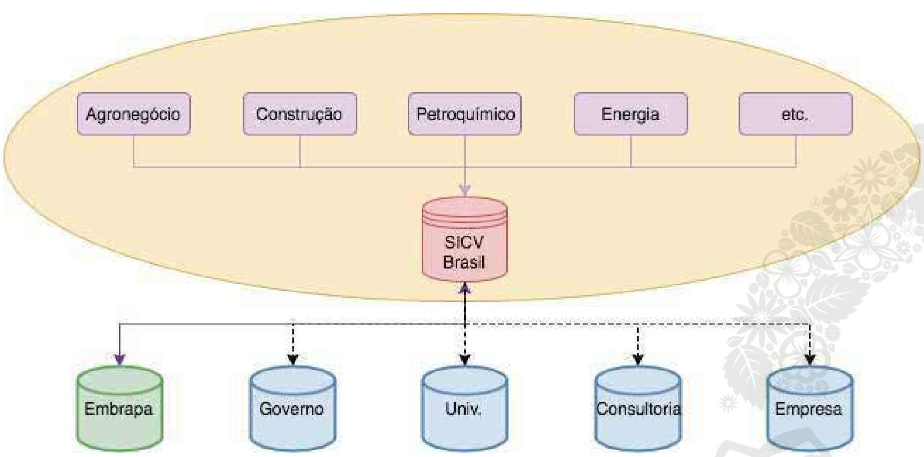
I. Definition of structure of software of LCA that supports the creation of LCA data network;

II. Establishment of technological and organizational models in the creation of "nodes" of the network; and

III. Definition of criteria for selection of "nodes".

Regarding to phase I (definition of the LCA software), we chose soda4LCA, a system designed to support the creation of LCA database networks (KUSCHE et al., 2012). Among soda4LCA's features, it is worth mentioning the management of public and open LCA databases, so that a single system installation can logically separate data. This resource allows, for example, the creation of specific bases by sector, such as agribusiness and fuels, within the SICV Brasil itself. In addition, the system has a network interface that allows communication between different instances for data exchange. In order to meet Brazilian specificities, some resources have been developed for soda4LCA, such as user management, process of revising datasets and remodeling of the messaging service. These resources are in the process of being sent to the soda4LCA repository, which is expected to be incorporated into the system root in 2017.
With regard to Phase II of defining the technological and organizational model for creating "nodes", two business models were defined. The first, possible only for public entities such as Embrapa, allows the technological structure to be maintained in the physical structure of IBICT. Such support includes backup, software update, and network monitoring. In this model, the administrative management of the system is the responsibility of the IBICT partner institution. In order to implement this model, it

Figure 2 - Structure supported by SICV Brasil



With regard to Phase III (definition of criteria for selection of "nodes"), it was established that both public and private institutions, be they small, medium or large, individual or sector representative, could become a "knot" of the SICV Brazil. However, as the resources available to support the addition of new "nodes" are limited, the implantation of new "nodes" of the SICV Brazil will begin with the institutions representing the sectors to be prioritized by the PBACV Technical Inventory Committee.

4| CONCLUSIONS

The creation of the procedure to create "nodes" linked to the SICV Brasil will favor the availability of inventories of several Brazilian productive sectors, bringing benefits both to the institutions that provide inventories and to society in general. The "Embrapa Node" of SICV Brasil, still in the consolidation phase, can be considered a milestone, since it will enable one of the institutions that most invest in research in the area of LCA in Brazil to actively contribute to the advancement of the methodology in the country. The data that will be made available in the SICV Brasil through this "node" will allow the creation of new studies in LCA. At the same time, it is understood that Embrapa acquires a robust system of ACV data management and reduces costs with information technology infrastructure. With the established SICV Brazil "nodes" methodology, it is expected that new institutions will be able to join the Brazilian database of LCA databases, allowing the Brazilian bank to expand its activities in the promotion of LCA in the country.

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SOCA – A DATABASE ADD-ON FOR LIFE CYCLE SUSTAINABILITY ASSESSMENT

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ABSTRACT:

Purpose: To reach the Sustainable Development Goals 2016 (SDG) and en-sure human well-being the sustainable production and consumption of prod-ucts and services along their entire life cycles is indispensable. This empha-sizes the importance of combining Social and Environmental Life Cycle As-sessment (S-LCA, E-LCA) and Life Cycle Costing (LCC) in one approach: Life Cycle Sustainability Assessment (LCSA). However, the application of LCSA in practice is still not very disseminated. One reason is the lack of comprehensive databases allowing the efficient calculation of environmental, economic and social impacts of product life cycles at a time. This study aims to contribute to research and facilitate LCSA by introducing and assessing the first database for LCSA – ecoinvent-soca.
Methods: To address the lack of databases for LCSA, social data was mapped from the industrial sectors and commodities in the PSILCA database to the pro-cesses in ecoinvent 3.3. A case study analyzing simultaneously the environ-mental, social and economic impacts of textile production in India was carried out to assess the usability, reliability and benefit of the "social add-on" soca for LCSA.
Results and discussion: Soca completes the environmental and cost infor-mation provided already in the ecoinvent database by generic social inventory data. It covers 53 indicators addressing social aspects of workers, local com-munities, societies and value chain actors. The results of the case study, proved by sensitivity analyses, revealed different hotspots, especially compar-ing social and environmental impacts.
Conclusions: The case study demonstrates the usability of soca for combined social, environmental and economic life cycle assessment. Further, the hotspot analysis highlights the importance of combining the three dimensions of sus-tainability in a single tool to ensure the same methodological basis and, hence, comparability of the impacts for one product system. Therefore, ecoinvent-soca is a promising advance for LCSA, and towards achieving the SDG and human well-being.

Keywords:

Life Cycle Sustainability Assessment; Database; Social Life Cycle Assess-ment; Sustainable Development Goals; Case study; Sustainability

1| INTRODUCTION

The Sustainable Development Goals 2016 (SDG) (UN, 2016) highlight that eradicating poverty and ensuring human well-being can only be achieved combining social inclusion and protection, sustainable economic growth, and environmental conservation. Hence, the sustainable production and consump-tion of products and services, i.e. along their entire life cycles, are becoming increasingly central within this framework, showing the importance of combin-ing Social and Environmental Life Cycle Assessment (S-LCA, E-LCA) and Life Cycle Costing (LCC) to Life Cycle Sustainability Assessment (LCSA). Its main approach was presented by the UNEP/SETAC Life Cycle Initiative in 2011. However, the broad application of the method in comprehensive life cycle stud-ies is still hampered, not least because of the lack of databases allowing the efficient calculation of environmental, economic and social impacts of product life cycles at a time (ibid.).
This paper introduces the first approach to combine the three dimensions of sustainability in one database – ecoinvent-soca. Its usability and reliability for LCSA will be tested and critically analyzed on a small case study about textile production from jute in India. It is the objective of this study to contribute to the research of LCSA and facilitate the conduction of case studies in the field.

2| METHODOLOGY

To adress the gap regarding tools and databases for LCSA, social life cycle information was assigned to ecoinvent 3.3 (EC, 2016). This database was se-lected as foundation because it contains global industrial life cycle inventory data and cost information on energy and material supply, resource extraction, agriculture, waste management, transport services and others.
The social aspects added to ecoinvent are based on PSILCA v.1 (GreenDelta, 2016). PSILCA is a transparent database for S-LCA which provides com-prehen-sive generic inventory information to calculate social impacts of almost 15,000 industry sectors and commodities in 189 countries over their life cycles.
The social information and risks were assigned to the activities in ecoinvent 3.3 by mapping the process categories existing for specific countries and regions to the country-specific sectors of PSILCA. An exception were market processes and activities used for database administration and modelling. For these pro-cesses, no social risks were assumed because, in practice, they are not con-nected to any real working time and, hence, do not contribute effectively to a product life cycle.
In order to quantify the relevance of the social risks caused by a process in a life cycle, the working time to produce the reference product of a process was selected as activity variable for all indicators (Norris, 2006). The values for the "social add-on" were calculated based on the worker hours per USD output of the mapped processes in PSILCA multiplied with the price of the respective products in ecoinvent. For those activities in ecoinvent without costs – mainly waste material and their disposal – parameters for worker hours were determi-ned per unit of the reference products assuming that working time is similarly high to produce the same amount of different products.
Additionally, data quality was defined for every data point regarding reliability of the source, and temporal, completeness, geographical and further technical conformance (Ciroth, Eisfeldt 2016). Both the original data quality in PSILCA as well as the specific mapping procedures between PSILCA and ecoinvent were considered (Eisfeldt, 2017).
The combination of environmental, economic and social life cycle assessment was tested in a brief case study about the production of 1kg woven textile fa-brics of jute in India. For the calculation, the process "textile production, jute | textile, jute" in India was selected. The inventory includes the cultivation of bast fibres, their further spinning to yarn and weaving to textile including all ups-tream processes (EC, 2016). The use and disposal phases were not conside-red.
The product system was created and calculated in the LCA software openLCA 1.5 (GreenDelta 2017) based on the system model "Allocation, cut-off by classi-fication" of ecoinvent v.3.3 (EC, 2016). The environmental impacts were calcu-lated with the ILCD 1.0.8 2016 midpoint impact assessment method (IAM). For the S-LCA a rudimentary IAM describing an exponential relation between the impact factors was applied. Some representative categories were selected for both the social and environmental life cycle impact assessment (S-LCIA, E-LCIA). Regarding LCC, the approach by Moreau and Weidema (2015) was fo-llowed, defining the life cycle cost as the "sum of all value added over the life cycle", i.e. the difference between the cost of the output and the cost sums of the intermediate inputs of each activity (ibid.).

3| RESULTS AND DISCUSSION

3.1. Soca: Social add-on for ecoinvent

Based on the mapping and assignment of social inventory data to ecoinvent processes, an add-on for ecoinvent v.3.3, called soca, was developed. It com-plements the environmental and cost data of the activities by social impact in-formation on workers, local communities, entire societies and value chain ac-tors resulting in a complete database for LCSA. The first version of soca avail-able for openLCA contains 53 social indicators related to 17 subcategories. The information is provided as risk-assessed indicators modelled as elemen-tary output flows for the ecoinvent processes. So-called "social aspects", e.g. raw values and data quality, complement and document the information on the process level. Quantified by the risk level and working time for every ecoinvent activity, overall social impacts of product life cycles can be calculated for the first time in parallel with their environmental impacts and costs.
Being a pioneer project, the methodology also holds some weaknesses. For example, due to the mapping procedure described in chapter 2 all activities and products within a country or region belonging to the same category receive the same social information. Further, costs in ecoinvent are global averages, i.e. independent of the country and of the specific technology, which affects and possibly distorts the worker hours calculated for an activity on their basis.

3.2. Case study

The sustainability assessment of textile production from jute in India proved the possibility to calculate social, environmental and cost impacts simultaneously for one product system, i.e. with the same connection types for all dimensions.
Further, the analysis of the LCIA revealed different hotspots for social, envi-ronmental and economic categories (see fig. 1-3).
Regarding most of the selected social impact categories, the highest (direct) contributions are originated in the "textile production, jute" process itself fol-lowed by close upstream processes such as "yarn production, jute" and "jute production, rainfed" in India (see fig.1). However, for some categories, other processes, even much earlier in the upstream chain, are especially risky. For example, for "Restrictions of association and bargaining rights" and "Insuffi-cient safety measures" electricity production out of hard coal in India, "lubricat-ing oil production" in Rest-of-World (RoW), and even the transmission network construction for electricity, high voltage (RoW) have high relative contributions.

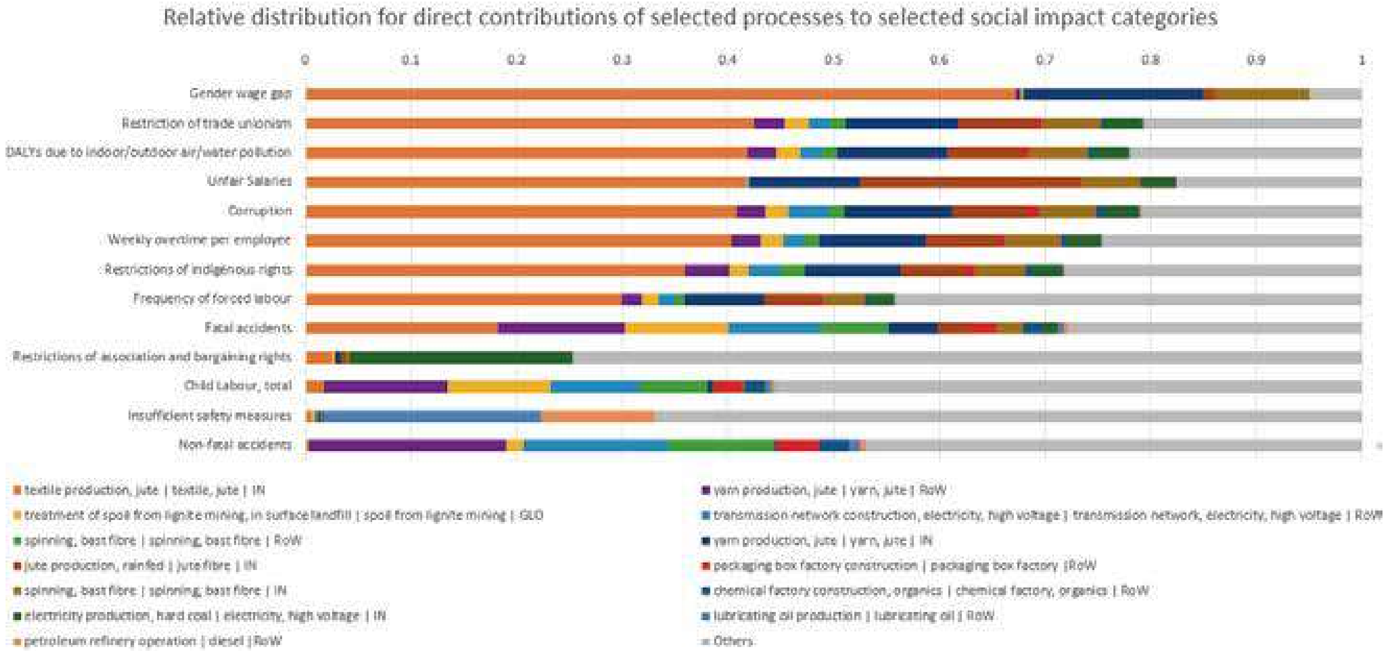

Figure 1: *Relative distribution of direct contributions of selected activities to selected social impact categories, own presentation*

In contrast to S-LCIA, the highest contributions to the selected environmental impact categories originate from activities further up the supply chain, especial-ly electricity production from hard coal in India (see fig. 2). "Global" treatment of spoil from mining contributes highly to freshwater ecotoxicity. Jute production activities mainly contribute to land use and can be considered as minor hotspots regarding freshwater ecotoxicity and freshwater and terrestrial acidifi-cation. However, the final textile production is irrelevant regarding the selected categories.

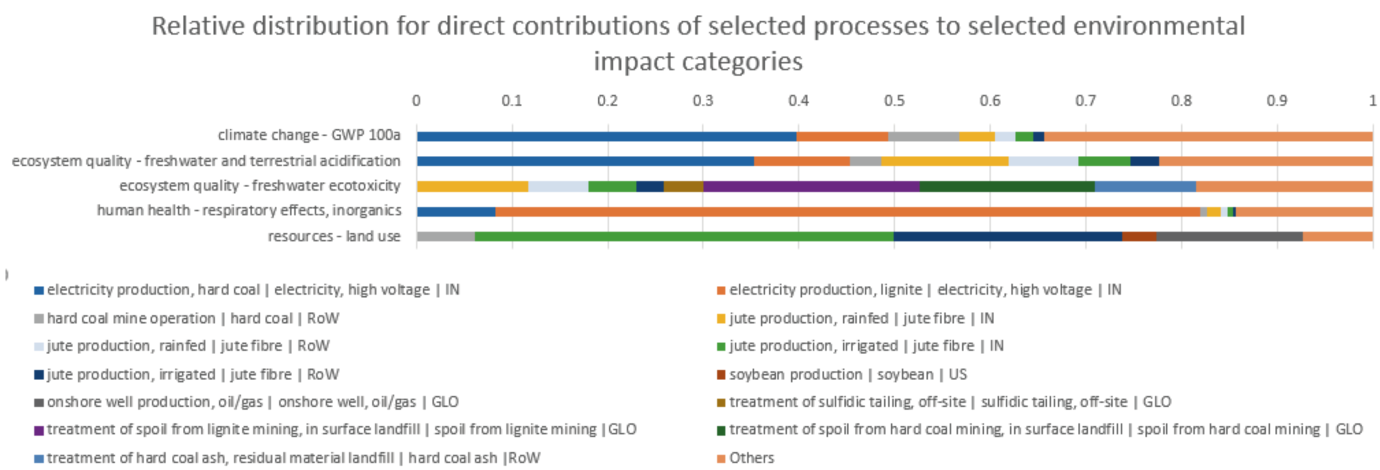

Figure 2: *Relative distribution of direct contributions of selected activities to selected environmental impact categories, own presentation*

Highest cost contributions (referring to added value of an activity) are generat-ed both by the material production processes (textile and intermediate jute pro-duction) as well as by electricity production from hard coal in India (see fig. 3).

Costs | $¥ Added value

Contribution	Process	Amount	Unit
21.41%	textile production, jute | textile, jute | cut-off, U - IN	0.25549	USD
10.59%	electricity production, hard coal | electricity, high voltage | cut-off, U - IN	0.12639	USD
09.67%	jute production, rainfed | jute fibre | cut-off, U - IN	0.11541	USD
08.89%	transmission network construction, electricity, high voltage | transmission network, electricity, high voltage | cut-off, U - RoW	0.10613	USD
05.28%	jute production, rainfed | jute fibre | cut-off, U - RoW	0.06306	USD
04.42%	transmission network construction, electricity, high voltage | transmission network, electricity, high voltage | cut-off, U - CH	0.05274	USD
04.18%	yarn production, jute | yarn, jute | cut-off, U - IN	0.04992	USD
02.89%	jute production, irrigated | jute fibre | cut-off, U - IN	0.03452	USD
02.49%	hard coal mine operation | hard coal | cut-off, U - RoW	0.02973	USD
02.49%	packaging box factory construction | packaging box factory | cut-off, U - RoW	0.02973	USD
02.29%	yarn production, jute | yarn, jute | cut-off, U - RoW	0.02728	USD

Figure 3: *Highest absolute & relative direct process contributions to LCC, source: openLCA 1.5*

The analysis of the results revealed various reasons for the different hotspots regarding the selected sustainability aspects. Besides by significant absolute social, environ-mental or economic risks themselves, the high contributions are also explained by the different impact calculation approaches. While life cycle costs are results of the summed value added, and environmental impacts of emissions, scaled to the target amount, social impacts are additionally related to the processes` working times. Hence, risks of labour intensive activities are weighted stronger in final social impacts than others. That explains, e.g., why electricity production processes are less relevant for most social impacts than for environmental ones. Similarly, eco-efficiency hotspots (environmental im-pacts per value added) (Goedkoop et al., 1999) could be calculated probably providing new interesting perspectives.

4| CONCLUSIONS

Ecoinvent-soca is the first complete database for LCSA allowing to assess the three elements of sustainability for the same product system independent from the type of process connections. Revealing different social, environmental and cost hotspots, the analysis further highlights the importance of conducting LCSA in a single tool to ensure the comparability of the impacts for one product system and the selection of the all relevant sustainability hotspots for mitiga-tion. Hence, despite its methodologi-cal shortcomings, soca is a promising ad-vance for LCSA and a starting point for further developments in the field, e.g. the combination of the separate impacts into overall sustainability indicators.

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INTERINSTITUTIONAL PARTNERSHIPS FOR THE DEVELOPMENT OF LCI DATABASE

PARCERIAS INTERINSTITUCIONAIS PARA O POVOAMENTO DE BANCOS DE DADOS DE ICV

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ABSTRACT:

The expansion of international Life Cycle Inventory (LCI) databases containing processes from various regions of the world is an longstanding demand of the Life Cycle Assessment (LCA) community. Managers of the main international databases also acknowledge this demand as they have been investing in making available more LCI datasets of products from non-European countries, such as the case of Brazil. In addition, production of national databases not only provides data, but also promotes LCA practice within the country. In this sense, a strategic partnership between ecoinvent, IBICT (the manager of the National Life Cycle Inventory Database - SICV Brasil), EMBRAPA, CTBE, UTFPR, Espaço Eco Foundation, Agroscope and Quantis Sàrl was created in the project called "Life Cycle Inventories of Brazilian agricultural products: a contribution to the ecoinvent database - ICVAgroBR", supported by the "Sustainable Recycling Industries" Program - SRI. Within this project, several representative datasets of important products of the Brazilian agribusiness will be provided to the ecoinvent and SICV databases, i.e. sugarcane, soybean, maize, mango, eucalyptus and beef. The publication in these databases will deliver to the international community LCI datasets with a very good representation of the Brazilian productive processes. This initiative also contributes to increase the reliability of the data, makes LCI more compatible and make possible to compare processes and products by complying with an international methodological standard, while taking into account the specificities of the country.

Keywords:

Database, Inventory, LCA, LCI.

RESUMO:

A ampliação dos bancos de dados internacionais de Inventários de Ciclo de Vida (ICV), abrangendo processos de várias regiões do mundo, é uma antiga demanda da comunidade de Avaliação de Ciclo de Vida (ACV). Os gestores dos principais bancos de dados internacionais reconhecem isto e há alguns anos vêm investindo na geração e disponibilização de datasets de ICV de produtos de países não europeus, como é o caso do Brasil. Adicionalmente, a criação de bancos de dados nacionais não só disponibiliza dados mas também promove a prática da ACV no país. Neste sentido, foi desenvolvida uma parceria estratégica entre ecoinvent, IBICT, gestor do Banco Nacional de Inventários de Ciclo de Vida – SICV Brasil, Embrapa, CTBE, UTFPR, Fundação Espaço Eco, Agroscope e Quantis Sàrl, no projeto “Inventários de Ciclo de Vida de produtos agrícolas brasileiros: uma contribuição ao banco de dados ecoinvent - ICVAgroBR", apoiado pelo programa “Sustainable Recycling Industries” – SRI. Com este projeto serão fornecidos aos bancos de dados ecoinvent e SICV datasets de ICV representativos dos sistemas de produção típicos de importantes produtos do agronegócio brasileiro: cana-de-açúcar, soja, milho, manga, eucalipto e carne bovina. A publicação nesses bancos de dados é um meio de fazer chegar à comunidade internacional datasets de ICV que representem fielmente os processos produtivos brasileiros. Esta iniciativa também contribui para a aumentar a credibilidade dos dados e a possibilidade de compatibilizar ICV e comparar processos e produtos, pelo atendimento a um padrão metodológico internacional, mas que leva em

1| INTRODUÇÃO

Os principais bancos de dados internacionais de inventários de ciclo de vida estão em contínua ampliação e atualização. Esforços têm sido empregados para que estes bancos sejam cada vez mais completos, abrangendo datasets (conjuntos de dados) de diferentes países. Dentre os bancos de dados internacionais de ICV, o ecoinvent versão 3 se destaca como o mais completo, contendo mais de 12800 ICV em muitas áreas, como energia, materiais de construção, produtos químicos, produtos agrícolas e florestais, biomateriais e biocombustíveis, transporte e tratamento de resíduos.
Há mais de dez anos, o ecoinvent iniciou um processo de internacionalização, visando criar competências em outros países para a criação de datasets de qualidade e representativos, a serem incorporados ao seu banco. A partir de 2010, com o desenvolvimento da versão 3 do ecoinvent, essa ação de internacionalização se intensificou. Foi aprovado o programa "Sustainable Recycling Industries" (SRI), financiado pelo "Swiss State Secretariat for Economic Affairs" (SECO), e implementado conjuntamente pelo "Swiss Institute for Materials & Technology", pelo "World Resource Forum" e pelo ecoinvent, direcionado ao Brasil, Índia e África do Sul (ECOINVENT, 2017).
No âmbito do programa SRI, em fevereiro de 2016 foi aberta a "Call for Tenders for Life Cycle Inventory (LCI) data collection, LCI dataset creation and submission to ecoinvent", na qual foi aprovado o projeto "Life Cycle Inventories of Brazilian agricultural products: a contribution to the ecoinvent database – ICVAgroBR", coordenado pela Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), o braço de pesquisa do Ministério da Agricultura, Pecuária e Abastecimento do Brasil, com a participação de cinco outras instituições: Centro Nacional de Pesquisa em Energia e Materiais (CNPEM); Fundação Espaço Eco (FEE); Universidade Tecnológica Federal do Paraná (UTFPR), Swiss Confederation, representada pelo "Federal Office for Agriculture" (Agroscope) e Quantis Sàrl.
Este projeto reúne uma equipe multidisciplinar, que inclui especialistas em sistemas de produção agrícola, florestal e pecuária de diferentes regiões do Brasil, assim como especialistas nacionais e internacionais em ACV, qualificados para a coleta de dados de ICV, criação, validação, documentação e submissão de datasets no padrão do ecoinvent v.3. Seu principal objetivo é fornecer ao ecoinvent datasets representativos dos sistemas de produção típicos de alguns dos mais importantes produtos do agronegócio brasileiro: cana-de-açúcar, soja, milho, manga, eucalipto e bovinos de corte.
Uma vez publicado pelo ecoinvent, os datasets serão também disponibilizados no Banco Nacional de Inventários de Ciclo de Vida – SICV Brasil, criado e gerido pelo IBICT (Instituto Brasileiro de Informação em Ciência e Tecnologia, vinculado ao Ministério da Ciência, Tecnologia, Inovações e Comunicação) no âmbito do Programa Brasileiro de Avaliação do Ciclo de Vida (por meio das Comissões Técnicas de Banco de Dados e de inventários). A oferta dos datasets deste projeto para o SICV Brasil será uma importante contribuição para disseminar a ACV junto ao setor produtivo do país.

2| MÉTODO DE TRABALHO

Os datasets a serem publicados no SICV Brasil e no ecoinvent seguiram o padrão de qualidade e metodologia indicados no "Guia QualiData" (IBICT, 2016), no "Overview and Methodology: Data Quality Guideline for the ecoinvent Database Version 3" (WEIDEMA et al., 2013) e em documentos complementares (NEMECEK & SHNETZER, 2011; NEMECEK & KAGI 2007).
Para garantir a adoção deste padrão metodológico, foram organizados treinamentos modulares, presenciais e remotos, envolvendo especialistas nos processos produtivos e na técnica de Avaliação de Ciclo de Vida (ACV), sendo os principais temas "Elaboração de datasets de ICV conforme ecoinvent v3"; "EcoEditor: edição e submissão de datasets"; e "Mudança de Uso da Terra segundo método do projeto WFLDB (SCHRYVER & LANSCHE, 2012), adotado pelo ecoinvent" (programado para março de 2017).
Além disso, foram elaboradas planilhas "modelo", desenvolvidas em Excel, preparadas para a organização dos fluxos de entrada, para o cálculo dos fluxos de saída e para a consolidação do inventário de processo, seguindo o padrão e validada pelo ecoinvent. Durante a elaboração dos datasets ocorre orientação técnica simultânea, provida pelo ecoinvent de forma remota.
Antes da submissão, os datasets são submetidos a uma rigorosa validação, realizada por especialista do Agroscope. Esta validação tem quatro etapas principais, compreendendo as análises de: 1) dados de atividade/processo (com relação à completeza e qualidade dos dados de produção); 2) modelagem e cálculos de emissão (com relação aos pressupostos da modelagem, checagem de plausibilidade, completeza e relevância dos modelos de emissão); 3) resultados de AICV; e 4) implementação no ecoinvent (com relação à adequação ao guia de qualidade de dados do ecoinvent v3, completeza e correção, fluxos de entrada e saída e propriedades destes fluxos, e metadados). Para a submissão dos datasets ao ecoinvent será usado o programa ecoEditor. Para a submissão ao SICV Brasil, será usado o OpenLCA e importação direta por meio de interface web.

3| Resultados e Discussão

O projeto em questão corresponde a um grande esforço de instituições de diferentes naturezas e propósitos (instituições de pesquisa e acadêmicas governamentais, OSCIP e consultorias, brasileiras e internacionais), reunidas com o objetivo maior de promover a ACV no Brasil e de oferecer contribuições à comunidade internacional de ACV.
Sua realização foi possível em decorrência de parcerias pré-existentes, profícuas, e pelo espírito de solidariedade da ainda incipiente comunidade brasileira de ACV. Todas as instituições brasileiras ofereceram uma grande contrapartida em tempo de dedicação ao projeto. Obviamente, o ecoinvent e o programa SRI foram os catalizadores desta iniciativa, provendo apoio financeiro e técnico.
O primeiro grande obstáculo a vencer para a viabilização deste projeto foi a burocracia. As instituições brasileiras, em particular as governamentais, têm estrutura jurídica pesada e morosa. Sendo muitas as instituições envolvidas, foram necessários meses de negociação para se chegar em um instrumento jurídico de consenso.
O projeto se iniciou com a realização de treinamentos, que representaram oportunidades para a troca de experiências da equipe e para o compartilhamento de material bibliográfico e de apoio. Tanto os treinamentos quanto as reuniões técnicas, quando realizados presencialmente foram extremamente ricos e proveitosos; entretanto, os eventos remotos foram prejudicados pela limitação tanto da ferramenta para reuniões virtuais quanto da rede de internet.
Estão sendo elaborados datasets representativos dos sistemas de produção típicos de alguns dos mais importantes produtos do agronegócio brasileiro: cana-de-açúcar, soja, milho, eucalipto e bovinos de corte, além da manga, uma fruta tropical de exportação.

Características específicas da agricultura, silvicultura e pecuária brasileiras precisam ser consideradas na elaboração dos datasets, requerendo adaptações: a) adoção de um nível de cobertura geográfica regional (e não nacional), considerando a dimensão continental do Brasil, coberto por sete diferentes biomas; b) ajuste de modelos para estimação de emissões, tendo em conta algumas importantes características dos solos (alta acidez, alto teor de alumínio e baixa fertilidade) e dos climas brasileiros (elevadas precipitações em algumas áreas e inverno ameno); c) inclusão do impacto de mudança de uso da terra, já que a fronteira agrícola brasileira encontra-se ainda em expansão; d) adoção de sistemas de produção (sendo a prática mais comum a sucessão de diferentes culturas, na mesma área, durante o ciclo agrícola); e) adoção da técnica de plantio direto; f) adoção de equipamentos de maior escala, com maior eficiência no consumo de combustível, devido às áreas de produção mais vastas. O respeito a estas especificidades garantirá a representatividade dos datasets que estão sendo construídos.

4| CONCLUSÕES

Parcerias entre instituições de pesquisa e acadêmicas governamentais, OSCIP e consultorias, brasileiras e internacionais, com apoio técnico do ecoinvent e apoio financeiro do SRI/SECO, permitiram a viabilização da construção de datasets de alguns dos principais produtos do agronegócio brasileiro, para publicação nos bancos de dados ecoinvent e SICV Brasil.

Publicar no banco de dados ecoinvent é um meio de fazer chegar à comunidade internacional inventários gerados para as condições brasileiras, melhor representando os seus processos produtivos. Dessa forma, a oferta dos datasets tanto para bancos de dados internacionais quanto para o SICV Brasil representa uma importante contribuição para a disseminação da ACV na comunidade brasileira.

A política dos bancos de dados de ICV internacionais de fomento ao desenvolvimento de massa crítica em países onde a ACV é ainda incipiente pode ser entendida como de interesse global e deve ser estimulada, preferencialmente em parceria com os gestores de bancos de dados nacionais.

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Design for sustainability

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A COMPARISSON OF ENVIRONMENTAL IMPACTS BETWEEN WOODEN AND ALUMINUM CHAIRS USING LIFE CYCLE ASSESSMENT

UNA COMPARACIÓN DE IMPACTOS AMBIENTALES ENTRE SILLAS DE MADERA Y ALUMINIO USANDO ANÁLISIS DE CICLO DE VIDA.

UMA COMPARAÇÃO DOS IMPACTOS AMBIENTAIS ENTRE CADEIRAS DE MADEIRA E ALUMÍNIO USANDO AVALIAÇÃO DO CICLO DE VIDA.

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ABSTRACT:
In today's highly competitive market, the selection of goods is based mostly on economic analysis such as volume discount or cost-benefit analysis. However, in the new eco-friendly business environment, selection is no longer based solely on those factors. More and more businesses and services are now taking the environmental impacts of their purchases into account as part of their environmental declaration. The aim of this paper is to report the results of a comparison of two types of chairs (wood & aluminum) for use in the food court of a shopping center in Salvador Bahia, Brazil. A case study approach is used. Life Cycle Assessment (LCA) is used to quantify the environmental impacts associated with the chairs throughout their life cycle. ILCD 2011 was chosen for assessing and comparing the impacts between the options. Software Stan® was used to characterize and balance the production line of the wooden Chair. Software Simapro® was used to run the LCA of each chair. The results gave an insight of the different tradeoffs when choosing one option over the other. Finally, a discussion regarding the interpretation of impacts and the importance of eco-labeling is made to motivate future works in the field.

Keywords:
LCA, Wooden furniture; Aluminum furniture; Eco-labeling; ILCD 2011

RESUMEN:
En el mercado altamente competitivo de hoy en día, la selección de bienes se basa principalmente en análisis económicos como los descuentos por volumen o el análisis de costo-beneficio. Sin embargo, en el nuevo entorno empresarial ecológico, la selección no puede basarse únicamente en esos factores. Cada vez más empresas y servicios están tomando en cuenta los impactos ambientales de sus compras como parte de su declaración ambiental. El objetivo de este trabajo es informar sobre los resultados de una comparación de dos tipos de sillas (madera y aluminio) a ser compradas para el área de restaurantes de un centro comercial en Salvador de Bahía, Brasil. Es utilizado un enfoque de estudio de caso. El Análisis del Ciclo de Vida (ACV) es utilizado para cuantificar los impactos ambientales asociados con las sillas a lo largo de su ciclo de vida. Fue escogido el método ILCD 2011 para evaluar y comparar los impactos entre las opciones. El Software Stan® fue utilizado para caracterizar y equilibrar la línea de producción de la silla de madera. El Software Simapro® se utilizó para ejecutar la ACV de cada silla. Los resultados obtenidos ofrecen una idea de las diferentes compensaciones ambientales al elegir una opción sobre la otra. Por último, se hace una discusión sobre la interpretación de los impactos y la importancia de las etiquetas ecológicas para motivar futuros trabajos en el campo.

Palabras clave:
ACV, Silla de madera; Silla de Aluminio; Etiqueta ecológicas; ILCD 2011

Palavras chave:
ACV, cadeira de madeira, cadeira de alumínio, rotulagem ambiental, ILCD 2011

1| INTRODUCCIÓN

Globalization has made it possible to get products and services from practically every part of the globe. The business environment in today's highly competitive market usually turns the selection of goods into an economic issue, where cost-benefit analysis and volume discount are among the most popular decision-making tools used. Consumers want higher quality, faster delivery as well as products tailored to their needs at a lower total cost (Monczka, et al., 2015). However, in the new eco-friendly business environment this selection is no longer based solely on those factors. Regardless the fact that there are still companies who believe that the more environmentally friendly they become the less competitive they are (Giuniperoa, et al., 2012), more and more businesses and services are now taking the environmental impacts of their purchases into consideration.

However, the issue of sustainability in purchasing is not an easy task when there is lack of information regarding the environmental impacts of the products to be purchased. Besides this, the market for environmentally friendly products is asymmetric regarding information, making it difficult to identify environmental performance before purchasing (Heinzle, et al., 2012).

Unfortunately, few products have embraced the environmental declarations and eco-labeling as part of their strategic. In Brazil, despite the relatively little LCA research, there are clear efforts to increase their use. The Brazilian Program for Life Cycle Assessment (PBACV in Portuguese) is aimed to straighten the methodology as well as sensitize the private and public sector over the perspective of life cycle. (INMETRO, 2015) and as for the framework, Brazil has developed their own norm: NBR ISO 14025 (ABNT, 2015), to make it easier to use.

1.1. Furniture industry in Brazil

The environmental impacts for goods such as furniture have been rarely reported in Brazil. The furniture production reached nearly 430 Million of goods in 2015 with a value of R$51.5 Billion (US$ 16.54 Billion), employing nearly 274,500 people. (Guinski, 2016). Despite the size of such market, the research in the field is relatively small, and there is an increasing need to consider the environmental factors to evaluate the best purchase that meets either economic and environmental requirements.

Research carried out by Rapôso (2014) indicates a relatively small amount of research related to furniture and sustainability in Brazil: in a literature research made between 2000-2012, only 47 publications were found: 9 theses and 38 papers / monographies. Less than 11% were international research publications.

The furniture industry in Brazil is characterized by the multiplicity of material and technologies applied to the productive sectors that compose it (Rapôso, 2014). A research document presented by DEPEC-Bradesco (Department of Research and Economic Studies-Bradesco) claims that most of the furniture made in Brazil is for the internal market (96%) where home furniture represents more than 2/3 of such markets. The same report claims that 84.5% of the furniture is wooden made, 8.8% is metal and 4.4% other materials. Therefore, wooden furniture is the most important material for either home and office furniture purchased in Brazil followed by metal furniture. Is in this context that a Shopping center located in the city of Salvador de Bahia, Brazil faces a dilemma: Choosing the best option for their indoor food court is now a matter of choosing not only the best price, but a combination of best looking, more resilient and more environmentally friendly products.

1.2. Wood and Aluminum process

For the study, a eucalyptus chair was selected as the wooden chair due its availability. In Brazil, the eucalyptus industry has extended using degraded pasture lands. The general process initiates with the seeding process, where the best species are selected per the climate/soil conditions. Then there is a maintenance time where growing and fertilizing take place. The harvesting and sawing are the next process, usually taking place nearby the forest plantation. The wood planks are then dried in kilns per species and technology available. The final plank is then displaced up to 650 Km from the city of Eunápolis to Salvador de Bahia, where the workshop is located. Final product can then be delivered to the client.

Regarding the Aluminum industry, the location of the bauxite (mineral base for aluminum) is nearby the surface. Due that reason, it is needed up to 1m2 of land per Ton of bauxite (Bolowich, 2016). At the same time, Brazilian law requires rehabilitation of natural conditions of all mining process after the mining is finished. Therefore, the mining must restore the land to a state that can deliver ecosystem services and natural conditions. The bauxite is then processed into Alumina smelting in a process called electrolysis. High amounts of energy are required during this process. At the end of this process, aluminum ingots are ready to be processed into deferments products, such as extruded tubes, the main raw material for the aluminum chair.

1.3. Goal and Scope

The objective of this paper is to report the results of a comparison of two types of chairs (Wood / Aluminum) to be used in the indoor food court of a shopping center in Salvador Bahia, Brazil. The study comprises the following key issues: (1) literature review for the raw material production process (2) data gathering for Life Cycle Inventory of wood / Aluminum chairs (3) Assessment of Life Cycle Inventory Impacts using ILCD 2011 as assessment method (4) comparison of results obtained (5) evaluation and discussion. The approach used was "cradle to gate", considering the goods been delivered to the shopping center to be used. Rather than simply using the inventory values presented in the databases, a more in deep approach was chosen. Using detailed information of the raw materials production to include a more regionalized result that considers the Brazilian reality, it was possible to include factors such as type of materials, real distances from plantation or mines, the Brazilian electricity grid and other minor factors that the very actual production process is currently using.

2| METHODS

Life Cycle Assessment (LCA) is used as scientific method to quantify the environmental impact of each type of chair. This study complies partially with ISO 14044 (2006) due to the need to use allocation to distribute resource use such as wood and energy. A simple resource usage approach is also used to contrast the conclusions derived by using such type of approach.

2.1. System Boundaries

To perform the comparison between the two types of chairs, a cradle to gate approach was used. Figure 1 and 2 show the simplified flow diagram of the life cycle of each type of chair. Since both processes involve the manufacturing of different products and byproducts, allocation of mass was required to represent an accurate consumption of resources.

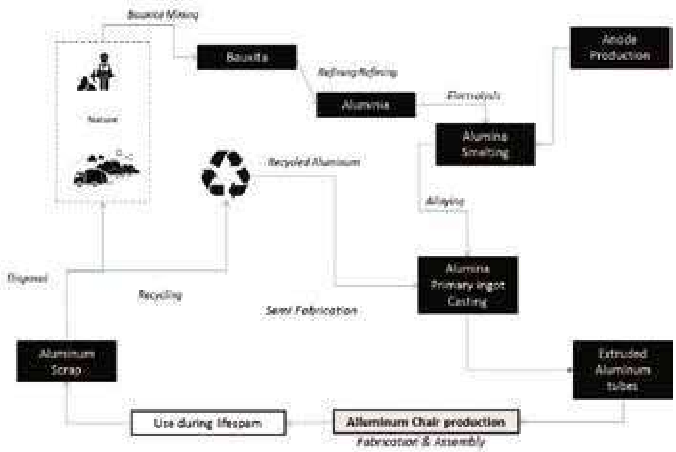

Figure 1: Simplified life cycle diagram for the aluminum chair. Adapted from The Aluminum Association (2013) and the Authors (2017)

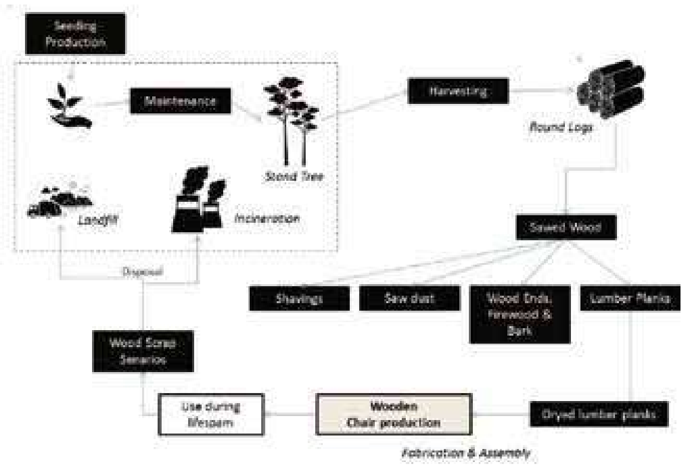

Figure 2: Simplified life cycle diagram for the wooden chair. From Authors (2017)

2.2. Functional Unit

Although the two types of chairs accomplish the same function, they have a different expected lifetime, different amount of material and different densities. Therefore, the functional unit used in this study was focused on the service both products provide until the next renovation of the area. It has been calculated approx. 10,000 hours of services of the chairs in the food court of a shopping center. (9 hours per day during 360 days for approximately 3 years). The base scenario is that during the 3 years, an aluminum chair would be replaced once, meanwhile one single wooden chair could stand the three years under normal usage conditions. This means 2 aluminum chair per one wooden chair.

2.3. Material Balances

One of the major changes for this work was the data gathering. The data included published literature such as The Environmental footprint of semi finished Aluminum Products in North América (2013) and the Life cycle assessment of rough-sawn kiln-dried hardwood lumber (2012) as source for the detailed processes. Other data was obtained directly from the source such as the wood chair process. To diminish the uncertainty, the software Stan® was used to conciliate the values of material of the pieces obtained by weighting.

2.4. Impact Assessment

The impact assessment Method used was ILCD 2011 due to its combination of methods and easy interpretation of the values that express the total environmental load of a product or process.

3| RESULTS AND DISCUSSION.

The results of the study show some important remarks as well as some advantages and disadvantages of one option over the other.

3.1. Resource usage approach.Method

The first analysis made was using a resource usage approach. The focus is on describing the most efficient use of resources and materials. Since both the wood and the aluminum requires the use of land either for eucalyptus harvesting or for bauxite mining, it is then presented a comparison of both products using one hectare of land (10,000 m2). The first comparison is regarding volume of material and land used for each type of chair based on their material. It is noted that the wooden chair weights 3.3 times more than the final aluminum chair (table 2). Also, the material loss in the production of the wooden chair is up to 46% (from dried wood planks to wooden chair), meanwhile the aluminum chair has just 4% loss of material during manufacturing.

Based on the experience of shopping center personnel on the same kind of chairs.

Material	Final Chair (Kg)	Raw Material (Kg)
Wooden Chair	6.4527	11.9794
Aluminum Chair	1.9580	2.0190

Table 2: *wooden & Aluminum mass comparison. From Authors (2017).*

Regarding the land used for each base material, the data shows a remarkable difference in production yield. If all the material extracted were used to produce both types of chair, it could be produced 118 times more aluminum chair than wooden chair as stated in Table 3.

Wood			Aluminum		
Land Use	1	Ha	Land Use	1	Ha
Stand Tree wood	291.60	Ton	Bauxite	10,000.00	Ton
Harvested Round logs	148.50	Ton	Alumina	3,471.02	Ton
Lumber Planks	76.03	Ton	Aluminum Ingot	1,776.36	Ton
Dried plank	69.12	Ton	Extruded Aluminum	1,378.10	Ton
Wooden Chairs	5,770	Chairs	Aluminum Chairs	682,573	Chairs

***Table 3:** Comparison of production quantities per one hectare of land. Adapted from (The Aluminum Association, 2013), (AHEC, 2012) and from Authors (2017)*

The result of the production approach suggests some clear advantages of the aluminum chair over the wooden chair. Not only is possible to produce more goods from one hectare of land, but also the final product shows a better yield during the manufacturing process. The light weight of the aluminum chair makes it more suitable for transport from the manufacturing facility to the clients.

3.2. Environmental impacts approach.thod

An environmental impact approach was made using LCA. A functional unit of 3 years of services is then used as the comparison means.
In general, both the aluminum chair and the wooden have their biggest burdens during the raw material acquisition (mining aluminum or harvesting the round logs). As for the environmental impacts the table 4 resumes the results of the functional unit comparison:
Based on the wooden and aluminum chair of the case of study.

Impact Category	Unit	Aluminum Chair	Wooden Chair
Climate change	kg CO2 eq	31.48678588	- 6.17324253
Ozone depletion	kg CFC-11 eq	0.00001393	0.00000093
Human toxicity, non-cancer effects	CTUh	0.00000485	0.00000148
Human toxicity, cancer effects	CTUh	0.00000104	0.00000100
Particulate matter	kg PM2.5 eq	0.02218390	0.00359517
Ionizing radiation HH	kBq U235 eq	6.76918034	0.36434059
Ionizing radiation E (interim)	CTUe	0.00003953	0.00000133
Photochemical ozone formation	kg NMVOC eq	0.12517186	0.02751874
Acidification	molc H+ eq	0.25988686	0.03869218
Terrestrial eutrophication	molc N eq	0.32177701	0.10179950
Freshwater eutrophication	kg P eq	0.00545089	0.00123919
Marine eutrophication	kg N eq	0.03088574	0.00937246
Freshwater ecotoxicity	CTUe	147.71354549	91.61975211
Land use	kg C deficit	978.81171478	- 16.42770243
Water resource depletion	m3 water eq	1.10753082	0.00579658
Mineral, fossil & ren resource depletion	kg Sb eq	0.00036799	0.00027689

***Table 4:** Characterization of the functional unit of aluminum/wooden chair using LCA ILCD 2011 Midpoint V1.08. From Authors (2017)*

In this case, the wooden chair present advantages in all categories, with a remarkable negative value (credit) on the environmental impact of climate change and land use. The value of Clime Change potential shown for the two aluminum chairs is expected since the Aluminum has been reported to have an average of 16.5 Kg of CO2 Eq. per Kg of material (Jégourel, et al., 2015). Other authors claim that the media is lower, such as 9.7 Kg of CO2 Eq. per Kg of aluminum. In Brazil, it has been reported 4.2 Kg of CO2 Eq. per Kg of aluminum. (ABAL; CNI; DIRET, 2012) This study reported 31.49 Kg of CO2 Eq. for two chairs of 1.96kg mass. This means a unit value of 8.03 Kg of CO2 Eq. per Kg of aluminum. In the other hand, the negative (credit) value in the Climate change impact factor was also expected since the wood is known as a carbon Sink. Having a mass of 6.45 Kg, the wood accounting in the chair should store up to 11.1 Kg of CO2 Eq. Due the different production process, such value is then stated as 6.17 of CO2 Eq.
In the case of the land use, the values are also expected when considering the process of land occupation for mineral extraction site for the aluminum, whose characterization factor is up to 7500 Kg de C def per m2a. In the other hand, the land use of the wood includes a transformation from pasture and arable whose characterization factor is up to-125 Kg de C def per m2a. (credit). As for the rest of factors, the Fig 3 present the comparison:

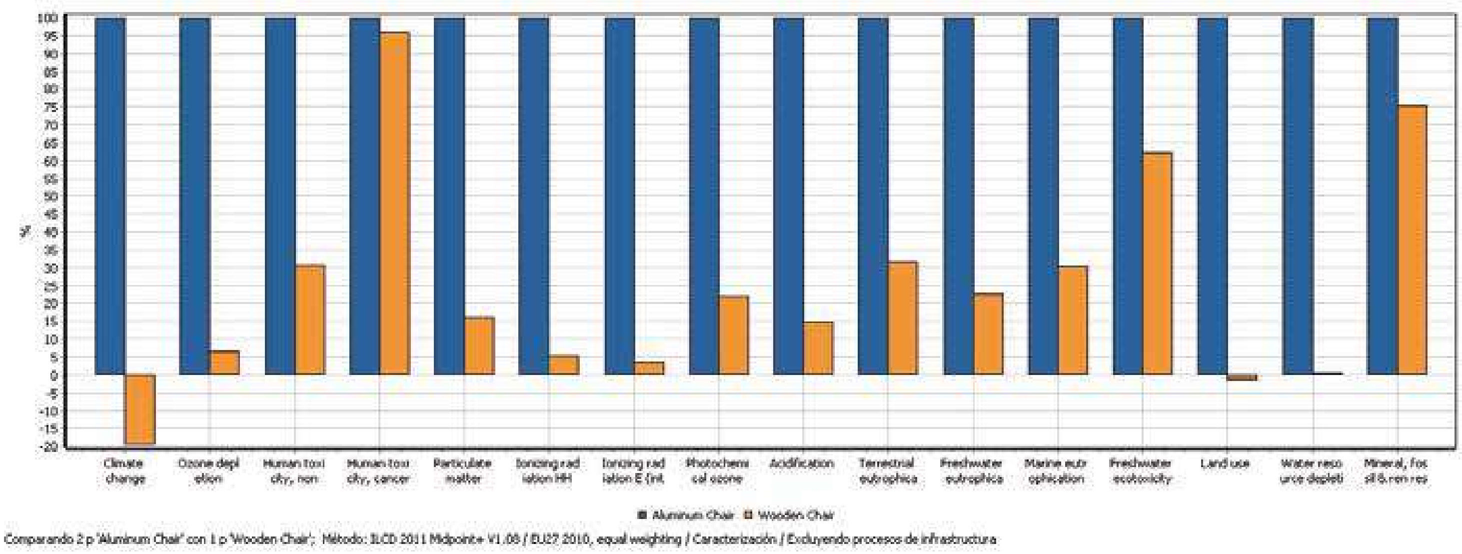

Figure 3: *Characterization of impacts. Wooden and aluminum chair. From Authors (2017)*

4| CONCLUSIONS.

The study presents the comparison of the environmental impacts of two different chairs to be used for 3 years in a shopping center in Salvador de Bahia, Brazil. The resource usage approach suggested remarkable advantages in the aluminum chair. In the other hand, when performing an environmental approach the result is different. The aluminum chair has in general biggest burdens and impacts due the energy intensity of the mining and aluminum production, as well as during the land use when considering environmental impacts. Given such scenario, it is then considered that choosing the wooden chair will become a more environmentally friendly purchase.
The results comply partially with ISO 14044 due to the allocation made during the production of the wood planks. The results are also referenced to the case of study in Salvador de Bahia, Brazil, since the distances measured from either the wood sources and the bauxite mines.
The study also demonstrates the high importance of knowing the environmental impacts of products when deciding between different alternatives of products. Even though a plain comparison of environmental impacts cannot be deduced from the direct reading of impacts of products in a simple label (due to the need of having a suitable functional unit), it is indeed agreed that having in hand such information could give more accurate purchase when taking in count the environment.
LCA has been proven to be an excellent method for assessing the environmental impacts of alternative products that perform the same service.

Acknowledgments

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ANÁLISIS DE CICLO DE VIDA COMPARATIVO BANDEJA DE EXHIBICIÓN, POLIPROPILENO VS ÁCIDO POLILÁCTICO

COMPARATIVE LIFE CYCLE ANALYSIS FOR AN EXHIBITION TRAY, POLYPROPYLENE VS POLYLACTIC ACID

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RESUMEN:

Para la exhibición de alimentos cárnicos en ambientes fríos se utiliza actualmente una bandeja de polipropileno (PP). Este trabajo busca evaluar el desempeño de un plástico elaborado a partir de ácido poliláctico (PLA) como materia prima alternativa para reemplazar el PP. El análisis fue realizado con base en las normas ISO 14044 y 14040 y sus límites se establecen de la cuna a la tumba. El modelo se desarrolló utilizando datos primarios de producción de bandeja y datos secundarios de Ecoinvent. La modelación de impactos se realizó utilizando el Software Umberto NXT LCA y los métodos de evaluación empleados fueron ReCiPe End point y CML 2001, el primero buscando conocer el impacto total sobre el ambiente y el segundo con el fin de obtener cada una de las huellas ambientales asociadas. Las etapas de manufactura, distribución, uso y disposición fueron modeladas con información primaria.

A pesar de que el PLA es una material obtenido a partir de una fuente natural y renovable, y que es degradable al final de su vida útil, se concluyó que esta opción tiene mayor impacto ambiental que la bandeja en PP en15 de 15 categorías de impacto analizadas

Palabras claves:

Bandeja, Análisis de Ciclo de Vida (ACV), Polipropileno (PP) Ácido Poliláctico (PLA), Umberto NXT LCA.

ABSTRACT:

For the exhibition of meat products in cold environments a polypropylene (PP) tray is actually used. This work evaluates the performance of a plastic made form Polylactic Acid (PLA) as a raw material alternative to replace the PP. The analysis was made based on the ISO 14044 y 14040 norms and the system boundaries are established form cradle to grave. The model was developed using primary data from the tray production and secondary data from Ecoinvent. The modelling of impacts was carried using the Software Umberto NXT LCA and the evaluation methods employed were ReCiPe End point and CML 2001, the first one with the intention of identifying the total impact on the environment and the second one to obtain each one of the associated environmental footprints. The manufacturing, distribution, use and disposal stages were modeled with primary information.

Even though PLA is a material obtained from a natural and renewable source, and that it is degradable by the end of its useful life, it was concluded that this option has a larger environmental impact than the PP tray in 15 of the 15 impact categories analyzed.

Keywords:

Tray, Life cycle assessment, (LCA), Polypropylene, Polylactic Acid, Umberto NXT LCA

METODOLOGÍA PARA EL DESARROLLO SOSTENIBLE DE MATERIALES BIOCOMPUESTOS

METHODOLOGY FOR THE SUSTAINABLE DEVELOPMENT OF BIOCOMPOSITES MATERIALS

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ABSTRACT:

Composite materials (CM) are used in the automotive, construction, electrical and packaging industries. The suitability for using two or more components to produce materials with hybrid properties such as high mechanical strength and lightweight have driven their market growth in recent years. The CM main ingredients are the plastic matrix and the filling. Both biopolymers and natural fibers belong to CM category and in this case, the product are denominated as biocomposite material (BM). According to our literature review of recent publications on BM, there was found a high emphasis on its technical performance. Some investigations analyze environmental aspects and very few consider the economic and social implications related to their production. Life cycle assessment (LCA) and other environmental evaluation tools have been proposed to fulfill the sustainable development requirements in the design and characterization of BM. Moreover, to date there is no methodology for integrating the technical, environmental, economic and social dimensions for MB design. This work describes a sustainable development methodology that integrates these four dimensions, evaluating each of them with quantifiable parameters (e.g. mechanical properties, LCA, life cycle cost and recyclability), facilitating the selection of MB components. This procedure will optimize technical and economic performance and enhance environmental and social benefits. As a case study, preliminary results of its application are presented in BM made with lignocellulosic residues in polymer/biopolymer hybrid matrices.

Keywords:

Sustainable development; Biocomposite materials; Methodology.

RESUMEN:

Los materiales compuestos (MC) son usados en la industria automotriz, construcción, eléctrica y de empaques. Su mercado ha crecido en los últimos años, porque pueden obtenerse materiales con propiedades híbridas al conjugar dos o más componentes, por ejemplo, alta resistencia mecánica y bajo peso. Sus ingredientes principales son la matriz plástica y el relleno. Tanto los biopolímeros como las fibras naturales se han incluido en los MC y en este caso, el producto se conoce como material biocompuesto (MB). Según una revisión de publicaciones recientes sobre MB se evidenció un fuerte énfasis en su desempeño técnico. Algunas investigaciones analizan aspectos ambientales y muy pocas consideran las implicaciones económicas y sociales relacionadas con su producción. Con el desarrollo sostenible han surgido metodologías de diseño y caracterización de productos, que incluyen evaluación ambiental, como el análisis del ciclo de vida (ACV). Además, hasta el momento no se ha encontrado una metodología que evalúe integralmente las dimensiones técnicas, ambientales, económicas y sociales para el diseño de MB. En este trabajo se describe una metodología de desarrollo sostenible que integra las cuatro dimensiones, evaluando cada una de ellas con parámetros cuantificables (por ejemplo, propiedades mecánicas, ACV, costo de ciclo de vida y reciclabilidad), facilitando la selección de componentes de los MB. Así se podrá optimizar el rendimiento técnico y económico y potencializar los beneficios ambientales y sociales. Como caso de estudios se exponen resultados preliminares de su aplicación en los MB fabricados con residuos lignocelulósicos en matrices híbridas polímero/biopolímero.

Palabras clave:

Desarrollo sostenible; Materiales biocompuestos; Metodología.

1| INTRODUCCIÓN

El diseño o rediseño de nuevos productos, entre ellos los nuevos materiales, se focalizan principalmente en obtener mejores propiedades técnicas a bajo costo (Prendeville et al. 2014). Sin embargo, los acuerdos en torno al desarrollo sostenible han llevado a considerar aspectos ambientales, sociales y otros intangibles (Ogunkah y Yang 2012). El diseño sostenible ha surgido como una metodología que integra diferentes aspectos del diseño muchas veces en competencia como el desarrollo económico y la preservación del medio ambiente (Knight y Jenkins 2009).

Los materiales biocompuestos (MB) se han desarrollado como una alternativa al uso de polímeros de origen petroquímico (Torres-Huerta et al. 2014) debido principalmente a su característica biodegradable. Sin embargo, el reemplazo parcial o total, aún requiere superar problemas de investigación, técnicos, económicos y experimentales (Gupta 2014; Xu et al. 2015). Los MB se componen de una matriz polimérica o biopolimérica y un refuerzo de fibras naturales. La integración de diferentes dimensiones sigue siendo un reto metodológico, más cuando se aplica a materiales complejos como MB (Zhao et al. 2016).
En este estudio se propone una metodología que integra las dimensiones técnicas, económicas, ambientales y sociales para la evaluación de MB. Cada dimensión es descrita, evaluada individualmente para seleccionar la opción más viable. Los resultados obtenidos corresponden a datos preliminares del estudio.

2| METODOLOGÍA

La Figura 1 muestra la metodología propuesta, basada en investigaciones previas de Ribeiro et al. 2008 y Carvalho et al. 2016.

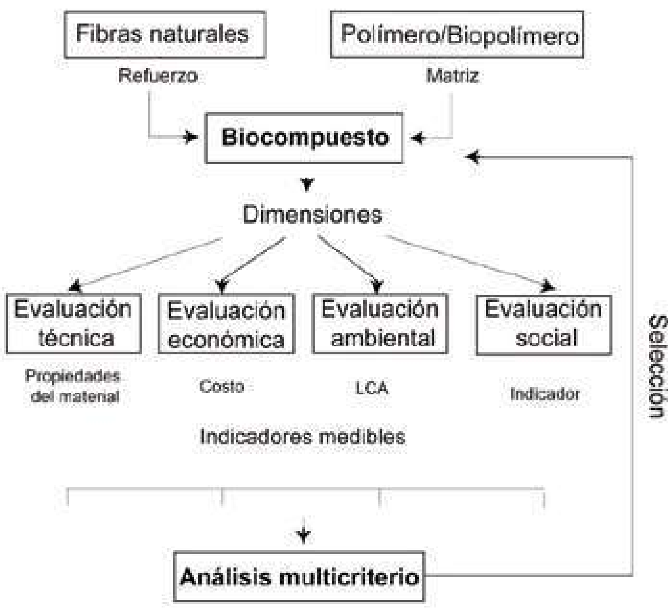

Figura 1 *Metodología para la evaluación de MB.*

Los MB son caracterizados de acuerdo a parámetros establecidos de cada dimensión. Para comparar los dos materiales los valores son adimesionalizados y ponderados. Cada dimensión es ponderada y se obtiene un indicador cuantitativo.

a. Evaluación técnica
La evaluación técnica se refiere principalmente a las propiedades mecánicas, químicas y/o físicas que los materiales deben cumplir para alcanzar los requerimientos técnicos del producto. Primero se identifican los requerimientos y su importancia relativa. Después, las propiedades de los materiales son correlacionadas con los pesos a través de una matriz de índices.

b. Evaluación económica
El costo del ciclo de vida es una recopilación y evaluación de todos los costos relacionados con un producto, a lo largo de todo su ciclo de vida, desde la producción hasta el uso, mantenimiento y eliminación (Benoît y Programme 2010). Los costos estimados en este documento se basan principalmente en valores obtenidos de la producción de los prototipos a nivel de laboratorio.

c.Evaluación ambiental

Esta dimensión se calcula mediante el ACV cradle-to-manufacture para el material biocompuesto de acuerdo a la metodología de las normas ISO 14040 y 14044 con el software SimaPro 8.3. En este estudio se consideran 8 categorías de impactos ambientales: agotamiento abiótico (A), potencial de acidificación (B), potencial de eutrofización (C), potencial de calentamiento global (D), toxicidad humana potencial (E), potencial de ecotoxicidad acuática de agua dulce (F), potencial de ecotoxicidad terrestre (G) y demanda energética acumulativa (H).

d. Evaluación social

El caso de usar fibras naturales extraídas a partir de residuos, puede generar fuentes de ingresos para las comunidades de agricultores y contribuir a la sostenibilidad y progreso de las regiones (Luz et al. 2010). Para su medición se tuvieron en cuenta categorías y subcategorías relacionadas con las metas del desarrollo sostenible (Sutherland et al. 2016). Para este estudio se incluyeron dos stakeholders: los pequeños agricultores y la sociedad.

3| RESULTADOS Y DISCUSIÓN

Como caso de estudio se elaboraron prototipos de estudio MB a partir de una bioresina epóxica y fibras naturales extraídas del seudotallo de plátano. La unidad funcional de estudio fue un tablero de dimensiones 0,5 m 0,01 m 0,5 m y se realizaron dos mezclas fibra:resina de 1:99 y 10:90. Las tablas 1, 2, 3 y 4 muestran los resultados obtenidos de las mediciones de los dos materiales. Tales datos fueron ponderados mediante análisis multicriterio, maximizando las dimensiones técnicas y sociales y minimizando las económicas y ambientales. El método utilizado es el de la entropía con un criterio mínimo, por lo tanto, al final se escoge la opción de los MB evaluados de menor valor.

Tabla 1. Evaluación Técnica

		10//90	1//99
Resistencia a la compresión	Mpa	8,96	16,79
	Adim.	53,4%	100,0%
Módulo de Young	Gpa	1,45	3,05
	Adim.	47,5%	100,0%
Tenacidad	Kj/m^2	0,56	1,14
	Adim.	49,1%	100,0%
Densidad	Vgr/cm^3	0,53	0,58
	Adim.	100,0%	91,4%
		62,5%	**97,8%**

Tabla 2. Evaluación Económica

	10//90	1//99
Materiales	$73.255	$73.422
Proceso	$8.000	$8.000
Costo total	**$81.255**	**$81.422**

Tabla 3. Evaluación Social

		10//90	1//99
Fibra recuperada/planta	gr	0,15	0,01
	Adim.	1,00	0,09
Costo adicional/racimo	$	232,0	21,2
	Adim.	1,00	0,09
		1,00	**0,09**

Tabla 4. Evaluación Ambiental

		10//90		1//99	
A	kg SB eq	5,93,E-04	1,00	6,61E-05	0,11
B	kg SO_2 eq	3,36,E-02	1,00	3,34E-02	0,99
C	kg PO^{-4}	9,09,E-03	1,00	9,06E-03	1,00
D	kg CO_2 eq	5,40,E+00	1,00	5,36E+00	0,99
E	kg 1.4 DBeq	7,31,E-01	1,00	7,17E-01	0,98
F	kg 1.4 DBeq	9,49,E-02	1,00	8,78E-02	0,93
G	kg 1.4 DBeq	2,99,E-01	1,00	3,00E-01	1,00
H	MJ	1,29,E+00	1,00	1,20E-01	0,09
			100%		**76%**

El aspecto técnico consideró 4 propiedades a las que se les asignó la misma importancia. El MB con el 1% de fibra fue el que presenta mejores propiedades técnicas y ambientales. En el primer caso, se debió posiblemente al aumento de los puntos de propagación de grietas en el material, por inclusión de la fibra; en el segundo, porque la bioresina es ambientalmente más amigable que sus contrapartes petroquímicas. El MB con el 10% de fibra presenta mejores características económicas y sociales. Aunque, el costo de la fibra es menor al de la bioresina, se pueden lograr ingresos adicionales para los agricultores, cuando se usa en una mayor cantidad material desechado.

Tabla 5. Datos de los 2 MB

MB	Eco	Amb	Téc	Soc
10//90	$81.255	100	0,63	100
1//99	$81.422	76	0,98	9,14
Crit.	**Min**	**Min**	**Max**	**Max**

Tabla 6. Calificación de los 2 MB suma ponderada

Prov.	Eco	Amb	Téc	Soc	
10//90	0,50	0,57	0,61	0,08	**0,12**
1//99	0,50	0,43	0,39	0,92	**0,88**
Sum.	1,00	1,00	1,00	1,00	**1,00**
W	0,00	0,02	0,06	0,92	

4| CONCLUSIONES

En este estudio se describió una metodología para el desarrollo sostenible de materiales biocompuestos (MB). La metodología integra cuatro dimensiones para la selección de mezclas de MB, mediante el análisis multicriterio de entropía. Un caso de estudio de selección de MB con diferentes proporciones de fibras extraídas del seudotallo de plátano y una bioresina fue presentado. El MB con mayor cantidad de fibra fue el material seleccionado. La evaluación integral brindará características para ser más fácilmente comparados con diferentes materiales comerciales.

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PARÂMETROS AMBIENTAIS PARA ECODESIGN (PAE): aplicação do método em produtos em metal

ENVIRONMENTAL PARAMETERS FOR ECODESIGN (EPE): application of the tool in products made on metals

PARÁMETROS AMBIENTALES PARA EL ECODISEÑO (PAE): aplicación del método en productos de metal

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RESUMO:

O presente estudo visa analisar os parâmetros de Programas de Rotulagem Ambiental com vistas a sistematizar seus dados e informações, facilitando a tomada de decisões no processo de design. Baseia-se em trabalhos anteriores que demonstram a importância da abordagem do pensamento de ciclo de vida atualmente na prática do design, bem como a necessidade de metas quantitativas para que objetivos ambientais sejam atingidos. O método adotado está fundamentado na aplicação da ferramenta Parâmetros Ambientais para Ecodesign (PAE), que visa facilitar e otimizar a utilização de critérios e parâmetros de rotulagens ambientais como referência para o design de produtos, mesmo que a obtenção do ecoselo não seja o objetivo da empresa. Isso é possível para categorias de produtos, materiais e processos, na tentativa de tornar mais acessíveis os parâmetros e metas ambientais do produto, especialmente para microempresas e pequenas empresas (MPEs). Primeiramente, foram analisados os sectores de produção mais importantes em Minas Gerais, Brasil, para se decidir sobre qual categoria de produto estudar. Em segundo lugar, todos os programas de rotulagem ambiental membros do Global Ecolabelling Network foram analisados a fim de se aplicar a ferramenta PAE. O resultado traz a aplicação da ferramenta PAE para a categoria de produtos em metal. Este estudo analisa quatro programas que possuem procedimentos de certificação específicos para produtos em metal: ABNT-Ambiental, Environmental Choice Nova Zelândia, Ecolabelling dos Países Nórdicos e Ecolabelling da República Checa. O estudo faz parte de uma pesquisa mais ampla que visa desenvolver uma plataforma digital para fornecer parâmetros ambientais em diversas categorias de produtos (definido até agora para produtos em madeira, papel e metal). Concluindo, os estudos têm demonstrado que a rotulagem ambiental pode ser uma fonte para o processo de design, aplicando a ferramenta PAE para traduzir as complexas diretrizes dos ecoselos e facilitar o acesso, especialmente para MPEs.

Palavras-chave:

Ecodesign; Design de produto; Rotulagem Tipo-1; Programas de Rotulagem Ambiental; MPEs.

ABSTRACT:

The present study seeks to analyse the quantitative and qualitative parameters, based on the life cycle, of Environmental Labelling programs in an attempt to systematise these data and information, in turn facilitating the decisions made in the design process. The study is based on prior works that demonstrate the importance of a life cycle thinking approach in current design tasks as well as the need for quantitative targets to achieve environmental goals. The method employed is founded on the application of the Environmental Parameters for Ecodesign (EPE) tool, which seeks to both facilitate and optimise the use of ecolabel criteria and parameters as references for product design, even if obtaining ecolabels is not the core aim of a company. This is possible for product categories, materials and processes, in an attempt to make the product environmental parameters and targets more accessible, especially to microenterprises and small businesses (MSEs). Firstly, it has been analysed the most important production sectors at Minas Gerais State, Brazil, to decide which product category to study. Secondly, all environmental labelling programs from the Global Ecolabelling Network have been studied to apply the EPE tool. The result shows the application of EPE tool for the category of products made on metals. This study analyses four programs which have specific certification procedures for products made on metals: ABNT-Ecolabel, Environmental Choice New Zealand, Nordic Ecolabelling and the Ecolabelling from Czech Republic. The study is part of wider research that aims to develop a digital platform to provide environmental parameters for divers product categories (defined so far for wood, paper and metal products). In conclusion, the studies have shown that environmental labelling can be a source for design process by applying EPE tool in order to translate the complex ecolabels guidelines and facilitate the access, especially by MSEs.

Keywords:
Ecodesign; Product design; Type 1 Ecolabelling; Environmental Labelling Programs; MSEs.

RESUMEN:
El artículo presenta un estudio para analizar los parámetros cuantitativos y cualitativos, basados en el ciclo de vida, de Programas de Etiquetado Ambiental con el fin de sistematizar los datos y la información, facilitando la toma de decisiones en el proceso de diseño. El estudio se basó en trabajos anteriores que demuestran la importancia del enfoque del pensamiento del ciclo de vida en la práctica del diseño actual, y la necesidad de metas cuantitativas para que se realicen los objetivos medioambientales. El método se basó en la aplicación de la herramienta Parámetros Ambientales para el Ecodiseño (PAE) que tiene como objetivo facilitar y optimizar el uso de los criterios y parámetros de etiquetas ambientales como referencias para el diseño de productos, incluso si la obtención de la etiqueta no es el objetivo central de la empresa. Esto es posible para las categorías de productos, materiales y procesos, en un intento de hacer que los parámetros y objetivos ambientales del producto sean más accesibles, especialmente para las micro y pequeñas empresas (MYPE). En primer lugar, los sectores de producción más importantes fueron analizados en el Estado Minas Gerais, Brasil, para decidir qué categoría de productos estudiar. En segundo lugar, se analizaron los programas de etiquetado ambiental miembros del Global Ecolabelling Network con el fin de aplicar la herramienta PAE. El resultado trae la implementación de la herramienta PAE para la categoría de productos de metal. Este estudio examina cuatro programas que tienen procedimientos específicos de certificación para productos de metal: ABNT-Ecolabel, Environmental Choice Nueva Zelanda, Etiquetado Ambiental de los países nórdicos y Etiquetado Ambiental de la República Checa. El estudio es parte de una investigación más amplia destinada a desarrollar una plataforma digital para proporcionar parámetros ambientales en diversas categorías de productos (hasta ahora fijado para productos de madera, papel y metal). En conclusión, los estudios han demostrado que el etiquetado ambiental puede ser una fuente para el proceso de diseño, desde la aplicación de la herramienta PAE para traducir las complejas directrices de las etiquetas y facilitar el acceso, especialmente para las MYPE.

Palabras clave:
Ecodiseño; Diseño del producto; Etiquetado de tipo-1; Programas de Etiquetado Ambiental; MYPE.

1| INTRODUÇÃO

Na última década, estudos têm mostrado que, atualmente e cada vez mais, a prática do ecodesign necessita de parâmetros específicos, sobretudo quantitativos, capazes de garantir que metas ambientais possam ser alcançadas (ALBINO et al., 2009; ASKHAM et al., 2012; CHANG et al., 2014; HAUSCHILD et al., 2005; HOUE e GRABOT, 2009; PARK et al., 2006; SANYÉ-MENGUAL et al., 2014; SOUSA e WALLACE, 2006).
Critérios apresentados em rotulagens ambientais (ecoselos) se apresentam como fonte de indicadores quantitativos, e também de prescrições qualitativas, que podem ser usados como referência para ecodesign.
Nesse sentido, a ferramenta PAE - Parâmetros Ambientais para Ecodesign é proposta por Pereira e Soares (2016), tendo como referência a análise dos Programas de Rotulagem Ambiental, isto é, a rotulagem do tipo I. Seu objetivo é sistematizar os dados e informações fornecidas pelos procedimentos apresentados pelos Programas de Rotulagens Ambientais, e disponibilizá-los, facilitando a tomada de decisão no processo de design, e dirigindo especial olhar para micro e pequenas empresas (MPEs).

2| METODOLOGIA

A metodologia adotada compreendeu duas fases. Primeiramente, foi realizado um estudo sobre os setores produtivos de interesse, para se compreender quais os ramos mais importantes, tomando-se como referência o Estado de Minas Gerais, Brasil. A categoria de produtos em metal foi definida como aquela de maior destaque na produção, ligada a atuação do design. Em seguida, foram feitas análises dos Programas de Rotulagem Ambiental que compõem o Global Ecolabelling Network (GEN), com o objetivo de encontrar procedimentos de certificação específicos a categoria de produtos em metal.
Foram selecionados os programas de rotulagem brasileiro ABNT Ambiental, o da Nova Zelândia, dos Países Nórdicos, membros do GEN, além do da República Tcheca, que mesmo não sendo membro do GEN, apresenta procedimentos ambientais para a categoria de móveis em metais.

3| RESULTADOS

A ferramenta PAE tem por objetivo apresentar organizadamente parâmetros ambientais, quantitativos e qualitativos, descritos de maneira didática e legível para sua aplicação prática e efetiva por designers. O Quadro 2 abaixo apresenta sua aplicação na categoria de produtos em metal.

Quadro 2 – Aplicação da ferramenta Parâmetros Ambientais para Ecodesign para a categoria de produtos feitos em metal.

Parâmetro 1: descrição do produto e matéria-prima	**Referência**
1.1 Janelas e portas devem usar certa proporção de reciclados (exceções no parâmetro 1.2): - Pelo menos 30% de alumínio reciclado nos perfis ou folhas da porta; - Pelo menos 20% de aço reciclado em perfis ou folhas da porta devem ser de aço reciclado. Aço inoxidável não é permitido em perfis de janelas ou folhas das portas. **1.2** A exigência de material reciclado não se aplica a: revestimento externo de componentes de madeira com finalidade contra intempéries; polímero composto, materiais que representem menos de 3% em peso da janela; dobradiças, puxadores, acessórios; isolamento de janela e porta externa; componentes não-renováveis em vidro de painéis de isolamento.	Programa de Rotulagem dos Países Nórdicos 2014 (NE, 2014).
1.3 Quando o aço contido no produto for de mais de 50% do seu peso total, deve-se usar material reciclado, e sucata como matéria-prima secundária na produção de aço, de pelo menos 20%. Se o teor de alumínio for de 15 a 50% do seu peso total, a entrada de materiais reciclados de alumínio deve ser de pelo menos 20%. Em um produto contendo mais de 50% de alumínio, a entrada de materiais reciclados deve ser de pelo menos 30%. **1.4** Os materiais de metal devem ser processados sem o uso de emulsões para corte (óleos solúveis e fluidos semi-sintéticos). **1.5** Chapas de aço não devem ser cobertas com cromo, níquel, estanho e seus compostos. Em casos excepcionais, quando há grande atividade física, pode haver superfície revestida com cromo ou níquel.	Programa de Rotulagem da República Tcheca (CENIA, 2015).
Parâmetro 2: utilização de substâncias perigosas	**Referência**
2.1 Os produtos de aço não devem ser tratados com compostos que contêm mercúrio, chumbo, cádmio, cromo hexavalente, arsênio ou seus compósitos (exceto quando permitido nos termos do parâmetro 2.4).	Programa de Rotulagem da Nova Zelândia (ECNZ, 2015).
2.2 O fabricante deve restringir a concentração de chumbo, cromo hexavalente e cádmio caso haja tratamento superficial no aço: valor máximo permitido em % para chumbo e cromo hexavalente = 0,1, para cádmio = 0,01.	Programa de Rotulagem ABNT Ambiental (ABNT, 2014).
2.3 Substâncias utilizadas para o tratamento de superfícies de móveis de metal, incluindo tecnologia de desengorduramento, não podem conter substâncias químicas que são classificadas como muito tóxicas, perigosas para saúde e meio ambiente e não devem ser classificadas como cancerígenas, prejudiciais ao sistema reprodutivo. **2.4** Zinco e aço revestido de liga de zinco podem ser passivados com soluções de cromato contendo cromo hexavalente (cromo 6+).	Programa de Rotulagem da República Tcheca (CENIA, 2015).
2.5 As peças pequenas, como parafusos, dobradiças, etc. são isentos dos requisitos acima, exceto as peças que são destinadas a entrar em contato freqüente com a pele. **2.6** O óleo combustível ou qualquer matéria-prima e/ou insumo que componha o processo não deve conter mercúrio ou seus compostos. **2.8** Os materiais de isolamento térmico não devem conter retardadores de chama halogenados contendo bórax ou ácido bórico.	Programa de Rotulagem dos Países Nórdicos 2014 (NE, 2014).
Parâmetro 3: acabamento da superfície	**Referência**
3.1 As perdas de revestimentos não devem exceder 10% em peso. Tinta em pó não deve exceder 30% em peso. Resíduos de revestimento não podem exceder 5% em peso.	Programa de Rotulagem da República Tcheca (CENIA, 2015).
Parâmetro 4: montagem do produto	**Referência**
4.1 A montagem deve estar de acordo com os princípios da reciclagem: produto de fácil desmontagem, o uso de juntas mecânicas para unir	Programa de Rotulagem da República

Fonte: Adaptado de Pereira e Soares (2016).

4| CONCLUSÃO

Este estudo se insere em pesquisa mais ampla, que tem como objetivo o desenvolvimento da plataforma digital "Prioridade Ambiental", que visa disponibilizar parâmetros quantitativos e qualitativos, oriundos de Programas de Rotulagem Ambiental (rotulagem Tipo I), permitindo seu uso para ecodesign e transferência de informação e tecnologia ao setor produtivo, com destaque a MPEs. Seu desenvolvimento baseia-se na aplicação da ferramenta PAE - Parâmetros Ambientais para Ecodesign (Pereira e Soares, 2016).

Foi definida a categoria de produtos em metal para este estudo como sendo aquela de maior destaque, após análise dos setores produtivos de interesse, tomando-se como referência o Estado de Minas Gerais. Os Programas de Rotulagem Ambiental, que compõem o Global Ecolabelling Network, foram cuidadosamente estudados com o objetivo de se encontrar procedimentos de certificação específicos para a categoria de produto em metal.

Cada critério específico contido nos procedimentos dos programas analisados foi organizado de acordo com a ferramenta PAE, incluindo materiais, substâncias perigosas, acabamento da superfície, montagem e fim-de-vida.

A ferramenta PAE pode contribuir para o ecodesign, na medida em que se apresenta como veículo de transferência de conhecimento para os atores envolvidos na fabricação de produtos. Trata-se de uma ferramenta capaz de traduzir as complexas orientações definidas pelos Programas de Rotulagem Ambiental, facilitando seu acesso àqueles interessados em adotar práticas que visem à diminuição de impactos ambientais, especialmente as MPEs.

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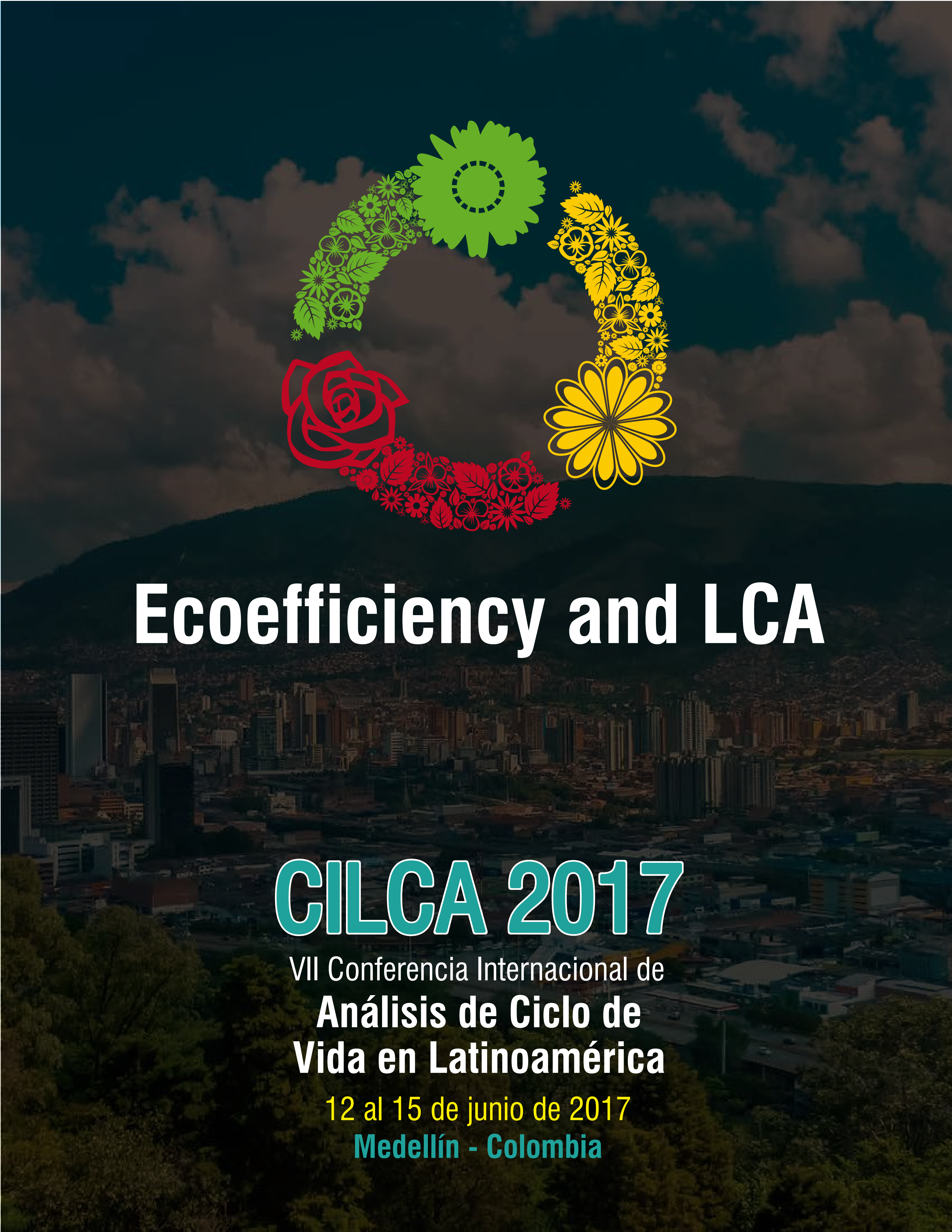
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PROPOSAL OF DESIGN PATTERNS IN MATERIAL AND ENERGY FLOW NETWORK MODELS

PROPUESTA DE PATRONES DE DISEÑO EN MODELOS DE REDES DE FLUJOS DE MATERIALES Y ENERGÍA

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ABSTRACT:

Efficiency and consistency are the key strategies to achieve a more sustainable development and address impending environmental threats like e.g. the global climate change. A powerful tool for impact assessment as well as efficiency optimization is the material flow analysis (MFA), using models of material and energy flow networks representing production processes. In different projects this type of models has been used for life cycle assessment (LCA), material flow cost accounting (MFCA), energy and resource efficiency analysis, consumption baseline calculations and a variety of other ecological, economical or efficiency analysis.

The elaboration of the complex models costs time and money, but in large part the resulting models are not very comprehensible due to complexity and missing common standards. By focusing on only one specific perspective normally the models are only apt for a part of the possible descriptive and analytical uses. Neither models nor components of models are commonly considered for reusability.

As an analogy to the design patterns used in computer science the author therefor proposes an investigation to perceive a framework of rules and patterns for material and energy flow modelling. Using a design pattern approach could propagate reusability within material and energy flow networks and help to enable multi-perspective analysis of production systems using only one optimized model for all the possible descriptive and analytical purposes.

Keywords:

material flow analysis (MFA), material and energy flow networks, eco efficiency, optimization, industrial processes, design patterns

RESUMEN:

La eficiencia y la consistencia son las estrategias clave para lograr un desarrollo más sostenible y abordar amenazas ambientales inminentes como p.ej. el cambio climático. Una herramienta poderosa para la evaluación de impactos y la optimización de la eficiencia es el análisis de flujos de materiales (AFM), utilizando modelos de redes de flujos de materiales y energía que representan los procesos de producción. En diferentes proyectos este tipo de modelos se ha utilizado para el análisis de ciclo de vida (ACV), la contabilidad de costos de flujo de materiales (CCFM), análisis de eficiencia energética y de recursos, cálculos de linea base de consumos y una variedad de otros análisis ecológicos, económicos o de eficiencia.

La elaboración de los modelos complejos cuesta tiempo y dinero, pero en gran parte los modelos resultantes no son muy comprensibles debido a la complejidad y falta de normas comunes. Al centrarse en una sola perspectiva específica, normalmente los modelos sólo son aptos para una parte de los posibles usos descriptivos y analíticos. Ni los modelos ni los componentes de los modelos se consideran comúnmente para una reutilización.

Como una analogía con los patrones de diseño utilizados en el desarrollo de software, el autor propone un marco de reglas y patrones para el modelado de redes de flujos de materiales y energía. El uso de un enfoque con patrones de diseño podría propagar la reutilización dentro de las redes de flujo de materiales y energía y ayudar a permitir el análisis multi-perspectiva de los sistemas de producción utilizando sólo un modelo optimizado para todos los posibles propósitos descriptivos y analíticos.

Además, los patrones de diseño pueden propagar de manera efectiva las soluciones más eficientes y consistentes a las necesidades de procesos industriales.

Como resultado, se introduce un conjunto de patrones de diseño propuestos en diferentes niveles de solución.

Palabras clave:

análisis de flujos de materiales (AFM); redes de flujos de materiales y energía; eco eficiencia; optimización; procesos industriales; patrones de diseño.

1| INTRODUCTION

With the publication of "The limits of growth" (Meadows & Club of Rome, 1974) nearly 40 years ago it already became clear that at a certain point only a sustainable development can ensure further economic and industrial growth without endangering our very livelihood as the human race. The key strategies of sustainable development are efficiency, consistency and subsistence, searching to improve input/output ratio, harmonizing production materials with our eco-system and questioning the need for the abundance of today's products, respectively (Grunwald, 2006; Schaltegger, Burritt, & Petersen, 2003).
Especially efficiency is seen as the most effective strategy, providing obvious benefits for the environment and the companies at the same time. In the struggle to limit climate change, energy efficiency counts as the most important measure to decrease the still rising greenhouse gas emission rate. Resource efficiency and particularly energy efficiency are seen as a key ingredient in fighting climate change (OECD/IEA, 2013). The consistency strategy aims at forming closed cycles in the material flows (cradle to cradle) and harmonizing the material and energy with ecosystem flows (e.g. renewable energies, bio or "eco friendly" materials). The overall goal is to increase the eco-efficiency of processes and products, by improving the ratio between the generated value and ecological impacts caused (Schaltegger et al., 2003; Schultmann, 2003).
Both efficiency and consistency approaches can be supported by the instrument of material flow analysis (MFA), using models of material and energy flow networks to assess, analyze, simulate and plan more efficient and consistent production systems (Lambrecht, 2011; Moeller, Prox, Schmidt, & Lambrecht, 2009; OECD, 2008; Penkuhn, 1997; Viere, Brünner, & Hedemann, 2011).

2| PROBLEM STATEMENT

By including all processes of a production system in a detailed material and energy flow network, the model can grow to a remarkable complexity, including sub-levels representing process details.
Due to missing standards or norms on how to model a production system in a material and energy flow network, the resulting network models are in large part exceedingly different in design, detailedness and completeness, among others.
The models might serve well for the original author and for the intended purpose (e.g. a LCA or an optimization project), but may not be adequate to enable (re-)use of the valuable knowledge and data stored in the model for analysis with different perspectives, wasting the opportunity of an actually integrated, multi-perspective view of a production system.
To fully appreciate the time and money invested in the elaboration of a material and energy flow model, it should serve for all kinds of analysis and tools applicable on such a model.
A solution could be a framework of rules and patterns for the modelling of production systems, which helps to structure the models in the best possible way and to support or at least facilitate integration of the different perspectives for eco efficiency evaluation and optimization, including among others exergy analysis (Dinçer, 2007; Velásquez, Agudelo, & Chejne, 2011) or material flow cost accounting (Bode, Bürkle, Hoffner, & Wisniewski, 2011; Möller, Viere, Prox, & Schmidt, 2011).

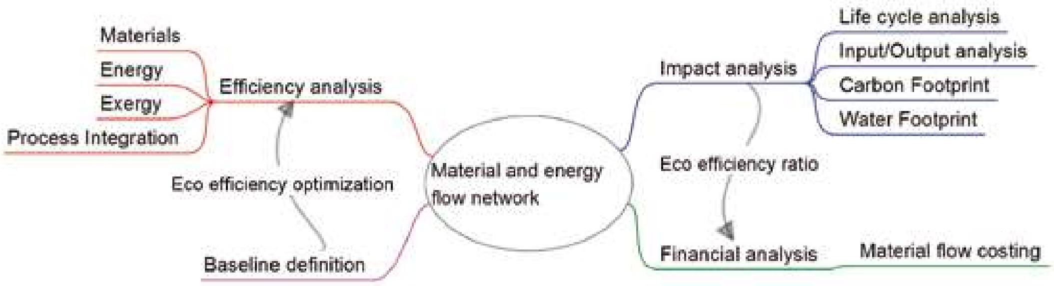

Figure 1: *Material flow networks and eco efficiency (own elaboration)*

An analogy from the realm of computer science (and also architecture and pedagogy) is the application of design patterns. These patterns evolve as the most effective, efficient and reusable solution to common (object oriented) design problems (Gamma, 1995). As object oriented design in computer science is also partly an approach to model a representation of real world objects and processes, it is considered if this approach can be used as well on material flow networks that represent industrial processes. The design pattern approach already has found its way into pedagogics and space systems architecting, among others (Bergin, 2012; Hein, 2012; Kelly, 2013).

3| METHODOLOGY

It is deemed possible to define a framework of methodically perceived design patterns and underlying modelling rules for material and energy flow network models which facilitate the creation and reuse of well structured, comprehensible models and enable a multi perspective analysis including efficiency analysis, impact assessment, financial analysis and baseline consumption calculation.
The main objective therefor is the development of a framework of design patterns and other modelling rules for the elaboration of material and energy flow network models that enable a multi perspective eco efficiency analysis of production systems. The specific objectives include

- Identification, abstraction, categorization and organization of common objects in production systems and their respective attributes and hierarchies

- Identification of common modelling challenges and best practices for their solution (including common antipatterns, i.e. worst practices)

- Investigation and formalization of the necessities (i.e. context and forces, see figure 2) of each of the mentioned analysis perspectives (including exergetic analysis)

- Extraction of an initial set of design patterns and modelling rules for the elaboration of material flow networks

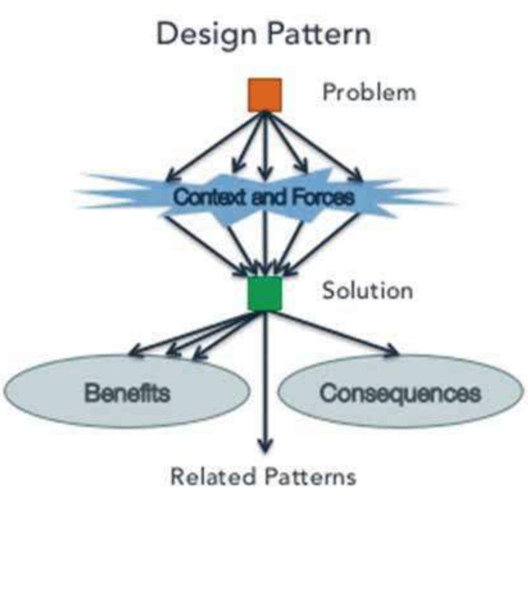

Figure 2: *Formation of design patterns and anti-patterns (White, 2014)*

To reach the proposed objectives a methodology consisting of various parts is deployed. After an extensive literature research on material and energy flow modelling and different analysis perspectives, the findings will be consolidated and enriched by a field study reviewing a multitude of model implementations and performing interviews with modelling experts. The extracted framework of patterns and rules will be documented in an adequate design pattern definition form and tested in a number of case studies.

4| RESULTS AND DISCUSSION

The expected result is a set of fundamental patterns and rules that can be applied in material and energy flow network models. Up to now 3 categories of design patterns in that realm have been identified. Modelling patterns help to solve problems on how to present real life production processes in the flow network models, e.g. the "infras-tructure equipment pattern" on how to include lighting or climatization in the model of a production system, when there is no direct connection to the reference flow. Efficiency patterns represent resource-, energy- or eco-efficient solutions for common production system efficiency challenges that can be reflected in modeling (and therefor simulation and planning), e.g. waste heat reuse patterns or renewable energy integration patterns. Consistency patterns focus on the industrial ecology approach to "close cycles" and may be applied also as integration between different models, trying to connect outputs (sub-products and wastes) of one production system with necessary resource inputs of another (Ayres, 1989).

5| CONCLUSIONS

It has been shown, that in the necessary strive for a more sustainable development, powerful tools which facilitate integral, multi-perspective views on production systems are needed. The lack of sufficient rules, definitions and patterns for material and energy flow networks restrains the full potential of these valuable models.

Therefor this investigation has been started to identify recurring components, common design problems and mandatory process information for the integration of different analysis perspectives.

The development of a framework of design patterns and modelling rules might help to solve the stated problems and serve as a practical tool for a better approach to identify and realize eco efficiency gains.

In the domain of object oriented programming the pattern approach not only helped to improve the overall design of system modelling, but also introduced a new and more effective communication where the mentioning of the name of a well-known pattern saved a lot of explications and details. A propagation of this type of "pattern language" could also facilitate the replication of eco efficient solutions in industrial processes.

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ANÁLISIS DE ECOEFICIENCIA DEL SISTEMA DE PRODUCTOS DEL ACERO RECICLADO

ECOEFFICIENCY OF THE STEEL PRODUCTS SYSTEM

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RESUMEN:
Se desarrolló un LCA de la cuna a la tumba considerando el sistema de productos de Gerdau en Chile, que produce sólo productos de acero reciclado para la construcción, bajo altos estándares de calidad. Para esto se consideró el cilco de vida de los dos principales productos de Gerdau, las barras de refuerzo y los perfiles de acero. Se condujeron varios talleres con la empresa para establecer primero los límites del sistema y la unidad funcional y posteriormente, para definir la función de valor para el modelo de eco-eficiencia conforme a la ISO 14045;2012.. El modelo de ecoeficiencia se desarrolló para ser implementado como parte de su gestión sustentable.

Palabras clave:
acero, LCA, eco-eficiencia,, ISO: 14045, gestión sustentable

MATERIAL FLOW COST ACCOUNTING AS A LIFE CYCLE IMPROVEMENT ASSESSMENT INSTRUMENT

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ABSTRACT:

Since several years Material Flow Cost Accounting (MFCA) is discussed as a cost accounting instrument within the life cycle assessment (LCA) framework. However, the role of MFCA as a life cycle assessment instrument is not evident, especially the differences to life cycle costing. This contribution discusses MFCA as a life cycle improvement assessment tool. Even if the title of the instrument refers to cost reductions, the concept can be used to reduce environmental impacts too, for instance product carbon footprints.

Keywords:
Material Flow Cost Accounting, Life Cycle Improvement Assessment, Process-Oriented LCA, Material Loss

1| INTRODUCTION

The 1993 SETAC code of Practice defines Improvement Assessment as a “component of an LCA in which options for reducing the environmental impacts of burdens of the system(s) under the study are identified and evaluated” (SETAC 1993, p. 24). Later, this dimension of LCA has been sunken into oblivion. However, improvement assessment is still an important part of LCA.
The aim of this contribution is to clarify how Material Flow Cost Accounting (MFCA, METI 2007, ISO 2017) can be used as a life cycle improvement instrument. Starting-points are obvious inefficiencies in production. MFCA can be applied to quantify the “true” costs of wastage or material loss systems (cf. Schmidt, Nakajima 2013). These costs not only include waste disposal costs. MFCA assess all costs along the supply chain that can be allocated to material losses, in particular the costs, which occur in the pre-chains. In other words, MFCA follows basic ideas of life cycle assessment and is not restricted to costs and specific system boundaries. MFCA in a broader sense assesses all economic and ecological impacts relating to material losses and therefore quantify inefficiencies within supply chains and product systems. In the following the building blocks of MFCA as a formal method are discussed.

2| METHODOLOGY – MFCA AS A FORMAL METHOD

Life cycle assessment can be seen as a set of decision support instruments. The focus of the instruments is on the assessment of environmental impacts of products or services. Decision makers in companies may use the insights provided by life cycle assessment to reduce the environmental burden of their products and services by selecting the raw materials and intermediate products with the lowest environmental impacts. Such a decision situation can be characterized as material selection. However, this is only one option to reduce environmental burdens. Another option is to improve internal production processes within a certain company: improved chemical processes, adoption of new technologies etc.
Different approaches can be applied to assess the improvement potential of redesigned internal processes, for example sophisticated optimization algorithms. An obvious procedure in the context of life cycle assessment is to conduct two different life cycle assessments, one for the already existing production system or supply chain (default scenario) and a second for the optimized production system (scenario of the optimized system). By calculating the differences between the two scenarios, the improvement potential can be quantified.
MFCA avoids the modeling of two different scenarios. A first advantage of such an approach is that MFCA reduces the modeling efforts. A second advantage is that this avoids inconsistencies in the modeling process. The disadvantage of this approach is that completely different process specifications and flow sheets are not possible. The application domain of MFCA is to avoid wastefulness.

As a consequence, MFCA has to provide means to derive the scenario of the optimized production system from the default scenario: a mapping between process specifications. Therefore, a specific keyword has been introduced: material loss. Material is used to identify and to designate avoidable waste formation within production systems. It can be supposed for an optimized production system that material losses do not longer occur. The specification of material loss becomes part of a mapping between the default scenario and the scenario of the optimized system. But this is not the only modification of the respective process specifications. The savings of material loss cause reduced raw materials, lower energy consumption etc. Different approaches are discussed to derive these reductions:

(1) Modeling experts specify directly the inputs (and other outputs: emissions) that go into material loss and the products. As a result, the process specification consists of the separated parts: one for products and one for material losses. The specification for products and material losses is applied in the default scenario, the specification for the products only in the scenario of the optimized production system (cf. Nakajima 2006).

(2) A second approach is to approximate the process specification for the optimized system with aid of allocation rules. In this approach only one process specification is r equired. In addition, an allocation rule must be stated, for instance economic allocation. An algorithm can apply the allocation rule to partition the process specification (cf. Viere et al. 2011).

(3) A third option is to provide means to directly specifying the process specifications for the default scenario and the scenario of the optimized system. Here, the entire process specification consists of two separated parts.
It is important to note that the approaches are based mainly on assumptions and knowledge about the technical processes. Because improvement assessments are future-oriented, primary data is not available. Later, after realizing the improvements, the assumptions can be compared with the realized improvements.
The approaches allow deriving modified process specification for all processes, for which material losses are specified. In the most cases, it is possible to calculate the scenario of the optimized production system. As a result, we get the inventories for the two scenarios. To assess the total improvement it is necessary to calculate the difference of the inventory of the default scenario and the inventory of the optimized production system. By multiplying the entries of the inventories with their respective market prices, the costs and revenues can be determined.
It is common to visualize the results as a so-called cost matrix. The cost matrix expands conventional cost reports by introducing two additional columns so that we get three columns: product, material and total costs. The "product" column shows the costs of the optimized production system, the "material loss" column the improvement potential (or the costs of being wasteful).

3| ENHANCEMENTS

In this chapter, we discuss challenges regarding system boundaries and non-linear production systems. So far, the system boundaries are not mentioned. Typical system boundaries in cost accounting are companies, plants or production systems. This is not sufficient to assess environmental impacts. It is necessary to model cradle-to-gate production systems. In such a case the MFCA approach can be used as a life cycle improvement assessment tool.
However, the calculation of cost reduction may be an attractive side effect of such an instrument. This makes it necessary to specify two different system boundaries: the life cycle and the company (or production process). MFCA as a formal method has to be applied two times: (1) for the assessment of environmental impacts and (2) for the assessment of costs. Because this takes place with aid of computers, nowadays this is not an important additional effort.
A methodological problem refers to the mapping between the default scenario and the scenario of the optimized system. This mapping approach expects that the modifications have – with regard to the behavior of other processes – only local effects. All other processes exhibit an approximately linear behavior and only have to be rescaled. This is done by the life cycle inventory calculation step (normally by applying a matrix method (Heijungs, Suh 2002)).
In some cases this is not an appropriate assumption. In cost accounting, it is very common to specify process with aid of affine-linear functions with fixed and variable costs. By ignoring fixed costs, the MFCA tends to over-estimate the improvements potential. Another problem are recycle streams (cf. Viere et al. 2010).

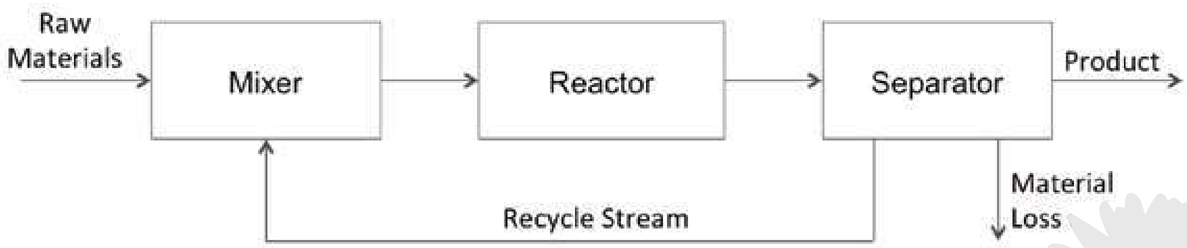

Figure 1. *Reference Model for Chemical Processes with Recycle Streams*

Figure 1 shows a reference model in chemical engineering (cf. Finlayson 2012). The aim of using MFCA could be to assess the improvement potential of an improved separator unit (reduction of the waste streams). Because of the recycle stream, this influences at least the mixer process. If the improved separator process results in a higher recycle stream, virgin raw materials can be saved. In other words, the production coefficients of the mixer process must be updated. Moreover, it can happen that the improvements influence the chemical reactor (different chemical equilibrium).

Providing modified process specifications for the mixer and the chemical reactor cannot do this, because a new steady state for the loop has to be determined. This introduces a new formal calculation method into the life cycle assessment: It is not longer possible to only adopt already existing procedures like the matrix method. It is necessary to apply approaches that deal with non-linear process specifications, for example the sequential modular approach or the equation-oriented strategy in chemical engineering (cf. Westerberg at al. 1979). These approaches allow the specification of non-linear processes, in our example for the mixer and the chemical reactor

4| CALCULATION STEPS OF MFCA

A calculation procedure of MFCA consists of the following steps, on the one hand for cost accounting and on the other for the whole life cycle:

(1) Calculation of all material and energy flows for the default scenario, calculation of inventories;
(2) Derivation of process specifications for the scenario of the optimized production system;
(3) Calculation of all material and energy flows for the scenario of the optimized production system, calculation of inventories;
(4) Calculation of improvement potentials as the difference of the both scenarios;
(5) Impact assessment or calculation of costs for the different inventories;
(6) Compilation of the results, in particular the cost matrix in and in a similar way the matrix for the environmental impacts.

5| CONCLUSIONS

This contribution illustrates the role of MFCA in the LCA framework: it is an improvement assessment instrument that mainly helps to assess the costs and environmental impacts of inefficiencies within production systems. So, MFCA is complementary to other LCA instruments.

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EVALUATION AND OPTIMIZATION OF THE ENVIRONMENTAL IMPACTS OF MICROALGAE PRODUCTION COUPLED WITH PHOTOVOLTAIC PANELS

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ABSTRACT:

Microalgae are considered as one of the main promising source of biofuel for the future. Microalgae are 10 to 20 times more productive than classical agricultural oleaginous crops currently producing biodiesel. Moreover, they do no compete with feed crop and they can uptake industrial sources of CO2. However, since they require larger energy supply, their environmental impacts are still unclear and many publications provide contradictory results. This study analyses the potential environmental impacts and energy balance of biodiesel production from microalgae of a virtual facility of 80 ha. The system under consideration uses standard open raceways under greenhouses coupled to photovoltaic panels to shadow the culture, and thus reduce photoinhibition and overwarming while producing local electricity. Two microalgae species were alternatively grown, Nannochloropsis oculata and Dunaliella salina for cold and hot months, respectively, in order to match the microalgae characteristics to the light and temperature of a given season. A functional unit of 1 MJ of biodiesel has been considered. The boundaries include production of raw materials, facility construction and dismantling, transport of materials and biodiesel production. The coupling with photovoltaic panel for local renewable electricity production improves the energy balance. We show that impact can be decreased by appropriately alternating the cultivation period of the two microalgal species.

Keywords:

Biodiesel; microalgae; Dunaliella salina; Life cycle assessment; Nannochloropsis oculata; Raceway; Renewable energy; photovoltaics.

1| INTRODUCTION

Microalgae are photosynthetic microorganisms that convert sunlight, water and carbon dioxide to algal biomass. Algal biomass are rich in oil, which can be converted to biodiesel using existing technology (Wijffels & Barbosa, 2010). Usually, agricultural oleaginous crops are widely used to produce biodiesel; however, oil content is much higher for microalgae than the 5% of total biomass for plants. Oil content of some microalgal species may exceed 60% of the dry weight (Chisti, 2008). Biodiesel production from microalgae is an emerging technology considered as a very promising alternative source of vegetal oil for biodiesel. Some characteristics of microalgae is the high productivity of biomass, no competition with feed crop, the possibility to uptake industrial sources of CO2 and its reduced competition for land (Lardon et al., 2009). However, the sustainability of this solution can be questioned. They require larger energy supply, their environmental impacts are still unclear and many publications provide contradictory results (Minowa et al., 1995). The development of a quantification of the environmental impacts of the microalgae production and its associated industrial processes is thus necessary. Besides, the solar radiations are, for a large part of the year, too high in comparison with the photosynthetic capacity of microalgae, which leads to photosaturation and photoinhibition (Minowa et al., 1995). The solar flux contributes to overwarm the microalgae cultures, and eventually induce mortality. Shadowing the microalgae with solar panels therefore turns out to be a promising solution both to increase productivity for hotter periods while producing local electricity for the process. This study analyses two aspect of microalgae production that will determine its future viability for production at large scale: the potential environmental impacts and energy and carbon balance.

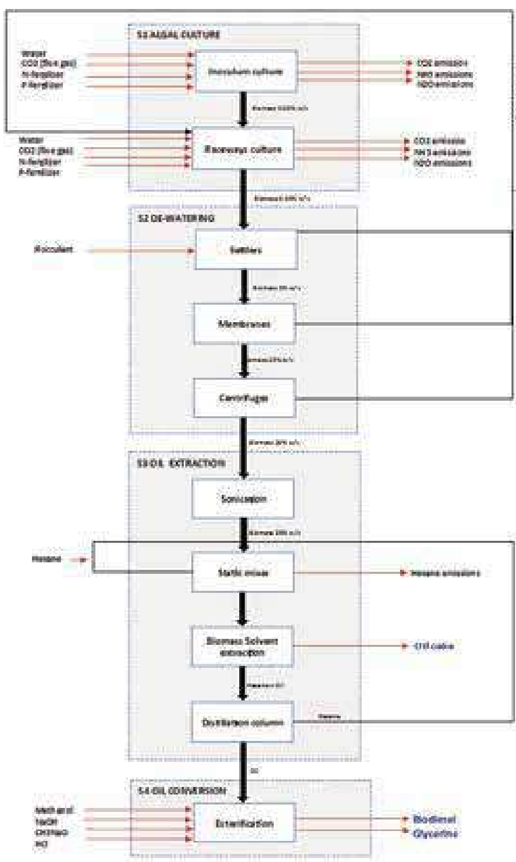
2| METHODOLOGY

The scope of the system includes the production of the biomass and its conversion into biodiesel, from a 'pond to gate" point of view. The construction, dismantling and final disposal of the infrastructure and machinery were also included, as well as the production of chemical and its transport. It does not include the distribution and combustion of the biodiesel. The functional unit (FU) considered is 1 MJ of algal methyl ester (biodiesel), to be used in a conventional internal combustion automobile engine. LCA software SimaPro v8.3 was used for modelling the data and generating results, by using the characterization factors from the ReCiPe 2008 method. The allocation between co-products is based on their energetic content (measured by their lower heating values-LHV). The co-products are the extraction residue (oilcake), glycerine and electricity.

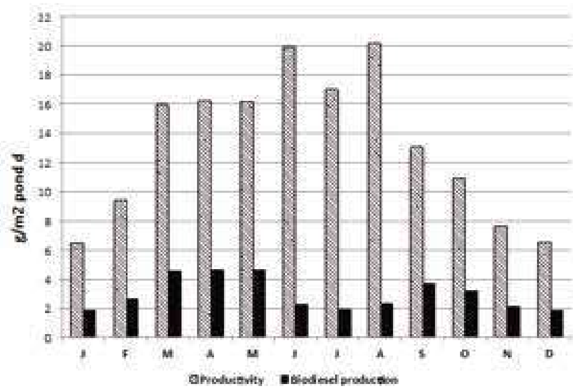
Overview of the system:

The process considers raceways systems for microalgae biomass production coupled with upstream inoculum production operations and downstream processes. Harvesting and dewatering steps helps to increase the biomass solids content for processing through subsequent conversion operations to obtain biodiesel: oil extraction and oil conversion.

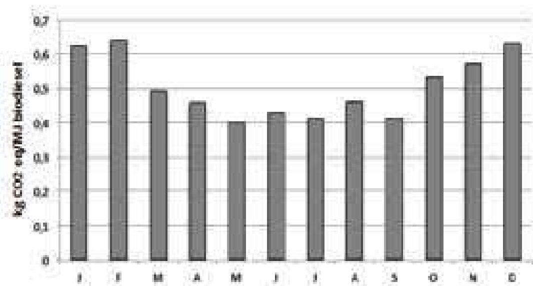
The design also includes the infrastructure construction, machinery production, piping system and dismantling. The process is divided into four main areas, also called sub-systems (Figure 1a). The facility is sized for a total production area of 80 ha (including inoculum ponds and downstream processes). The overall site layout assumes that ponds are grouped into unit “modules” of around 5 ha (50,868 m2) each. Each module represents a greenhouse, constructed of low E glass. The full facility contains 76.2 ha of biomass production raceways grouped into 15 individual greenhouses connected via a network of pipelines and roadways. The production facility is located in Mediterranean Europe; close enough to the seashore to provide access to seawater. The algae culture and transformation are on the same site. The used land is assumed to be initially shrub land and modelled as industrial area with vegetation. Microalgae specification: The analysis includes the use of Dunaliella salina and Nannochloropsis oculata. Dunaliella salina is a heat-resistant algal species, which lives between 7.5 and 37 ºC, and Nannochloropsis oculata is cold-resistant specie (optimal temperature at 26.7ºC). Both algae species achieve an efficient trade-off between growth rate, lipid accumulation and cultivation eases (Collet, et al., 2014) The analysis considers 18% and 45% lipid content (of dry basis content biomass), for Dunaliella tertiolecta and Nannochloropsis oculata, respectively. Algae culture: The microalgae cultivation consists of raceways of 9,106 m2 (2,731.95 m3) mixing with a paddlewheel (flow velocity of 20 cm s-1). The raceways are inoculated with biomass provided from inoculum ponds at a starting culture density of 0.05 kg/m3. The harvest is realized once a day, representing 10% of the total raceway volume. Nutrients requirements for the inoculum ponds and raceways are diammonium phosphate (DAP, 18%N, 20.2% P) for phosphorous requirements, and ammonium nitrate (NH4NO3, 35%N) for nitrogen requirements at 20% w/w each.



(a)



(b)



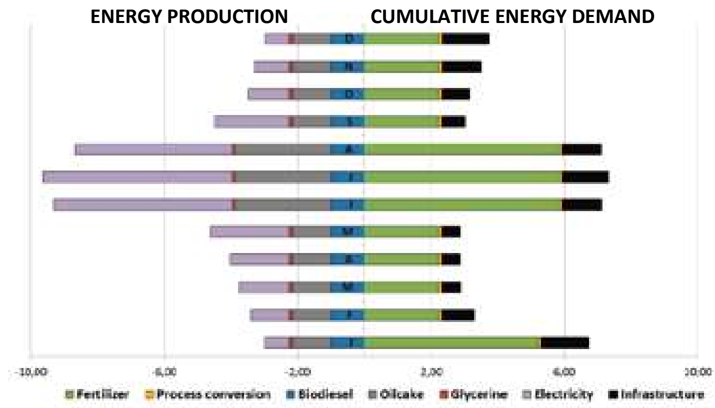
(c)

Figure 1 (a) Simplified flow diagram of the overall process. **(b)** Monthly productivity and biodiesel production. **(c)** Monthly CO_2 equivalent emissions per functional unit.

CO2 is supplied by flue gas (14% of CO2) from a nearby power plant located a 2 km and directly injected in the cultures. Also, freshwater is needed to compensate evaporative losses and a consequent increase in culture salinity. The water to the facility is provided by pipeline transport from a nearby local marine water resource and freshwater from outside facility boundaries. The volatile compounds emitted by raceways and inoculum ponds are CO2, N2O and NH3. These emissions depend on operating conditions (Collet et al., 2014). However, an average loss emission of each compound was assumed, which are correlated with others LCA studies (Collet et al., 2014). De-watering is based in the technology analyzed by NREL (Davis et al., 2016). The biomass is harvested from the ponds at 0.5 g/L density and concentrated across three dewatering steps consisting of gravity settlers; membranes and centrifugation to a final concentration of 200 g/L. Clarified water from each step is recycled to the cultivation raceways, less a small fraction removed as blowdown to mitigate build-up of salts and others inorganics. Oil extraction is carried out with hexane, in line with the oil extraction processes documented by Rogers et al. (2014) for a biodiesel plant production at commercial scale. Oil conversion is based on the process proposed by Haas et al. (2006). The final product obtained is a biodiesel with water content lower than 0.005% (v/v). Photovoltaic panels was based in the inventory for photovoltaic panel (PV) production reported by Stoppato [28], which considers a 0.65 m2 panel of polycrystalline silicon produced using current technologies, with 15% efficiency.

3| RESULTS AND DISCUSSION

Figure 1b shows the average monthly productivity and biodiesel production. N. oculata was preferred due to its higher lipid productivity, and D. salina was used only in the summer months (June, July and August). The productivities vary between 0.02 and 0.05 g·L-1·d-1 for N. oculata and from 0.06 to 0.07 g·L-1·d-1 for D. salina. The climate change impact decreases in summer (highest algal productivity) and increases in winter (lowest algal productivity) (see Figure 1c). Figure 2 identifies the energy flows generated by the production of 1 MJ of biodiesel. The energy content of the inputs is described by their Cumulative Energy Demand (CED), which accounts for the primary energy, which has been consumed to deliver the request product. The energy content of the products is describes by their LHV. The total set of products (biodiesel, oilcake, glycerine and surplus electricity) represents an energy amount ranging between 2.9 in winter to 9.6 MJ in summer. With higher light and temperature in summer, both algal productivity and electricity production in the photovoltaic system are enhanced. The CED values vary between 2.8 and 7.3 MJ, the fertilizer and infrastructure represented the highest energy demands. The energy ratio (consumption MJCED/production MJLHV) is favorable in almost all months. Reported results about the energy ratio in biodiesel production from microalgae also show values higher than 1 (Chisti, 2008, Collet et al., 2014). The choice of microalgae species with high lipid content and sustained growth rates are necessary to obtain an energetically efficient process (Energy ratio > 1) (Chisti, 2008, Lardon et al., 2009). Analyzing the same scenario, but excluding photovoltaic panels the energy ratio decreases around 50%-70% (Figure 3).



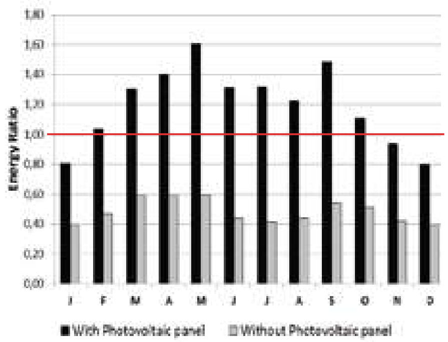


Figure 2 *(a) Energy demand and Energy production associated with production of 1 MJ biodiesel. (b) Effect in the Energy Ratio by considering photovoltaic panel*

4| CONCLUSIONS

The environmental impact can be decreased and energy balance increased by appropriately alternating the cultivation period of the two microalgae species and using photovoltaic panels to shadow the cultures during the hottest periods. Progresses are expected to reduce the impact of the culturing phase and downstream process, in order to compete with terrestrial crops in terms of greenhouse gas. For most of the other impacts, microalgae turn out to be more efficient.

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ECO-EFFICIENCY APPLIED TO THE PROMOTION OF URBAN SUSTAINABILITY IN STREET LIGHTING SERVICES

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ABSTRACT:

Introduction: urban public service managers gradually learn to incorporate urban sustainability as an element of their decisions. An element of the current moment is The 2030 Climate Agenda with its objective 11: making cities and human settlements inclusive, safe, resilient and sustainable. However, there are few analytical tools to support the decision of public agents. The paper will present a proposal for applying the concept of eco-efficiency in the management of public street lighting services and will demonstrate its feasibility as a model for decision making in the sector.

Objective: to propose an analytical model that allows decisions on the renewal of public lighting infrastructure to ensure greater eco-efficiency in the transition to innovative technologies, in order to mitigate the environmental impacts and their cost of installation, operation, maintenance and decommissioning.

Method: the Life Cycle Assessment (LCA) technique and the GHG Protocol tool were used to evaluate the environmental dimension of eco-efficiency. The Life Cycle Cost Assessment (LCC) technique and the tools of Net Present Value, Internal Rate of Return and Payback were used to evaluate the economic dimension of eco-efficiency. This led to a measure of eco-efficiency associated with different solutions presented to the public manager. The model was tested to compare solutions for public lighting in the city of São Paulo.

Results: An Analysis Model was developed to evaluate in an integrated way the economic and environmental performance (ecoefficiency) of products and installations for Public Lighting services.

Keywords:

Urban sustainability, eco-efficiency, street lighting, LCA, LCC, GHG protocol.

RENTABILIDAD ENERGÉTICA DE CULTIVOS AGRÍCOLAS DE URUGUAY

ENERGY PERFORMANCE OF URUGUAYAN AGRICULTURAL CROPS

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ABSTRACT:

Climate change, the increase in the world population and the reduction of the supply of fossil fuels will lead to an intensification of agricultural production with better environmental performance and energy efficiency. Goals in which our progress can only be evaluated through a perspective of life cycle analysis that considers all the dimensions of agricultural systems. Although this strategy has been used in the Northern Hemisphere, little is known about the performance of agricultural systems in Latin America. The situation described is important for countries whose economy is based on exportation of agricultural biomass (grains. fibers. etc.), such as Uruguay. This study assessed the energy return of investment (EROI) of maize (5.5-6.7 Mg/ha), grain sorghum (5.1-7.8 Mg/ha). wheat (2.8-5.1 Mg/ha), sweet sorghum (9.4 Mg/ha), switchgrass (13.8 Mg/ha) developed in long-term experiments. These evaluations considered the energy costs of field preparation, planting, post-planting, harvesting, and transport steps and the caloric energy of harvested product. Switchgrass had the highest EROI (>22) following by sweet and grain sorghum (>9.5). Moreover, the energy yield was highest for switchgrass (1.3 kg/MJ) and minimum for wheat (0.22-0.35 kg / MJ). These results allow us to identify the most relevant stages to optimize the energy efficiency of the crops studied.

Keywords:

EROI; corn; sorghum; wheat; switchgrass.

RESUMEN:

El cambio climático, el incremento de la población mundial y la reducción de la oferta de combustibles fósiles conducirán a una intensificación de la producción agropecuaria con mejor desempeño ambiental y eficiencia energética. Objetivos en los que nuestro avance solo puede ser evaluado mediante una lógica de análisis de ciclo de vida que considere todas las dimensiones de los sistemas agropecuarios. Aunque esta estrategia ha sido usada en el Hemisferio Norte, poco se sabe del desempeño de sistemas agropecuarios en América Latina. La situación descrita es de alta relevancia para países cuya economía está basada en la exportación de biomasas agropecuarias (granos. fibras. etc.), como Uruguay. Por este motivo, este trabajo evaluó la rentabilidad energética (EROI) de cultivos de maíz (5.5-6.7 Mg/ha), sorgo grano (5.1-7.8 Mg/ha), trigo (2.8-5.1 Mg/ha) si se considera con o sin el retiro de rastrojo y de sorgo dulce (9.4 Mg/ha) y switchgrass (13.8 Mg/ha) desarrollados en experimentos de largo plazo luego de 6 años de evaluación. Donde se consideraron los costos energéticos de las fases de preparación de campo, siembra, postplanting, cosecha, trasporte y la energía calórica del producto cosechado. Switchgrass tuvo el mayor EROI entre los cultivos evaluados (>22), seguidos por sorgo dulce y grano (>9.5). Además, la rentabilidad energética fue máxima para el switchgrass (1.3 kg/MJ) y mínima para el cultivo de trigo (0.22-0.35 kg/MJ). Estos resultados permiten identificar las etapas más relevantes para optimizar la eficiencia energética de los cultivos estudiados.

Palabras clave:

EROI; maíz; sorgo; trigo; switchgrass.

1| INTRODUCCIÓN

Uruguay ha destacado en Sudamérica por su economía basada en la producción de commodities agropecuarios de buena calidad (por ejemplo, carne bovina y ovina, leche, madera, lana). Un país favorecido por sus condiciones naturales (oferta de suelo fértil y agua de buena calidad) que ha expandido su área agrícola de 300 mil a 1 millón há. (periodo 2004 - 2016) e intensificado su producción a 1,8 cultivos anuales por ha (DIEA, 2015) para responder a la demanda internacional por commodities agropecuarios. Sin embargo, poseer ofertas ecosistémicas abundantes no implica tener sostenibilidad ambiental, dado que la destrucción de los ecosistemas y el desarrollo de riesgos sociales son amenazas evaluadas y gestionadas (Kessler et al. 2007). Por esta razón, este trabajo evaluó - desde una perspectiva de riesgos ambientales - la información (etapas e insumos) de dos tipo de cultivos de interés para Uruguay: cultivos de grano (maíz, sorgo grano y trigo) con o sin retiro de los residuos dejados en la cosecha; y cultivos para biomasa (sorgo dulce para silo y switchgrass para fardos secos. La información relevada de estos cultivos se utilizó para estimar la rentabilidad energética de los cultivos (EROI) y permitir una comparación de desempeño de las etapas y los sistemas estudiados.

2| METODOLOGÍA

Uruguay ha destacado en Sudamérica por su economía basada en la producción de commodities agropecuarios de buena calidad (por ejemplo, carne bovina y ovina, leche, madera, lana). Un país favorecido por sus condiciones naturales (oferta de suelo fértil y agua de buena calidad) que ha expandido su área agrícola de 300 mil a 1 millón há. (periodo 2004 - 2016) e intensificado su producción a 1,8 cultivos anuales por ha (DIEA, 2015) para responder a la demanda internacional por commodities agropecuarios. Sin embargo, poseer ofertas ecosistémicas abundantes no implica tener sostenibilidad ambiental, dado que la destrucción de los ecosistemas y el desarrollo de riesgos sociales son amenazas evaluadas y gestionadas (Kessler et al. 2007). Por esta razón, este trabajo evaluó - desde una perspectiva de riesgos ambientales - la información (etapas e insumos) de dos tipo de cultivos de interés para Uruguay: cultivos de grano (maíz, sorgo grano y trigo) con o sin retiro de los residuos dejados en la cosecha; y cultivos para biomasa (sorgo dulce para silo y switchgrass para fardos secos. La información relevada de estos cultivos se utilizó para estimar la rentabilidad energética de los cultivos (EROI) y permitir una comparación de desempeño de las etapas y los sistemas estudiados.

2.1. Información sobre la zona de estudio

Se utilizó para este estudio información de la base de datos de experimentos de largo plazo mantenidos desde 2008 por la Estación Experimental Mario Cassinoni (Paysandú, Uruguay). Esta información es representativa de los cultivos de secano desarrollados en los suelos de aptitud agrícola de Uruguay, los que abarcan 1,4 ha. La información usada en este trabajo proviene de los cultivos sembrados en una rotación de cultivos de grano de dos años de duración (maíz–trigo-sorgo grano) con o sin retiro de residuos de cosecha, un monocultivo anual (sorgo dulce para silo) y un cultivo perenne (switchgrass).

2.2. Inventario de ciclo de vida y estimación del EROI

El alcance del estudio abarca desde la preparación del suelo hasta la cosecha de cada cultivo. El inventario del ciclo de vida (LCI) fue organizado en cinco etapas: preparación de suelo, siembra, tratamientos post siembra, cosecha y transporte. Donde en cada etapa se consideraron los insumos (fertilizantes, pesticidas, combustibles, aceite), consumo de energía y agua, emisiones y maquinaria. La información del LCI fue compilada y organizada en planillas de cálculo, donde las dosis y cantidades de cada insumo o producto fueron transformadas en unidades de energía equivalente para su tranformación en megajoules. Los coeficientes de conversión se tomaron de bases de datos públicas, publicaciones arbitradas o coeficientes de conversión propios. Para cada cultivo se realizó la razón entre energía producida y energía invertida, lo cual e denominó EROI (enery return on investment) (Hall et al., 2014) expresado en unidades de MJ/MJ. La energía producida fue la energía equivalente a la masa producida por el poder calorífico cada biomasa (grano y/o tallos mas hojas). El valor de energía neta expresa la cantidad de energía que se genera mientras la relación energética estaría dando una idea de cuanta energía se genera en función de la que se consume.

3| RESULTADOS Y DISCUSIÓN

Los rendimientos más altos en materia seca fueron con switchgrass (13.77 Mg.(ha.año)-1) como se observa en la Tabla 1. Le siguieron en importancia el sorgo dulce con 8.96 Mg.(ha.año)-1 y el sorgo grano con retiro de rastrojos con 7.8 Mg.(ha.año)-1. Por el contrario, el cultivo que presento los menores rendimientos fue el trigo sin retiro de rastrojo (2.84 Mg.(ha.año)-1). En los tres cultivos graníferos, las productividades en grano fueron mayores que la de rastrojos, 61% vs. 39% respectivamente.

El análisis de la energía neta producida por hectárea destaca al switchgrass con el valor más alto (229 GJ.ha-1), el cual duplica el valor logrado por el otro cultivo destinado a biomasa, cultivo de sorgo con 114 GJ.ha-1. Marco en el cual, los cultivos de grano presentaron energías netas similares o inferiores al cultivo de sorgo dulce cuando se realiza un retiro del ratrojo, Acción que en el largo plazo depreciaría la acumulación de carbono orgánico en le suelo y la sustentabilidad del sistema (Stevenson & Cole, 1999).

Tabla 1. Valores medios anuales del período 2009-2014 para los datos de: rendimiento en grano (G), tallos y hoja (TyH), energía neta (En), EROI, eficiencia energética (Ee) y rastrojo retirado (RR) de los cultivos: maíz, sorgo grano, trigo, Sorgo dulce y switchgrass desarrollados en los experimentos de largo plazo de la EEMAC (Paysandú, Uruguay).

Cultivos	RR	Rendimiento			En	EROI	Ee
		G	TyH	Total			
		Mg.ha-1			GJ.ha-1	MJ.MJ-1	
Maíz	No	5.48	0	5.48	77,0	7,53	0,46
	Si	4.12	2.57	6.69	95,8	8,26	0,51
Sorgo grano	No	5.14	0	5.14	74.6	8.21	0.50
	Si	4.63	3.14	7.77	103.5	9.76	0.66
Trigo	No	2.84	0	2.84	34,2	3,61	0,22
	Si	3.16	1.92	5.08	68,7	5,76	0,35
Sorgo dulce	--	0	8.96	8.96	114,5	10,53	0,62
Switchgrass	--	0	13.77	13.77	228,9	22,40	1,30

En la estimación del EROI, se puede observar que el switchgrass logró un valor alto, el doble del EROI del sorgo dulce -otro cultivo usado para biomasa – y un valor muy superior al logrado por los cultivos para grano (7.53 – 9.76 MJ.MJ-1). Los valores de EROI informados para cultivos en grano se encuentran en el orden de magnitud y, tal vez algo superiores, a los informados por Weißbach et al (2013) para cultivos de maíz. En cuanto a los EROI de switchgrass y sorgo dulce los valores son muy altos, similares a los esperables para el etanol desde caña de azúcar (Murphy & Hall, 2010).

La Figura 1 muestra que la preparación de los suelos y la siembra consumen entre 8-27% y 22-39% de la energía invertida en cultivos anuales, con excepción del switchgrass. Este ultimo cultivo, un cultivo perenne, presenta un gasto de energía muy bajo en las etapas mencionadas y un alto consumo de energía en las actividades de postplanting. Situación debida al uso de fertilizantes nitrogenados (100 Kg de N/ha/año) en las etapas de rebrote del cultivo.

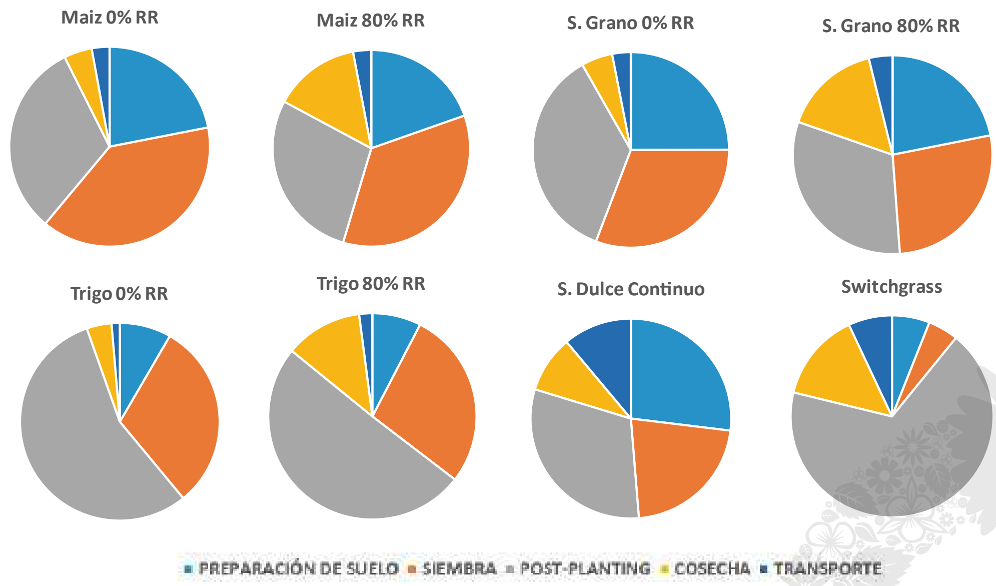

Figura 1. *Participación porcentual de las etapas (preparación de suelo, siembra, postplanting, cosecha y transporte) en el consumo de energía.*

4| CONCLUSIONES

El cultivo que presentó los mayores valores en productividad fue el switchgrass (13.77 Mg.ha-1), siendo un 240% superior al promedio de los demás cultivos evaluados. El EROI obtenido fue muy alto para switchgrass y sorgo dulce en relación con los otros cultivos evaluados y biocombutibles descritos en la literatura.

Los cultivos de grano presentaron valores de EROI en el orden de magnitud esperable, aunque levemente superiores a casos informados. Donde el retiro de rastrojo mostró cambios relevantes tanto en el EROI como en la sustentabilidad del manejo de los suelos.

Los resultados obtenidos permitieron identificar etapas relevantes para optimizar la eficiencia energética de los cultivos estudiados para las condiciones del Uruguay.

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EVALUACIÓN DE ECO-EFICIENCIA DE TECNOLOGÍAS UTILIZADAS EN EL TRATAMIENTO DE AGUAS DOMÉSTICAS EN CHILE

ASSESSMENT OF ECO-EFFICIENCY OF TECHNOLOGIES USED IN THE TREATMENT OF DOMESTIC WATERS IN CHILE

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RESUMEN:

Chile cuenta con el 99,8% de tratamiento de aguas domésticas en zona urbana, siendo este el de mayor cobertura a nivel latinoamericano, debido a la aplicación de la norma de emisión que establece los límites máximos permisibles para ser vertidas a un cuerpo de agua. Actualmente Chile cuenta con 278 plantas de tratamiento de aguas domésticas en operación, donde la tecnología de tratamiento más utilizada es la de lodos activos con 65,5%, seguidos de las lagunas con 27,7% y tecnologías no convencionales como biofiltro con un 1,7%, lombrifiltro 0,4% y otros. Si bien, todas las tecnologías utilizadas en el país permiten cumplir los estándares normativos, existen diferencias en función de los insumos y eficiencias que alcanzan. Por este motivo el objetivo de esta investigación fue evaluar indicadores de Eco-eficiencia para las diferentes tecnologías de tratamiento, utilizando como unidad funcional 1 kg de DBO5 removida, junto con una función de valor asociada al volumen capaz de tratar la planta. Se analizaron 15 PTAs situadas a lo largo de todo Chile, utilizando la metodología de análisis de ciclo de vida para cuantificar los impactos ambientales, mediante el software SimaPro, con el método ReciPe Midpoint.

Los resultados determinaron que el lombrifiltro es la tecnología más eco-eficiente para las categorías cambio climático y eutrofización de agua dulce, en comparación a lagunas aireadas, lodos activos y biofiltro, las cuales presentan la energía utilizada como un contribuyente importante en los impactos ambientales, seguido del relleno sanitario y uso de químicos.

Palabras clave:

eco-eficiencia; planta de tratamiento; aguas urbanas; análisis de ciclo de vida.

ABSTRACT:

Chile has 99.8% of domestic water treatment in urban areas, being the one with the greatest coverage in Latin America, due to the application of the emission standard that establishes the maximum permissible limits to be discharged to a body of water. Currently Chile has 278 domestic water treatment plants in operation, where the most used treatment technology is active sludge with 65.5%, followed by lagoons with 27.7% and unconventional technologies as a biofilter with a 1 , 7%, lombrifiltro 0.4% and others. Although all the technologies used in the country allow compliance with regulatory standards, there are differences depending on the inputs and efficiencies they achieve. For this reason, the objective of this research was to evaluate Eco-efficiency indicators for the different treatment technologies, using as a functional unit 1 kg of BOD5 removed, together with a value function associated with the volume capable of treating the plant. We analyzed 15 PTAs located throughout Chile, using the methodology of life cycle analysis to quantify the environmental impacts, using SimaPro software, with the ReciPe Midpoint method.

The results determined that the lombrifiltro is the most eco-efficient technology for the categories climate change and freshwater eutrophication, compared to aerated lagoons, active sludge and biofilter, which present the energy used as an important contributor in the environmental impacts, Followed by landfill and use of chemicals

Keywords:

eco-efficiency; treatment plant; urban water; life cycle assessment.

1| INTRODUCCIÓN

El derecho al agua potable y al saneamiento es un requisito indispensable para la consecución de otros derechos humanos (UNESCO, 2016). Entre 1900 y 2015, los niveles de cobertura en América Latina y el Caribe pasaron del 84,9% al 94,6% en materia de agua y del 67,3% al 83,1% en saneamiento (BID, 2015), manteniendo el desafío de seguir aumentando al acceso de éstos servicios a la comunidad.

Chile, es el país con mayor cobertura de tratamiento de aguas residuales domesticas de Latinoamérica, con un 99,8% en zonas urbanas. Dentro de los distintos tratamientos secundarios, el más utilizado es lodos activos con 65,5%, seguidos de las lagunas con 27,7% y tecnologías no convencionales como biofiltro con 1,7%, reactores biológicos secuenciales con 2,5%, zanjas de oxidación con 1,4 y lombrifiltro 0,4% (SISS, 2016). Para cada tecnología de tratamiento de aguas domésticas y capacidades de la planta existen distintos flujos de entrada, como es el consumo de energía que varía entre 0,17 - 1,7 kWh/m3, cloruro férrico entre 0,01 – 19,5 kg/m3, polímeros entre 0,001 – 1,98 kg/m3 e hipoclorito de calcio entre 0,03 – 18,9 kg/m3, entre otros químicos y uso de petróleo como combustible para satisfacer necesidades energéticas las cuales igual varían según los requerimiento de la planta (Niero et al., 2014, Foley et al., 2009, Amores et al., 2013). Además de flujos de salidas como generación de lodos en promedio de 1,07 kg/m3 (Lorenzo-Toja, 2014), emisiones atmosféricas por uso de calderas y residuos sólidos.

Si bien, todas las tecnologías de tratamiento permiten una descarga con el cumplimiento de los estándares normativos; en el caso de Chile el DS N°90/2001; la variación en los tipos y cantidades de insumos requeridos en una planta de tratamiento implica diferencias en sus impactos ambientales y eficiencia. Varios autores han realizado investigaciones para determinar los impactos ambientales en plantas de tratamientos de aguas domésticas (Rish et al., 2014, Morrison et al., 2016, García et al., 2013, Lorenzo-Toja., 2014) mediante la metodología de análisis de ciclo de vida, que cuantifica los impactos ambientales asociados a un producto o servicio en todo el ciclo de vida, a partir de flujos de entradas y salidas (ISO, 2006a), logrando determinar por ejemplo que el consumo de electricidad en la tecnología de lodos activos, fue identificado como uno de los principales contribuyentes al agotamiento de recursos fósiles y la generación de gases efecto invernadero (GEI) (Corominas et al., 2013).

En el último tiempo han salido varias metodologías de ACV con distintos enfoque, como lo es el Ecodiseño, Declaraciones Ambientales de Productos y la Eco-eficiencia. Esta última fue estandarizada en el 2012 por la normativa ISO 14.045 (ISO, 2012), correspondiente a una herramienta cuantitativa que relaciona los impactos ambientales potenciales de un producto o servicio a lo largo de todo su ciclo de vida con una función de valor de interés, donde éste puede ser de carácter económico, funcional, culturales, entre otros; siendo así una herramienta práctica para la gestión de los aspectos ambientales y del valor en paralelo (ISO 14.045; 2012). En los estudios realizados de eco-eficiencia en planta de tratamiento de aguas domésticas, la mayoría de los autores han ocupado una función de valor económica (Lorenzo-Toja et al., 2014, Stanchev et al., 2016, Lorenzo-Toja et al., 2016), donde es discutible en términos de evaluar servicios como lo es el saneamiento, ya que éstos se encuentran regulados, como es el caso de Chile, las sanitarias son reguladas con sus utilidades, resultando sin interés de partes de ellas.

Es por ello que el objetivo de este estudio es realizar una evaluación de eco-eficiencia de las tecnologías de tratamiento secundario de aguas residuales domésticas utilizadas en Chile, con el fin de determinar que existen tecnologías más eco-eficientes no convencionales.

2| METODOLOGÍA

2.1. Descripción de los sistemas y evaluación de ciclo de vida

Se estudiaron 15 plantas de tratamiento de aguas residuales domésticas de Chile, de las cuales cinco plantas corresponden a lagunas aireadas ubicadas en su mayoría en la zona norte, con purgas de lodos de 1 vez al año para 3 plantas utilizando una estabilización de lodos mediante tiempo residencia. Ocho plantas de lodos activos con aireación prolongada principalmente ubicadas en la zona sur, donde para la estabilización de lodos se encuentran: digestión anaerobia con generación de biogás, el cual se utiliza para demanda energéticas internas de la planta, estabilización por cal y tiempo de residencia de 25 días. Una planta de tecnología de biofiltro, principalmente en un lecho fijo con material de PVC, en el cual los microorganismos se encuentran adheridos como película al medio filtrante, se genera lodos activos similares a los lodos activos, con una estabilización de digestión anaerobia y generación de biogás, quemado para el mismo funcionamiento. Y finalmente una planta con sistema TOHÁ o lombrifiltro en el que logra la degradación de la materia orgánica mediante lombrices Eisenia Foetida, con la particularidad que ésta tecnología no requiere químicos (sólo cloración) y generando compost en vez de lodos.

Para la determinación de los impactos ambientales, se utilizó como unidad funcional 1 kg de DBO5 removida, debido a la principal función de un tratamiento secundario. La Figura 1, muestra los límites del sistema considerados en el estudio, en donde para la tecnología de lombrifiltro se deja fuera del alcance el compost.

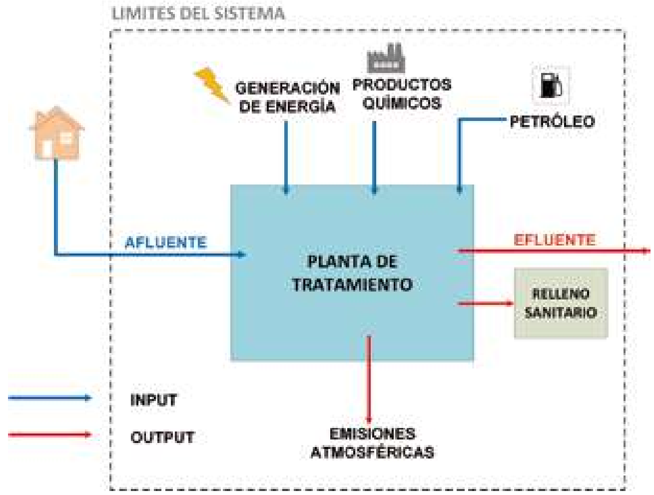

Fig. 1. *Límites del sistema de las plantas de tratamiento en estudio*

El método de evaluación de impacto utilizado fue ReCiPe Midponit, mediante el software SimaPro. Las categorías de impacto seleccionadas fueron: Cambio climático (CC), Toxicidad humana (TH), Eutrofización de agua dulce (EU), Ecotoxicidad de agua dulce (ET), Acidificación terrestre (AT) y Agotamiento fósil (AF), elegidas por ser las categorías más estudiadas en otros estudios de ACV y de interés para plantas de tratamiento. Para la calidad de datos se tomó el año 2015 como referencia.

2.2. Inventario de ciclo de vida

Para la construcción del inventario de ciclo vida, se trabajó en conjunto con la Superintendencia de Servicios Sanitarios (SISS) del Ministerio de Obras públicas (MOP), aportando datos de autocontroles y parámetros operacionales de las plantas de tratamiento en estudio, correspondiente al cumplimiento de la legislación vigente de Chile (DS N°90 y PRO023).

2.3. Eco-eficiencia

La evaluación de Eco-eficiencia se realizó mediante la norma internacional 14.045 (ISO, 2012), donde para la construcción del indicador, se seleccionaron las 3 plantas de tratamiento con más bajos impactos en la evaluación de ciclo de vida. Utilizando una función de valor representada por el volumen tratado de cada planta en 1 año.

Las categorías de impactos seleccionadas para el indicador de Eco-eficiencia son, cambio climático por ser de gran interés y eutrofización de agua dulce correspondiente al impacto ambiental característico del tratamiento de aguas residuales a los cuerpos de aguas.

3| RESULTADOS

3.1. Evaluación de ciclo de vida

En la Figura 1 se observa que la tecnología de lodos activos y biofiltro son las que presentan menores impactos ambientales en todas las categorías evaluadas, siendo biofiltro la tecnología con mejor desempeño ambiental. Las plantas de lodos activos presentan impactos muy variados que van desde 0,9 a 3,4 kg $CO2$ eq/kg DBO5 removida en la categoría de cambio climático, 0,4 a 1,6 kg 1,4-DB eq/kg DBO5 removida en toxicidad humana como lo muestra la Tabla 1. Esta variación se debe a las diferentes escalas de plantas evaluadas, donde las de mayor tamaño presentan servicios a poblaciones equivalentes que varían entre 300.000 a 3.000.000 habitantes, en comparación a las pequeñas plantas que poseen coberturas que varían entre 500 a 20.000 habitantes. En este sentido las plantas de gran tamaño presentan mejor desempeño ambiental, lo que ha sido planteado por Lorenzo-Toja, (2014). Por otro lado, la tecnología lombrifiltro resulto con mayores impactos que biofiltro, sin embargo estos no superaron una diferencia del 10%.

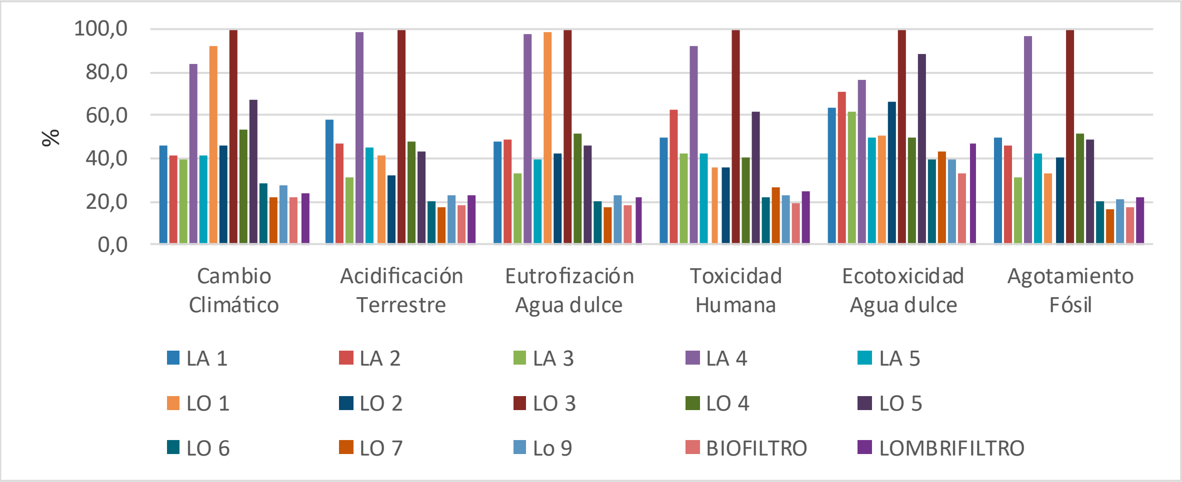

Figura 2. Impactos ambientales de las plantas en estudio. (LA: Lagunas aireadas, LO: Lodos activos)

A partir de un análisis de contribución se determinó que la energía es un punto crítico para las categorías de: agotamiento fósil, acidificación terrestre, cambio climático y eutrofización de agua dulce, representando sobre el 50% de los impactos ambientales. Los indicadores de desempeño ambiental asociados a la remoción de materia orgánica alcanzaron valores de 5 kWh/kg DBO5 para lagunas y lodos activos, 1,2 kWh/kg DBO5 para biofiltro y 0,9 kWh/kg DBO5 para lombrifiltro, resultando éste último el sistema que presenta mayor eficiencia energética.

Para la categoría ecotoxicidad de agua dulce el relleno sanitario fue el que más contribuyó con alrededor del 62% de los impactos para todas las tecnologías, debido principalmente cobre, cloro y níquel, con una contribución de 55,5%, 18,5% y 14,4% respectivamente. Los indicadores de desempeño ambiental asociados a los residuos sólidos fueron de 0,2 a 0,5 kg/kg DBO5 removida. Finalmente para la categoría toxicidad humana las principales contribuciones se encuentran repartidas entre la energía, relleno sanitario y uso de químicos, tales como polímeros, cloro e hipoclorito de sodio, principalmente por sustancias en el agua como el magnesio 44,4% y cloro con un 18,5 %.

Tabla 1. *Indicadores de impacto ambiental para los distintos tipos de tecnologías en estudio considerando 1 kg de DBO5 removida.*

Tecnologías		Lagunas Aireadas		Lodos Activos		Biofiltro	Lombrifiltro
Categoría de impacto	Unidad	μ	σ	σ		valor	valor
Cambio Climático	kg CO2 eq	2,1	0,9	2,2	1,3	0,94	1,03
Acidificación Terrestre	kg SO2 eq	0,0120	0,01	0,0077	0,01	0,004	0,005
Eutrofización Agua dulce	kg P eq	0,0011	0,001	0,0010	0,0007	0,0004	0,0004
Toxicidad Humana	kg 1,4-DB eq	1,4	0,5	1,0	0,6	0,45	0,58
Ecotoxicidad Agua dulce	kg 1,4-DB eq	0,12	0,02	0,11	0,05	0,06	0,09
Agotamiento Fósil	kg oil eq	0,5	0,2	0,4	0,3	0,18	0,22

3.2. Evaluación de ecoeficiencia

Los resultados de la evaluación de eco-eficiencia se muestran en la Tabla 2, resultando la tecnología más eco-eficiente lombrifiltro para ambos indicadores de impactos seleccionadas, con una capacidad de tratar casi 8 m3 para emitir 1 kg de CO2, en comparación de biofiltro y lodos activos que tratan 5 m3 para la emisión de 1 kg de CO2 para la categoría cambio climático, del cual el indicador de eco-eficiencia del lombrifiltro es aproximadamente 2 veces mayor que el indicador de lodos activos y biofiltro. Esto se debe principalmente a que los únicos insumos que requiere ésta tecnología son energéticos e hipoclorito de sodio para la desinfección demostrando que su pequeña escala no alteró su eco-eficiencia De la misma forma es para la categoría eutrofización del agua dulce con un indicador de 2 veces mayor que el indicador de biofiltro y lodos activos.

Tabla 2. *Evaluación de eco-eficiencia.*

Categoría de impacto	Unidad	Lodos Activos	Biofiltro	Lombrifiltro
Cambio Climático	m^3/kg CO2 eq	4,65	4,80	7,68
Eutrofización Agua dulce	m^3/kg P eq	11.959,38	11.726,60	17.850,18

4| CONCLUSIONES

Se logró determinar la tecnología de tratamiento más eco-eficiente siendo ésta lombrifiltro, al ser comparadas con tecnologías como, lagunas aireadas, lodos activos y biofiltro, demostrando que las tecnologías emergentes y no convencionales pueden llegar a ser más eco-eficientes que las convencionales en Chile.

Las plantas de mayor escala presentan menores impactos ambientales y mejor desempeño ambiental, además de estar involucrada la economía de escala, sin embargo una planta pequeña como lo es lombrifiltro pueden competir en evaluaciones de eco-eficiencia.

Finalmente, en chile la tecnología de lombrifiltro es recientemente utilizada en tratamiento de aguas domésticas atendiendo a localidades rurales de baja población, lo que estudios de este tipo ayudan a destacar su eco-eficiencia para la utilización a mayor escala como en otro lugar del mundo.

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Educational LCA and promotion

CILCA 2017

VII Conferencia Internacional de

Análisis de Ciclo de Vida en Latinoamérica

12 al 15 de junio de 2017

Medellín - Colombia

BIOSCOPE: A QUANTITATIVE TOOL FOR BIODIVERSITY IMPACT ASSESSMENT OF SUPPLY CHAIN USING INPUT-OUTPUT DATA

BIOSCOPE: UNA HERRAMIENTA CUANTITATIVA PARA LA EVALUACIÓN DE IMPACTO A LA BIODIVERSIDAD DE CADENAS DE SUMINISTRO USANDO DATOS DE ENTRADA/SALIDA.

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RESUMEN:
Para entender el impacto global a la biodiversidad debido a actividades comerciales se requiere entender la influencia de las actividades económicas de una cadena de suministro a lo largo de diversas regiones, además se requiere el modelado de la perturbación de hábitats que causen pérdidas (o ganancias) del número de especies. La abundancia de especies – un indicador usado comúnmente para medir el daño a la diversidad – se refiere a la fracción de especies que se han perdido en comparación con un área natural o sin intervención.
BioScope (Platform BEE, PRé Sustainability, Arcadis, CODE, 2016) es una herramienta cuantitativa para la evaluación de impactos a la biodiversidad; dicha herramienta utiliza la base de datos de entrada/salida Exiobase 2.2 (The EXIOBASE consortium, 2007) combinada con el método de impacto ambiental ReCiPe (M. Goedkoop, et al. 2009). Exiobase es una compilación de datos promedio de actividades económicas por sector y por país o región; los datos se dividen en 163 industrias o sectores y cubren 43 países más 5 regiones para el 'resto del mundo'. Por otro lado, ReCiPe es método para la evaluación de impacto ambiental y en este caso, el método se adaptó específicamente para biodiversidad. Como punto de inicio, la herramienta requiere un listado de la cantidad gastada en materias primas y su país de origen; al combinar esta información con Exiobase los flujos comerciales de un producto se pueden mostrar en un mapa mundial. Al realizarse el cálculo utilizando el método adaptado, se obtienen resultados que muestran el impacto en la biodiversidad para ocho categorías (por ejemplo: cambio climático, uso de suelo para agricultura, escasez hídrica, etc.). Los impactos se muestran en especies.año y pueden visualizarse por materia prima y país en un mapa mundial.

Palabras clave:
biodiversidad; evaluación de impacto; herramienta entrada-salida;

ABSTRACT:
Understanding the global biodiversity impacts from commercial activities requires an understanding of the influence of economic activities, along the supply chain and in different regions, and the modelling of how such activities disturb habitats and cause a loss (or gain) in species numbers. Species abundancy - a common indicator to measure impacts on biodiversity - is described as the fraction of species that has been lost, in comparison with a natural or undisturbed area.
BioScope is a quantitative tool for biodiversity impacts, based on the input-output database Exiobase 2.2 (The EXIOBASE consortium, 2007) coupled with the environmental impact assessment method ReCiPe (M. Goedkoop, 2009). Exiobase compiles average data of economic activities in a given sector and country or region; it is divided in 163 industry and services sectors and covers 43 countries and 5 'rest of World' regions. On the other hand, ReCiPe is a life cycle assessment method that allows the calculation of environmental impacts; in this case, the method was adapted to specifically assess biodiversity. As inputs, the tool requires a list of amounts spent per commodity and country or region; by combining this information with Exiobase, the trade flows of a product's provision are mapped worldwide. A calculation is performed using the adapted ReCiPe method and the results show the biodiversity impact for eight impact categories (e.g. climate change, agricultural land occupation, water scarcity, etc.). The impacts are shown in species.year and can be displayed, per commodity and country, on a World map.

Keywords:
Biodiversity; Impact Assessment; Tool; Input-Output;

1| INTRODUCTION

Companies are increasingly aware that their businesses are highly depending on natural capital (Fauna & Flora Internations, ACCA, KPGM, 2012). This is already obvious for the agri-business, but the trend is also rising in more industrial sectors. However, getting a good understanding of the damages arising from its operations is still difficult for a company: there are many schemes to follow, and the outputs are most of the time either too high level and not bringing much leads for practical improvements, or too detailed and requiring long studies, cumbersome data collection, and highly technical staff to deal with these data. Another limitation is that, even locally, there exist many levels at which biodiversity impacts can be described: species abundancy, robustness of the system measured by the gene pool or the variety of genes, habitat, functional value of the ecosystem, for example what is the economic value it generates, etc.

The most common indicator to measure the damage to diversity is species abundancy, which can be described as the fraction of species that has been lost in comparison with a natural or undisturbed area.

BioScope , a free access web-tool, provides businesses with a simple and fast indication of the most important impacts on biodiversity arising from their supply chain. It provides a simple user interface where companies can enter data that are simple and easy to gather: How much is spent on each of the important commodities, and where the suppliers are located.

The tool is based on the input-output database Exiobase 2.2 (The EXIOBASE consortium, 2007) coupled with the environmental impact assessment method ReCiPe (M. Goedkoop, 2009), adapted to specifically assess biodiversity. The results show the biodiversity impact for eight impact categories (e.g. climate change, agricultural land occupation, water scarcity, etc.) in species.year and can be displayed on a World map per commodity and country.

The results brought by BioScope are aimed at helping companies to formulate meaningful actions to further assess and reduce the impact of their business on biodiversity. Furthermore, it indicates the potential impact of the commodities purchased, but also of their (related) upstream supply chain. The main objective of this paper is to briefly present the method for calculating biodiversity integrated in BioScope.

BioScope has been developed by PRé Sustainability, Arcadis and CODE, commissioned by Platform BEE (Biodiversity, Ecosystems and Economy); a collaboration between IUCN NL and VNO-NCW financed by the Dutch ministry of economic affairs.

2| METHODOLOGY

The two key elements to calculate biodiversity impacts due to economic activities are:

1. An inventory of commodities used in a given supply chain; this is done by specifying the expenditure per commodity

2. A biodiversity impact model, which will translate these regionalized economical activities into meaningful indicators that describe their influence on eight impact drivers: Climate change, Terrestrial acidification, Freshwater eutrophication, Terrestrial ecotoxicity, Marine ecotoxicity, Freshwater ecotoxicity, Agricultural land occupation and Water scarcity.

2.1. Inventory

In this case an input/output (I/O) model is used. This modelling approach represents the interdependencies between different branches of a national economy, or different regional economies. For that reason, inputs and outputs are specified in monetary terms. For example: to produce one euro worth of steel, it is required to purchase X euro from the fossil fuel sector, and Y euro from the ore sector. Although the use of an input/output database is rough in terms of detail, it can adequately describe a complete economy.

The input/output database chosen for BioScope is Exiobase. This database works with a standard model of the economy; it covers 43 countries, that together represent 90% of the World's economy, and 5 'Rest of the World' regions that cover the remaining 10%. The Exiobase team have collected data for all 48 regions on economic activities, environmental and some social aspects, distinguishing 163 industrial and service sectors (Tukker, 2014). All trade flows between these sectors are also specified, which leads to millions of trade flows. Since for each sector, the main environmental impacts were collected, if one knows the expenditure per commodity for each sector, then it is possible to understand the impacts of a supply chain.

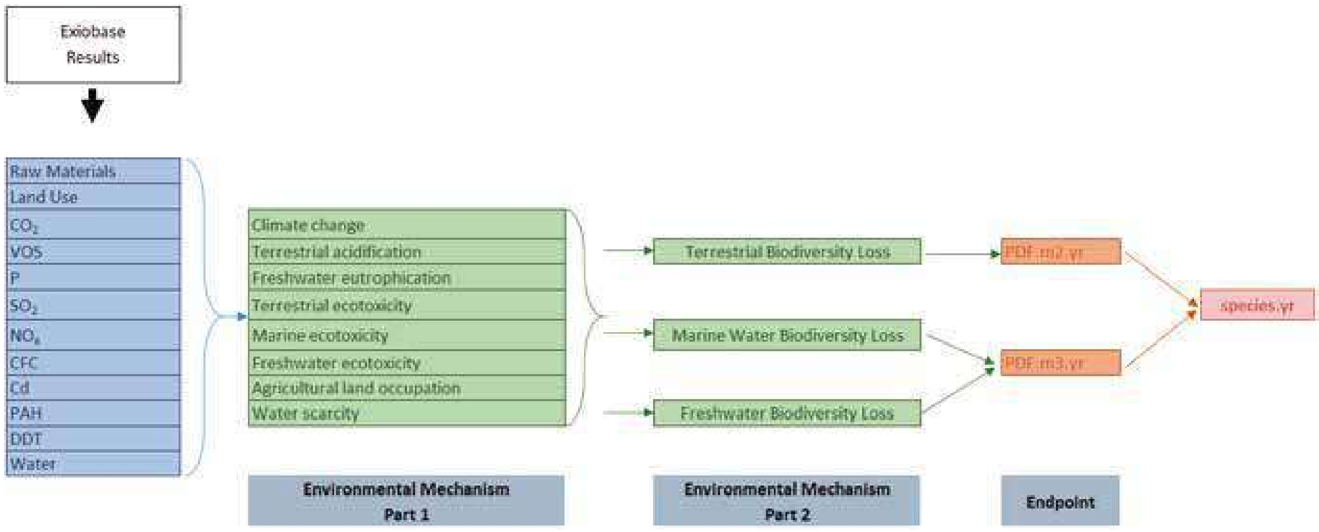

Figure 1 *Adapted ReCiPe method for biodiversity*

2.2. Biodiversity Impact

For translating the influence of economic activities into biodiversity impacts a method is required, in this case an adapted version of ReCiPe was integrated. This adapted method links each activity with several impact drivers by using characterization factors and thus provides a general indication of how the emissions and resources specified by Exiobase are linked to loss of biodiversity.

As shown on **Figure 1**, once the resources and emissions are derived from Exiobase, the impacts are calculated via eight impact drivers in a two-step approach. The unit for biodiversity impact is PDF.m2.yr, with PDF as the Potentially Disappeared Fraction of species. Loss of species is calculated in a certain area (hence m2) or volume (hence m3), during a certain time (hence the addition of years). A conversion factor was included to bring PDF.m2.yr and PDF.m3.yr under one common unit: species.yr. This factor works by dividing the results for land and water by the average species density on land per square meter, and the average species density in water per cubic meter.

The unit species.year is a measure for how many vascular plants and lower organisms, on land and in water, are expected to disappear because of the assessed activities. These lower organisms are typically at the beginning of the food chain, and if something goes wrong there, it will affect higher organisms, on which impacts are much more difficult to model. For this reason, calculating from a focus on lower organisms and vascular plants provides an indicator of the health of the ecosystem.

It is assumed that, if the cause of this extinction stops (for example, the activities of a company), then the number of species will start to go up again. For instance: 30 species.year means that 30 species are extinct for 1 year OR 3 species for 10 years. If, on the second year, the assessment from the same company shows 25 species.yr, it means that 5 species will start to reappear.

3| RESULTS AND DISCUSSION

Some points of attention when using Exiobase are:

• Dividing an economy in 143 sectors provides a rather coarse classification of economic activities. So if expenditure is made in a specific industrial activity, it is not always clear to which sector it belongs. For instance, a lot of the big names in apparel the industry make, of course, apparel, but are also important players in retailing, which is considered to be another sector. Another issue is that apparel is also considered a very broad sector, from t-shirts to sport shoes. Since all inputs are considered per Euro, the use of this approach does not allow to add specific materials or the way it is produced and thus the price is what determines the impact.

• Data gathering per region could differ as each country has its own way of defining sectors, and collects its data according to that sector classification. For Exiobase, all that information had to be re-allocated to fit the framework of 143 sectors; this can of course create distortions. For example, Germany uses a classification of just over 40 sectors, while the US and Japan use about 500 sectors, and the Netherlands use just over 130.

• A particular problem are the Rest of the World regions, as often very little data is available.

4| CONCLUSIONS AND RECOMMENDATIONS

This tool gives an approximation of the biodiversity impact resulting from the supply chain of the commodities purchased by businesses. The main objective is to help companies to identify their potential impacts and thus set up meaningful actions towards biodiversity conservation.

It is important to note that the use of country level data on economic activities and their impacts means that the confidence of the outcome is limited. For a complete impact assessment, subsequent steps will always remain necessary. In the near future the tool will be update to use the latest version of Exiobase (version 3) and ReCiPe 2016.

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O REPOSITÓRIO DIGITAL COMO FERRAMENTA PARA DIFUSÃO DO PENSAMENTO DO CICLO DE VIDA E APOIO À CAPACITAÇÃO EM ACV

THE DIGITAL REPOSITORY AS A TOOL FOR DIFFUSION OF LIFE CYCLE THINKING AND SUPPORT FOR LCA CAPACITY BUILDING

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RESUMO:

A necessidade da capacitação em Avaliação do Ciclo de Vida (ACV) e Inventários é apontada por diversos autores: a) Programa Brasileiro de Avaliação do Ciclo de Vida (Brasil, 2010) incentiva formação de especialistas em níveis: técnico, graduação e pós-graduação; b) a Iniciativa do Ciclo de Vida pede mais estudos de ACV para produzir lições aprendidas, melhorar técnicas e metodologias, formar redes de especialistas e transferir conhecimento científico para a sociedade (Life Cycle Initiative, 2016); e c) estudo da UNEP sobre capacitação (Valdivia, Ugaya, Bajaj, 2013) apontou necessidade de disseminar melhores práticas para parceiros e consumidores. A proposta deste trabalho é apresentar os repositórios digitais: bases de dados online que reúnem e organizam a produção científica da instituição ou área temática (Instituto Brasileiro de Informação em Ciência e Tecnologia, 2016). Trata-se de estratégia de disseminação de publicações científicas online proposta pela Open Archives Initiative (Viana; Márdero-Arellano; Shintaku, 2005). O Repositório de ACV (RACV), com lançamento previsto para março de 2017 é iniciativa do IBICT para agregar valor à difusão do Pensamento do Ciclo de Vida e às ações de capacitação, em apoio às demandas mencionadas. São resultados esperados do RACV: a) agregar conhecimentos dispersos e recuperá-los através de poderosa ferramenta de busca; b) compartilhar publicações entre especialistas; c) disseminar dissertações e teses entre pesquisadores da academia, indústria e sociedade; d) preservar lições aprendidas; e e) atender critérios da publicação: “Global Guidance Principles for LCA Databases” (Sonnemann, 2016) de: confiabilidade; qualidade dos dados; evitando duplicação de esforços e garantindo comparabilidade e aplicabilidade múltipla por meio de recursos de interoperabilidade.

Palavras-chave:

Repositório Digital Temático; ACV; Repositório de Publicações Científicas; Capacitação em ACV; Formação em ACV, Pensamento do Ciclo de Vida.

ABSTRACT:

The need for capacity building in Life Cycle Assessment (LCA) and Inventories is pointed out by several authors: a) Brazilian Life Cycle Assessment Program (Brasil, 2010) encourages the training of specialists at technical, undergraduate and graduate levels ; b) the Life Cycle Initiative calls for further LCA studies to produce lessons learned, improve techniques and methodologies, train networks of experts and transfer scientific knowledge to society (Life Cycle Initiative, 2016); and c) UNEP study on training (Valdivia, Ugaya, Bajaj, 2013) pointed to the need to disseminate best practices to partners and consumers. The purpose of this paper is to present the digital repositories: online databases that gather and organize the scientific production of the institution or thematic area (Instituto Brasileiro de Informação em Ciência e Tecnologia, 2016). This is a strategy for dissemination of online scientific publications proposed by Open Archives Initiative (Viana; Márdero-Arellano; Shintaku, 2005). The LCA Repository (RACV), scheduled for launch in March 2017, is an initiative from IBICT to add value to the diffusion of Life Cycle Thinking and training actions in support of the aforementioned demand. Results expected from RACV are: a) aggregate dispersed knowledge and retrieve them through powerful search engine; b) share publications among specialists; c) to disseminate dissertations and theses among academics, industry and society researchers; d) preserve lessons learned; and e) meet criteria of the guide: "Global Guidance Principles for LCA Databases" (Sonnemann, 2016): reliability; quality of data; avoiding duplication of effort and ensuring comparability and multiple applicability through interoperability features.

Keywords:

Digital Repository; LCA; Repository of Scientific Publications; Capacity building in LCA; Life Cycle Assessment Training; Life Cycle Thinking.

1| INTRODUÇÃO

Os repositórios digitais (RDs) de publicações surgiram com o movimento do acesso aberto, trazendo solução à necessidade das instituições de ensino superior (IES) de expandir o acesso a resultados de pesquisa; aumentar a competição e reduzir o monopólio dos periódicos; refrear custos e destacar a relevância da instituição e das bibliotecas; servir como indicadores potenciais da qualidade da universidade; demonstrar a relevância científica, social e econômica das atividades de pesquisa, aumentando seu status e valor público (Crow, 2002). Os RDs funcionam como agregadores de documentos científicos e tecnológicos e podem ter caráter institucional ou temático.

As instituições que realizam estudos de ACV necessitam ter acesso aos inventários de ciclo de vida (ICVs) que são usados para mapear fluxos de matéria e energia nesses estudos. Essas informações já são abrangidas por bases de dados de inventários, como o SICV Brasil. Entretanto, outros tipos de documentos, igualmente relevantes, como: artigos científicos, teses, livros e relatórios de pesquisa, não são contemplados. Esses documentos podem ser encontrados em sítios da internet, porém apenas em fontes de informação dispersas e independentes, o que pode gerar buscas longas e extenuantes. Tal realidade aponta o problema de pesquisa: como integrar essas publicações de ACV - fisicamente dispersas em: sites de instituições, arquivos de periódicos científicos, bases de dados de inventários e outras fontes - dentro de uma base única, permitindo sua disponibilização e disseminação eficazes.

O objetivo geral do trabalho é propor um modelo de Repositório de ACV (o RACV), como uma base de dados de publicações científicas e tecnológicas de acesso aberto e demonstrar de que forma ele pode contribuir para a difusão do Pensamento do Ciclo de Vida (PCV) e para apoiar a Capacitação em ACV (CACV), em resposta às demandas manifestadas na literatura.

1.1. Revisão bibliográfica

Repositórios digitais (RDs) são bases de dados online que reúnem e organizam a produção científica da instituição ou área temática (Instituto Brasileiro de Informação em Ciência e Tecnologia, 2016). Um Repositório institucional (RI) é um RD direcionado à organização, preservação e disseminação da produção intelectual dos colaboradores de uma instituição. Já um Repositório temático (RT) é aquele que dissemina publicações de uma determinada área do conhecimento (Viana e Márdero-Arellano, 2006).

O PCV é a compreensão de que, no mundo moderno, tudo se inter-relaciona, e especialmente com o meio ambiente, causando impactos ao longo de todo o ciclo de vida de bens e serviços (Sonnemann et al., 2016). Já a CACV é abordada nos levantamentos de Sonnemann et al. (2016) como uma atividade que abrange preparação educacional a partir de: cursos de formação, seminários de treinamento e projetos de pesquisa.

2| METODOLOGIA

2.1. Dar resposta ao problema identificado.

Para agregar publicações de fontes diversas em RT único, com acesso web, buscas sofisticadas e disseminação, foi criado, no software DSpace - versão 5.4 - o repositório RACV. Entretanto, acompanhando a perspectiva internacional, especialmente continental, da Iniciativa do Ciclo de Vida (LIFE CYCLE INITIATIVE, 2016) e do estudo da UNEP (VALDIVIA, S.; UGAYA, C. M. L.; BAJAJ, S., 2013), para apoio à CACV e à difusão do PCV, considera-se necessário implantar um projeto de criação de repositórios em toda a América Latina (AL), o qual denominaremos abreviadamente de Projeto RCAP-AL. O desenvolvimento crescente de repositórios temáticos em escala Regional, criados com os mesmos padrões do RACV, permitirá a obtenção de um sistema de Curadoria digital de publicações de acesso aberto, garantindo sua acessibilidade contínua e utilização futura.

2.2. Definir indicadores para avaliar os resultados esperados do RACV.

Conforme estabelecido inicialmente, os resultados esperados eram:

2.1.1. Agregar conhecimentos dispersos e recuperá-los em poderosa ferramenta de busca - Para medir estes resultados, os indicadores são:

No caso do RACV: a) quantitativo de depósitos por fonte de informação em um dado período de tempo, no local considerado; e b) quantitativo de buscas / fonte / tempo / local considerado. No caso do Projeto RCAP-AL: a) depósitos / fonte / tempo / local, comparados entre países da Am. Lat.; b) buscas / fonte / tempo / local / comparados entre países da AL.

2.2.2. Compartilhar publicações entre especialistas – a) No caso do RACV:

o indicador é a quantidade de especialistas cadastrados como depositantes ou inscritos para notificações automáticas / tempo / local considerado; b) No caso do Projeto RCAP-AL: especialistas depositantes OU notificações automáticas / tempo / local, comparados entre países da AL.

2.2.3. Disseminar Dissertações e Teses entre pesquisadores da academia, indústria e sociedade - Os indicadores são: No caso do RACV:

a) quantitativo de depósitos de D e de T, por fonte de informação, em um dado período de tempo / local considerado; b) quantitativo de buscas de D e de T, por fonte de informação, em um dado período de tempo / local considerado. No caso do Projeto RCAP-AL: a) depósitos D e T / fonte / tempo / local, comparados entre países da Am. Lat.; b) buscas D e T / fonte / tempo / local, comparados entre países da AL.

2.2.4. Preservar e disseminar documentos de lições aprendidas (LAs) – No caso do RACV

será necessário, primeiramente, criar na ferramenta: comunidade de LAs, templates para registro de LAs, registro de contatos de especialistas, cadastro de especialistas, notificação automática para LAs etc. Depois, então, se poderão medir os resultados. No caso do Projeto RCAP-AL, os repositórios já devem ser desenvolvidos com todas estas funcionalidades, utilizando indicadores que permitam medir resultados também por critérios de localidade e comparação com demais países da AL.

2.3. Garantir atendimento aos princípios de Sonnemann et. al. (2016) e do Shonan Guidance Principles

Tanto no que se refere ao RACV quanto para aplicação ao caso do Projeto RCAP-AL, foi consultado Sonnemann e Vigon (2011), verificando-se a adequabilidade de seus parâmetros à construção de bases de dados de publicações.

2.4. Demonstrar o potencial do RACV para apoiar a difusão do PCV e a CACV Foram consultados:

a) Brasil, 2010; b) Life Cycle Initiative, 2016; e c) Valdivia, Ugaya, Bajaj, 2013, os quais apontaram a necessidade de criar um repositório como o RACV e também a ampliação de seu escopo em um projeto de abrangência Regional para a Am. Lat., como o RCAP-AL, voltados para as mesmas finalidades.

3| RESULTADOS

3.1. Construção do RACV

Foi dividida em quatro etapas: Planejamento, Customização, Implantação e Lançamento. Atualmente cumpre-se a etapa de Implantação. O protótipo deverá ser apresentado em maio, durante o Fórum Brasileiro de ACV. O Lançamento está previsto para junho, durante a CILCA 2017.

O usuário se inscreve na coleção e recebe aviso automático de e-mail sempre que ocorre novo depósito.

3.2. Avaliação dos resultados esperados do RACV.

Estes resultados são aqueles apresentados na “Metodologia”, e que correspondem aos indicadores mencionados nos itens 2.2.1, 2.2.2, 2.2.3 e 2.2.4.

a) No caso do RACV, pelo fato de se encontrar na etapa de “Implantação”, não tendo sido completamente povoado, esses resultados ainda não foram obtidos.

b) No caso do Projeto RCAP-AL, cujos repositórios também não foram implantados: os resultados também não podem ser obtidos. Além disto, os critérios de medição talvez sofram alterações em função de: abrangência, amplitude, aplicabilidade etc. das regiões consideradas.

3.3. Os princípios de Sonnemann et al. (2016) e do Shonan Guidance Principles

O Shonan Guidance Principles (Sonnemann e Vigon, 2011) demonstrou não ser apropriado para estabelecer padrões para bases de dados de publicações. Entretanto, embora suas orientações sejam aplicáveis exclusivamente a bases de inventários e datasets, seus princípios demonstraram ser apropriados para subsidiar estudos voltados à definição de critérios para repositórios. Na verdade, foi o que ocorreu a partir da década de 90 com o movimento do acesso aberto, e com o trabalho da OAI, em que esses mesmos fundamentos embasaram a seleção dos padrões tecnológicos tanto para criação de periódicos eletrônicos como de RDs. Deste modo, tendo sido construído dentro dos critérios da OAI, o RACV mantém-se compatível com os princípios de Sonnemann e Vigon (2011), como se vê a seguir:

a) Confiabilidade dos dados: garantido no software DSpace, com atribuição, ao objeto digital, de um identificador permanente, o DOI (Digital Object Identifier); a1) No caso dos demais repositórios latino-americanos o princípio é o mesmo, respeitadas as devidas proporções e especificidades;

b) Qualidade dos dados: garantido no RACV com a atuação dos revisores (avaliação por pares), que são dois: Administrador da Coleção, e Revisor da Descrição bibliográfica e da Indexação; b1) No caso dos demais repositórios latino-americanos o princípio é o mesmo, respeitadas as devidas proporções e especificidades;

c) Duplicação de esforços: evitada com os padrões OAI, dentre eles o software DSpace; c1) No caso dos demais repositórios latino-americanos o princípio é o mesmo, respeitadas as devidas proporções e especificidades; e

d) Interoperabilidade: satisfeito por meio do esquema de metadados DC, do protocolo OAI-PMH, e do software DSpace; d1) No caso dos demais repositórios latino-americanos o princípio é o mesmo, respeitadas as devidas proporções e especificidades.

3.4. Difusão do PCV e apoio à CACV

No caso do RACV – a) Quanto à difusão do PCV, o RACV tem sua estrutura interna categorizada em vinte e duas comunidades temáticas, visando representar ao máximo todas as sutilezas e sofisticações da ACV; b) Quanto ao apoio à CACV, a literatura indicou que o RACV deveria disponibilizar recursos de aprendizagem, mídias interativas e materiais didáticos, nos níveis técnico, graduação e pós-graduação. Assim, foi incluída a comunidade de “Objetos educacionais”, subdividida em categorias ou coleções específicas. Do mesmo modo foi incluída a comunidade de “Eventos em ACV” para reunir publicações produzidas em Congressos, Conferências etc., com subcomunidades correspondentes a cada ano de realização dos eventos.
No caso do Projeto RCAP-AL - O apoio à CACV e à difusão do PCV, inicialmente realizados em repositórios isolados, poderão, eventualmente, ser feitos de modo colaborativo uma vez que esses sistemas já possuem padrões tecnológicos para interoperabilidade. Em tempo oportuno, podem ser estruturadas redes ou federações, beneficiando toda a Região. Tais objetivos podem ser alcançados por meio de acordos de cooperação firmados com organizações do setor produtivo, de áreas de governo ou sociedade em geral, como: instituições de ensino superior (IES) etc.

4| CONCLUSÕES E RECOMENDAÇÕES

O RACV parece adequado à difusão do PCV uma vez que dissemina literatura de ACV, podendo incluir lições aprendidas, contatos de especialistas, melhores práticas etc. Igualmente, pode apoiar atividades de CACV já que os documentos submetidos dão subsídio a: ensino, pesquisa, extensão, eventos científicos, treinamentos com especialistas, produção de papers, inovações etc. Já repositórios construídos no âmbito do Projeto RCAP-AL, ou seja, na perspectiva da Região, parecem cumprir o mesmo papel, porém com abrangência para o restante da AL.
Quanto aos padrões e orientações para construção de RDs - sejam eles construídos localmente ou em escala regional - o Shonan Guidance Principles (Sonnemann e Vigon, 2011) não pode ser adotado. Entretanto, seus princípios, resumidos em Sonnemann et al. (2016) demonstraram ser válidos, especialmente quando definidos critérios apropriados ao tipo de informação, atributos e função dessas bases de dados. Nesse caso, o padrão atual que atende a todos esses princípios é o da iniciativa OAI. Em vista disto, os autores recomendam o uso desse padrão quando do desenvolvimento de RDs, sejam institucionais ou temáticos.
Quanto ao PCV e à CACV, recomenda-se que o RACV também: a) acompanhe linhas de pesquisa de IES e realize captação de patentes, estudos de ACV e relatórios de inventários do setor produtivo; b) contribua para a criação de redes de especialistas por meio da troca de contatos; e d) dissemine LAs, por meio de recursos criados para tal. Já no caso do Projeto RCAP-AL, recomenda-se estabelecer estratégias de atuação e planos de trabalho regionais que incluam políticas de incentivo a: a) criação de Curadorias de apoio à CACV e PCV; b) agregação de publicações de CACV e PCV em repositórios nacionais; c) submissões específicas de CACV e PCV; d) criação da gestão documental nos repositórios remotos; e) outras.
A construção do RACV também permitiu aos autores aperfeiçoarem metodologia própria de desenvolvimento de repositórios temáticos (RT) em áreas de ciência e tecnologia.

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LCI BACKGROUND DATA: TODAY'S CHALLENGES AND FUTURE OPPORTUNITIES BEYOND THE LCA COMMUNITY?

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ABSTRACT:

Consistent and high quality life cycle inventory data is the basis for any life cycle assessment or footprint study. However, more and more initiatives and practitioners are relying on LCI background data, while the quality and consistency of background data is not necessarily improving. Reasons include that sophisticated tools allow the technical combination of various sources of LCI background data, although these data have been modelled based on different quality guidelines. Furthermore, background data is often accessible only in aggregated form, which hinders the analysis of the raw data.

Several sectorial and national databases built on various types of background data and with their particular modeling principles are quickly evolving. While such emerging databases and initiatives increase the regional and sectorial data availability, they also bear the risk of inconsistency in terms of modeling principles, data quality and transparence.

In this paper we are analyzing the potential influence of background data on final LCA results. Further, we present our future concept on how to model background LCI data in order to allow the combination of different sectorial databases without compromising the overall quality of the results. Our vision is to foster the sound and easy use of LCA data beyond the LCA expert community.

Keywords:

Background data, LCI, regionalization, database

Green Economy an sustainable policies

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ENVIRONMENTAL IMPACTS EVALUATION OF THE RENEWABLE ENERGY POLICY PROPOSED BY THE ECUADOR GOVERNMENT AT COP21

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ABSTRACT:
At the Conference of Parties COP21, the Ecuador Government made a commitment to reduce greenhouse gas emissions by 20.4% to 25% in 2025, compared to the computed emissions in 2010. The main emission reduction policies described in the National Determined Contributions, NDC, are focused on the energy sector, with the intention to incorporate 2,828 MW of installed hydroelectric power to the current generation. This article aims to assess environmental impacts as consequence of changes in Ecuador's energy matrix, comparing two scenarios, with and without NDC accomplishment. The different environmental impact categories will be taken into account for both scenarios, with global warming being analyzed mainly from 2010 to 2020. According to results, the government's strategy to opt for greater hydropower insertion in the future will have a better performance in terms of greenhouse gas emissions. In fact, the magnitude of emissions avoided is consistent with presented at COP21.

Keywords:
Climate Change; Energy Matrix; NDC, IPCC

1| INTRODUCTION

Per the Ecuador' emissions inventory for 2010, the energy sector is responsible for 50% of national GHG emissions (MICSE, 2013). At the Twenty-First Conference of the Parties - COP21, the government established its commitment to reduce GHG emissions between 20.4% and 25.0% by 2025, taking in consideration the year of 2010 as the base scenario.(NDC, 2016).
The main policy to reduce emissions exposed in the NDC is to incorporate 2.828 MW of installed hydroelectric power to the current electricity generation matrix (NDC, 2016). The strategy is based on the country's high hydroelectric potential and consists of building eight new hydroelectric plants, three of which are already in operation, and other five that are in advanced construction phase.
This study aims to evaluate the environmental impacts of the changes in the Ecuadorian electricity generation matrix, by carrying out a consequential analysis of the comparison between two future scenarios: the first scenario is designed if the intentions in the NDC are met; the second scenario is the business as usual. Stablishing the trends on the energy matrix expansion for supplying energy demand with the current structure. Different impact categories will be taken for account on both scenarios, the analysis focus will be on climate change, with the global warming potential index. (IPCC, 1992)
The base year for this study is 2010, which is the reference year of the NDC. On 2010 the electric generation structure had an installed capacity of 4.761 MW, with half of the capacity coming from hydroelectric generation and, the other 50% from thermoelectric plants. The main fuels used on Ecuador thermoelectric generation are natural gas, oil and diesel. According to the national electric expansion plan (MEER, 2014), the useful hydroelectric potential is 21,520 MW. Other small scale projects described in the plan will not be accounted in this study due to lack of more advanced information.

2| METHODOLOGY

The methodology consists on the creation of two future scenarios, as previously described. The first scenario **(Scenario A)** will have a high percentage participation of hydroelectricity (70%), whilst the second scenario **(Scenario B)** is the business as usual. The hydroelectric matrix remains the same as in the base year (2010), corresponding to 25% of the matrix in 2020, and the expansion of energy supply comes from the implementation of new thermoelectric plants. In both scenarios energy growth will be considered the same, only energy sources participation will be different.

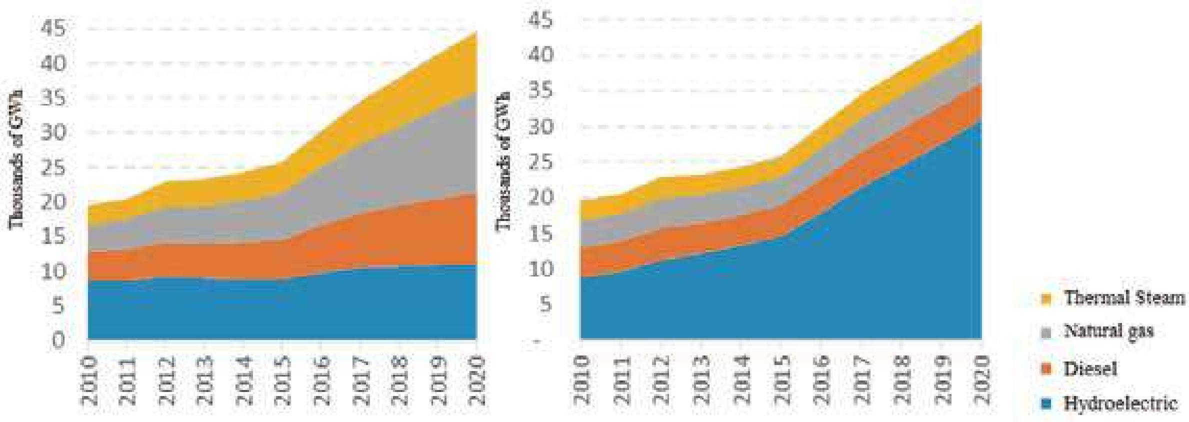

Figure 1 – *Electricity generation (a) Scenario B and (b) Scenario A.*

To create the two future scenarios, the economic energy model employed was based on the perspective of integrated resource planning (PIR). The model was developed in LEAP, Long-range Energy Alternatives Planning System software for energy analysis, considering all future demands and availability of resources until 2020. Energy demand' projected is 44.629 GWh (Castro and Galo, 2016). Figure 1 presents electricity generation expansion in Scenarios A and B, according to the LEAP model calculations.

The system boundary is presented in Figure 2, including all thermoelectric and hydroelectric plants existing in the 2010' system. The life cycle boundary evaluated the system until the generated electricity becomes available for sale on the integrated national system - SNI, not including transmission and distribution' stages. Table 1 summarizes the methodology used in this study.

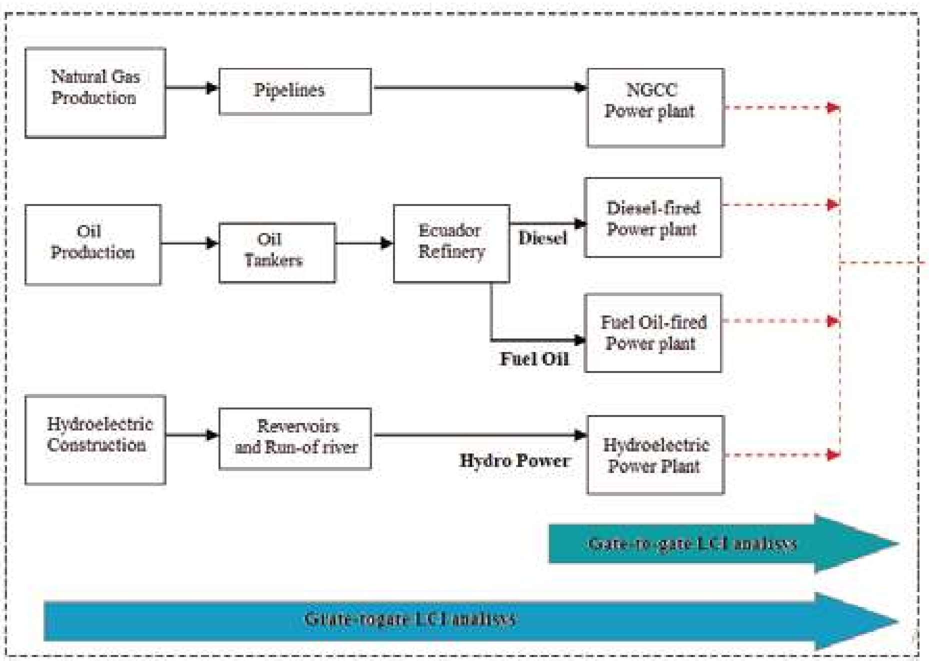

Figure 2 – *Research' system boundary.*

Table 1- *Description of purpose and scope of the LCA.*

Objective	Evaluation of the environmental impacts of the change in Ecuador's electricity generation matrix, projected for two future scenarios: A and B.
Considered Systems	Storage power plants; Natural Gas thermoelectric; Thermoelectric with Oil Derivatives (Diesel + Biodiesel).
Systems' boundary	From the cradle to the gate of the power plant.
Geographic scope	Ecuador.
Temporal scope	From 2010 to 2020.
Functional unit	1 kWh generated.
Inventory modeling	Consequential approach.
LCA method	*Midpoint* analysis, CML *Baseline*; *endpoint Ecoindicator 99*
Software	SimaPro 8.3.0.0
Environmental impacts categories	Depletion of abiotic resources; Depletion of fossil fuels; global warming; Depletion of the ozone layer; Human toxicity; Ecotoxicity (hydric and terrestrial); Photochemical oxidation; Acidification; Eutrophication.
Data source	Ecoinvent v3.1.

3| RESULTS ANALYSIS

The calculated results reflect the emissions corresponding to each of the electricity generation sources, divided into 3 groups: Hydroelectricity (Run-of-river stations + Storage power stations); to Oil Derivatives (Diesel + Biodiesel); and Natural Gas thermoelectric. Subsequently, the participation percentage of energy sources and the amount of energy generated in each scenario were considered in order to find the total GHG emitted. The calculations show that for the electricity generation mix in 2010, the emissions would be 5,06E-01 kg CO2eq/kWh, of which, thermoelectric generation would be the main responsible.

In an article written by Ramirez et al. (2013), in 2012, when already a large part of the government project was implemented, 62% of the national electricity generation came from hydroelectricity. In this situation GHG emission at the time was 3,51E-01 kg CO2eq/kWh, by the electric matrix (Ramirez et al., 2013). These values point that the government's stimulation for renewable energies' policy has been presenting positive results.

In the Ecuadorian NDC the emission reductions foreseen for 2025 are 8,98 MtCO2eq, whilst this research presented an emission reduction between scenarios of 9,42 MtCO2eq. The government calculation for the NDC considers only the stage of operation of the electric matrix, gate to gate, while this study was carried out counting the whole life cycle of the electricity generation from cradle to gate of the plan. Thus, the results found are in accordance with the foreseen made by Ecuadorian Government since, considering the whole life cycle, electricity generation is the main responsible for GHG emissions.

The results for the midpoint impact categories using the CML-baseline method (Guinée et al. 2002) are shown in **Table 2.**

Table 2 – *Midpoint environmental impacts results for each product type*

Damage category	Unit	Product1: run-of-river station	Product2: storage power station	Product3: Natural Gas	Product 4: Oil
Abiotic depletion	kg Sb eq	1,91E-08	2,40E-08	2,38E-08	8,94E-08
Abiotic depletion (fossil fuels)	MJ	4,07E-02	5,68E-02	1,01E+01	1,29E+01
Global warming (GWP100a)	kg CO2 eq	4,48E-03	1,55E-01	5,99E-01	8,98E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	3,46E-10	4,82E-10	1,64E-08	1,55E-07
Human toxicity	kg 1,4-DB eq	6,59E-03	9,80E-03	5,71E-02	1,73E-01
Fresh water aquatic ecotox.	kg 1,4-DB eq	7,51E-03	1,21E-02	2,20E-02	2,93E-02
Marine aquatic ecotoxicity	kg 1,4-DB eq	5,85E+00	8,45E+00	7,85E+01	9,94E+01
Terrestrial ecotoxicity	kg 1,4-DB eq	2,39E-05	2,80E-05	5,77E-05	6,51E-04
Photochemical oxidation	kg C2H4 eq	1,14E-06	1,32E-05	1,16E-04	3,68E-04
Acidification	kg SO2 eq	1,98E-05	2,81E-05	2,35E-03	9,42E-03
Eutrophication	kg PO4--- eq	7,62E-06	1,06E-05	9,63E-05	5,31E-04

For the endpoint category, Eco Indicator 99 (H) method was applied. Results are shown in Table 3.

Table 3 – Environmental damages endpoints results, for each of the 3 product types.

Damage category	Unit	Product1: run-of-river station	Product2: storage power station	Product3: Natural Gas	Product 4: Oil
Human Health	DALY	1,33E-08	4,28E-08	2,88E-07	9,49E-07
Ecosystem Quality	PDF*m2yr	1,78E-03	7,56E-03	6,55E-03	5,39E-02
Resources	MJ surplus	4,89E-03	6,82E-03	1,36E+00	1,73E+00

4| CONCLUSION

Environmental and life cycle assessments employed, indicate that the government's plan to opt for a mostly hydroelectric matrix in the future will have a very significant performance in reducing national emissions. In all cases analyzed, hydroelectric plants presented better results than thermal sources. The magnitude of the avoided thermal emissions is in line with the proposal presented by the government at COP21. Hydropower is not a source free of atmospheric emissions, and there is still much to be done in collecting inventories for reservoirs around the world. Thus, we conclude that an interesting study to be developed would be the recurrent water footprint of the expansion of Ecuadorian hydroelectricity.

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HOW TO ACCOUNT FOR LULUC EMISSIONS IN CORPORATE SUPPLY CHAINS?

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ABSTRACT:
Deforestation and other land use change is recognized as a key contributor to global greenhouse gas (GHG) emissions. The agriculture, forestry and other land-use related activities account for 24% of global GHG emissions, representing the second largest emitting sector after energy. Within this, 49% of GHG emissions are from land use and land use change such as deforestation (IPCC, AR5, 2014). For companies with significant agricultural or forestry activities within their supply chain, land use change may be among the most significant impacts they have on climate. Measuring land use and land use change (LULUC) emissions in corporate supply chains requires a consistent accounting/modeling approach. This paper presents an approach with special focus on indirect land use change, allocation of LULUC emission impact across time, and accounting for delayed emissions and sequestration of carbon for products made from forest-derived biomass.

Keywords:
Land use, land use change, emissions accounting, corporate supply chain, scope 3 emissions, guidance, GHG, carbon footprint

1| INTRODUCTION

Today, most leading corporations see acting on climate change as an important business imperative. Globally, corporations are increasingly setting greenhouse gas (GHG) reduction targets that include their supply chains, encouraged by COP21, the UN Climate Change Conference in Paris in 2015, as well as the momentum built around programs such as Science Based Targets (SBT) which encourages companies to set climate targets which are in line with the level of decarbonization required to keep global temperature increase below 2 degrees Celsius compared to pre- industrial temperatures and the We Mean Business Coalition which provides a common platform to accelerate the transition to a low carbon economy. Corporate commitments on forests have also been rapidly growing. SBT not only requires companies to set aggressive reduction targets for their own operations, but also to set "meaningful" targets for addressing emissions within their full value chain (if "scope 3" contributes at least 40% of total emissions). In addition, over 400 members of the Consumer Goods Forum have pledged to achieve deforestation-free supply chains between 2020 and 2030.

While existing guidance (e.g. IPCC, PEF, PAS2050, GHG Protocol) provides direction on how these emissions should be accounted for, they are not consistent among each other nor do all of them cover the newest findings in this rapidly evolving field. This presents a barrier for corporations to appropriately mobilize efforts to address LULUC emissions under their climate action plans in a transparent and consistent way.

This paper outlines three critical areas where consensus for a harmonized accounting approach is necessary. It is the result of the efforts from a pre-competitive initiative to develop a consensus-based methodological guide and credible reference to allow companies to account for LULUC-related emissions in their corporate footprints, corporate GHG targets, and product footprints in an accurate, credible, and consistent manner. Each chapter addresses one specific topic, explores the existing methodological options and shares a recommendation as presented in the recently developed consensus-based guidance on LULUC emissions accounting for corporate supply chains.

2| METHODOLOGY

In 2016, Quantis convened more than 40 diverse partners from industry, academia, governments, and non-profit organizations around the world to jointly develop the mentioned guidance document. With six workshops over the period of a month the partners actively participated in content development, which was subsequently assembled by Quantis into a first draft report. Three review phases followed to provide feedback on both structure and content before the final guidance was published in 2017. The final guidance is accompanied by an annex which serves as a scientific review, including additional background and discussion on the aspects covered in the guidance. Not intended as a standard, but rather a guidance that organizations can optionally follow, it aims to reflect the current consensus regarding best practices on these topics. As such, it serves as a building block for other tools and standards in the future

3| RESULTS AND DISCUSSION

There are three main topics that where perceived as particularly crucial for a consistent and transparent approach to LULUC emissions in corporate supply chains.

3.1. Indirect land use change

Many companies have already set aggressive emission reduction targets (e.g. zero-deforestation). Now, they want to incorporate them into their GHG accounting as a way to track their progress. Although not explicitly stated, it can be inferred that such commitments refer in most cases only to direct land use change (dLUC), as it is not under a company's direct control or ability to measure indirect land use change (iLUC) which is defined as "the change in the use or management of land which is a consequence of direct land use change" (WFLDB, 2013). While dLUC is measurable, iLUC occurs due to global market mechanisms with many influencing factors and can only be modelled, not measured (Valin et al., 2015). Life cycle assessment (LCA) and carbon footprinting models can model and link land use change to its indirect drivers. However, the many different methods (biophysical/causal descriptive, economic equilibrium models, rule-based, and integrated assessment models) use often different approaches when modeling iLUC which has led to widely varying estimates. This has created high uncertainty and little consistency. As a result, iLUC impacts have, in many cases, been excluded from total LUC emissions accounting.

Addressing either of these dynamics (dLUC and iLUC) alone is not sufficient to adequately address land use change. As such, the guidance recommends that corporate land use programs focus on both preventing land use change associated with the land where one's supplies are being sourced (dLUC), as well as alleviating the global demand for new cultivated land (iLUC). For further details on the modeling approach please refer to the consensus guidance.

3.2. Allocating impact across time

It is crucial that past emissions are treated consistently across time. According to IPCC, the global warming impact of LUC should be allocated over a time frame of 20 years (IPCC, 2006). This has been accepted as general practice for carbon footprinting. Yet, there are different ways to allocate the impact across these 20 years depending on what allocation curve is used. Existing methods are i) single allocation where all the LUC burden is allocated once (e.g. first year after LUC), ii) equal allocation where the LUC is equally distributed over a period of time (e.g. over 20 years), iii) linear and exponential discounting where the LUC GHG emissions decrease gradually/exponentially over a certain time period (Davis et al. 2014). In figure 1 the different allocation approaches are illustrated, using a 20 year time period. All of these allocation methods are currently applied and used differently by modeling practitioners in different or even similar situations. This creates inconsistency and an issue of noncomparability. Because this allocation method also defines how the burden of LUC is distributed over time, it can influence behavior of companies with regards to their practices for eliminating or preventing LULUC. Thus, assessing the implications of each allocation method is key. To create consistency and allow for comparability, the guidance recommends using the linear discounting method as a default method. For some special cases, for example when dealing with plantations (e.g. cocoa), the equal allocation method can be applied.

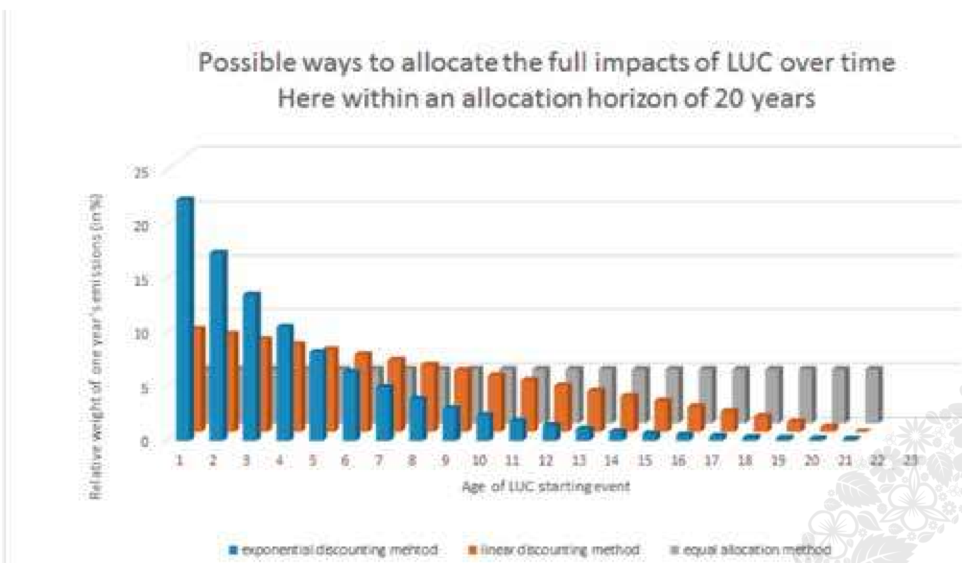

Figure1: Illustration of the impact allocation methods. *Note: for each method, the sum of all bars is equal to 1. Each bar is the share of the full LUC emissions to be allocated to the assessment year.*

3.3. Delayed emissions and sequestration for products made from forest-derived biomass

Carbon accounting methods are typically based on the carbon neutrality concept. This means that the use of wood is - except for permanent land use changes - defined as carbon neutral. As the harvested wood is assumed to regrow within a few decades, the time lag between emission and regrowth is not considered. This might not be relevant for annual or short rotation biomass, but might be very important for forest biomass with longer rotation periods and potential temporal or permanent storage of carbon in products.
The current GHG standards (e.g. PAS 2050, ISO 14067, GHG Protocol) do not account for the timing of carbon emissions and sinks. Consequently, there is the risk that the true climate reduction potential is not identified (either underestimated or overestimated) or that policy instruments might be inefficient or even counterproductive by promoting less preferred climate mitigation options.

We therefore recommend that when products or commodities consist of forest-derived biomass, the effect of removing the biomass on forest growth should be considered where relevant (e.g. by using the GWPbio approach (Cherubini et al. 2011)). For such products and commodities, the sequestration of carbon within products during use and end of life should be considered where relevant.

4| CONCLUSIONS

To set credible and transparent GHG targets, companies require an understanding of the LULUC impact related to their supply chains. To ensure a consistent understanding between stakeholders, a consistent approach when calculating land use and land use change impacts is needed. A consistent approach for iLUC, allocating impact across time, and accounting for delayed emissions and sequestration of forest products allows companies to create more consistency and transparency when calculating LUC impacts in corporate supply chains. These calculations ultimately support companies in setting achievable and transparent corporate targets.

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PRESENTATION OF A NOVEL LIFE CYCLE ASSESSMENT WEIGHTING METHOD TO APPLY IN POLICY-MAKING IN PERU

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ABSTRACT:

Weighting in Life Cycle Assessment (LCA) has been used in the Life Cycle Impact Assessment phase in terms of decision-making and policy support in order to transfer life-cycle oriented knowledge to policy makers and other stakeholders in a clear and efficient manner. Despite this utility, this step has always been controversial in LCA due to a series of factors, including: i) the certain level of subjectivity linked to the weights that are provided; ii) the higher uncertainty levels that accumulate in the LCIA once the characterization results are manipulated; and, iii) the lack of methodological innovation in this field as compared to other, more active, methodological spheres linked aimed at improving life cycle thinking methods.

In this context, policy-makers in many developing and emerging countries are experiencing trouble to face an ever-growing front of diverse environmental threats. For instance, in Peru, a country that has traditionally suffered several environmental threats due to dwindling glaciers, increasing water stress along the overpopulated Pacific coast or the uncontrolled extraction of biotic (i.e., deforestation, overexploited fisheries, etc.) and abiotic (e.g., illegal mining) resources, the recent signature of the Treaty of Paris has implied that the environmental priorities have shifted towards climate change. While this issue has consequences at a much broader scale, we argue that from an LCA perspective this should not be ignored by practitioners, since it could have large repercussions on how LCA practitioners should report their results to policy-makers, and how the latter will receive this information.

Hence, the main objective of this study is to present a method to deliver a nationally-specific weighting method for midpoint impact categories. To do so, a series of meetings were held at the Peruvian LCA Network in order to delve into the main challenges linked to the proposal of specific weighting standards for the Peruvian context. In this phase a set of 18 different impact categories commonly used in LCA were aggregated into a smaller sample of 14 indicators. Thereafter, a survey was made online to engage experts, both in Peru and elsewhere, in giving a set of preferences between pair of indicators. The high number of respondents (approximately 100) allowed computing a series of weights based on their responses, although certain corrections and adjustments were made in order to guarantee the applicability of the method.

Two different case studies, previously published in the literature in terms of characterization results, the production of pomegranate in coastal Peru and the Peruvian electricity mix, are computed and analyzed using the weighting method proposed. Results show that a clear message to policy-makers with little experience in LCA can be pushed forward if this weighting method is adopted. In addition, the advantages and limitations of using these types of methods are also discussed.

Keywords:
LCA; normalization; weighting.

Green Marketing Ecollabeling and EPDs

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THE EUROPEAN ENVIRONMENTAL FOOTPRINT INITIATIVE (EF)

LA INICIATIVA EUROPEA PARA LA HUELLA AMBIENTAL DE PRODUCTOS Y ORGANIZACIONES

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RESUMEN:

Cualquier compañía interesada en distribuir o promover un producto 'verde' en el mercado Europeo se enfrenta con una parafernalia de regulaciones y condiciones que debe cumplir. Para enfrentar éste problema, la Comisión Europea (CE) ha publicado una comunicación titulada 'Single Market for Green Products' ('Mercado Único de Productos Verdes'). De éste modo, la CE propone el uso de dos métodos para el Análisis de Impacto Ambiental (ACV) para evaluar la huella ambiental de productos (PEF por sus siglas en inglés) u organizaciones (OEF) y las cuales son compatibles entre sí. Esta iniciativa incluye una prueba piloto para desarrollar reglas por categoría de producto o a nivel organizacional, amabas conocidas como PEFRs y OEFSRs respectivamente.
Aunque ésta es una iniciativa de la CE, no se restringe a países Europeos. Si en un futuro se establece una legislación basada en dichos principios, productos de origen Latinoamericano que quieran ser comercializados en Europa tendrán que calcular su correspondiente huella ambiental (PEF). El propósito de éste trabajo es describir las mayores innovaciones propuestas por ésta iniciativa.

Palabras clave:

huella ambiental de producto; huella ambiental organizacional; PEF; PEFCR; OEFSR; UE;

RESUMEN:

Any company interested in circulating or promoting a product with environmental advantages in the European market is confronted with a paraphernalia of methods and initiatives to comply with. For this reason, in 2013, the European Commission (EC) has published a communication entitled 'Single Market for Green Products' to address these problems. Here the EC proposes the use of two life cycle assessment methods (LCA) to assess the environmental footprint of products (PEF) and organizations (OEF) and both are compatible with each other. This initiative includes a three year pilot which will develop rules at the level of a product category and of an organization sector, PEFCR and OEFSR respectively.
Although this is an initiative of the EC, it is not restricted to European countries. If the EC establishes future legislation based on these principles, products from Latin American countries that are traded in Europe may have to calculate their PEF profile. The purpose of this work is to describe the main innovations introduced by this European initiative.

Keywords:

environmental footprint of products; environmental footprint of organizations; PEF; PEFCR; OEFSR; EU

2| INTRODUCTION

Any company interested in circulating or promoting a product with environmental advantages in the European market is confronted with a paraphernalia of methods and initiatives to comply with, this mainly because each country has its own methodology and communication standards. For example in the UK, the environmental impact of products or services are required to follow the PAS 2050 standard (British Standards Institution, 2011) which focuses on an single environmental issue (Greenhous Gas Emissions GHG); while products for the French market are required to comply with the BP X30-323-0 methodology for environmental labelling and consumer communication (ADEME, 2010).
For this reason, in 2013, the European Commission (EC) has published a communication entitled 'Single Market for Green Products' with the aim of creating a uniform methodology and guidance applicable at the European Union level. With this initiative the EC proposes the use of two compatible life cycle assessment methods (LCA) to assess the environmental footprint of products (PEF) and organizations (OEF). Furthermore, this initiative includes a four-year pilot phase aimed at developing rules at product category level (PEFCR) and at the level of an organization or sector (OEFSR). These rules are being developed and tested by 26 pilots. At the end of 2017, the PEFCRs and OEFSRs pilots will be approved and the rules for developing new PEFCRs and OEFSRs will be ready for use.
The purpose of this work is to describe the main innovations introduced by this European initiative.

2| METHODOLOGY

2.1. Representative Product

For the development of a model that represents all products within a product category, the EC introduced the concept of representative product. For each product category, at least one representative product is required to be defined and it shall be: (i) a real product being sold on the European market or (ii) a virtual product which doesn't actually exists. In the case of a virtual product it should be modelled on the EU average market share of all existing technologies and materials in the category of products in scope.
In order to determine what to include in a PEFCR, the EC required a simplified PEF study of the representative product. The main objective of this study is to evaluate the representative product and several scenarios and thus:

- Identify environmental hotspots
- Facilitate the comparison between products falling within the same product category
- Facilitate the development of benchmarks

2.2. Hotspot Analysis

In the pilot phase of the European Commission, four types of hotspots are considered: impact category, life cycle stage, process and elementary flows (European Commission, 2016). **Table 1** shows an overview of each hotspots type.

Table 1 *Summary of hotspot analysis*

Item	At what level does relevance need to be identified?	Threshold
Most relevant impact categories	Normalised and weighted results	Impact categories cumulatively contributing at least 80% of the total environmental impact (excluding toxicity related impact categories)
Most relevant life cycle stages	For each most relevant impact category	All life cycle stages contributing cumulatively more than 80% to any impact category
Most relevant processes	For each most relevant impact category	All processes contributing cumulatively more than 80% to any impact category
Most relevant elementary flows	For each most relevant process	All elementary flows (foreground emissions) contributing cumulatively at least to 80% to the impact (caused by the foreground emissions only)
Hotspots	For most relevant life cycle stages, processes, and elementary flows	50% of the impact on any of the most relevant impact categories, before normalisation and weighting (i.e. on the characterised results), excluding toxicity related impact categories

During the pilot phase the communication testing will focus on the most relevant impact categories and life cycle phases. The most relevant processes and impact categories are important to determine data requirements.

2.3. Data and Quality Requirements

The EC is developing clear instructions for data collection and setting the minimum quality requirements (European Commission, 2016). The principle of materiality is applied, that means two relevant elements dictate what data needs to be collected and what level of quality is required. The materiality principle comprises:

1. Level of influence: what level of influence on the process has the company or stakeholder applying the PEFCRs?

2. Impact relevance: What are the most relevant processes that drive the environmental profile of the product?
To determine the quality of the data, there are four criteria that can be and qualified using five levels, from very good (1) to very poor (5). The data quality score of a dataset is the average of the scores of four criteria. Precision (P) as generic criteria and three context-specific quality criteria, namely technological (TeR), geographical (GR) and temporal (TiR) representativeness.
When developing PEFCRs for a product category, some specific elements should be included:
- The minimum list of processes to be covered by company-specific data;
- The list of activity data that the applicant must declare;
- Data quality tables for the specific context quality criteria;
- Data to be used by default;
- The list of mandatory secondary datasets to use.

When a PEFCR is applied during the execution of a PEF study, it will be necessary to determine for each process in the life cycle if 1) it belongs to the list of most relevant processes identified in the PEFCR and 2) how much influence the company that executes the study has on this process. A data needs matrix is provided by the EC summarizing all the possibilities (European Commission, 2016).
The development of these requirements, the applicability of the data needs matrix and the mandatory use of pre-defined secondary data are an essential step in ensuring the comparability desired by the European Commission.

2.4. Circular footprint formula

The EF initiative also introduced a single end-of-life formula entitled circular footprint formula. The use of this formula is mandatory in the pilot phase of the European Commission. While pilots applied this formula to their baseline results, some of them also tested alternative formulas.

3| RESULTS AND DISCUSSION

It is important to note that the content described in this work focused in the current state of the pilot phase. Since this is a process under development and the rules are being tested and adjusted in the pilot phase, there may be changes in the future. Therefore it is difficult to determine with certainty when and to what extent the PEF approach will be fully adopted and/or mandatory for products in the European market, still for those interested in testing these rules and applying the rules to their own products or learn more about how to model environmental impacts for products included in the 26 pilots the results outcomes and recommendations from this phase will be ready by the end of 2017.

4| CONCLUSIONS AND OUTLOOK

The EF initiative has brought many technical novelties compared to conventional LCA practice. Examples of these include the representative product, hotspot analysis, data and quality requirements, and a single end-of-life formula.
Until 2020, the European Commission does not plan to adopt PEF and OEF environmental footprint methods in any policy or legislation. However, the EC will briefly begin to consider possible policies related to the PEF and OEF. Some of the pilots who are currently developing PEFCRs intend to use the approach in their products. Also, some of the EU countries, for example Italy, already adopted EF in their new labelling program "Made Green in Italy".
If the application of PEF and OEF becomes the standard in Europe, Latin American countries who wish to trade their products in the EU may have to align with the PEF initiative and follow the rules and methods described here. This means companies will have to apply the PEFCRs and follow the guidance from the results of the pilots to.

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LA COMUNICACIÓN COMO HERRAMIENTA DE DIFUSIÓN DE ACV PARA PÚBLICO GENERAL: PRESENTACIÓN DE LA ECOETIQUETA AMBIENTAL TIPO III

A COMUNICAÇÃO COMO FERRAMENTA DE DIFUSÃO DA ACV PARA O GRANDE PÚBLICO: APRESENTAÇÃO DA ROTULAGEM AMBIENTAL TIPO III

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RESUMO:

A rotulagem ambiental consiste na concessão de um selo a um produto que atenda a determinados critérios ambientais. Esse selo informa o consumidor sobre o desempenho ambiental do produto. Atualmente existem três tipos de rotulagens ambientais: I - certificação que utiliza considerações e pensamentos com foco no ciclo de vida do produto; II - autodeclaração pelo próprio fabricante; III – declaração que utiliza informações de Avaliação do Ciclo de Vida conforme a ABNT NBR ISO 14040. A Rotulagem Ambiental tipo III traz benefícios tanto ambientais como econômicos e sociais, tais como melhora do perfil ambiental do produto, aumento da competitividade industrial, visibilidade do fabricante, entre outros. Embora ela apresente diversos benefícios e seja um dever das organizações prestar informações claras e confiáveis à sociedade, muitas empresas encontram dificuldades em apresentá-la de forma eficiente ao público. A apresentação da rotulagem ao consumidor final é um processo de comunicação que pode ser realizado por meio da embalagem, do rótulo, da propaganda, do marketing impresso ou digital. Desta forma, o consumidor tem acesso a informações que direcionam sua escolha, fomentam o consumo consciente e aumentam o valor agregado do produto. O objetivo deste trabalho é discutir as dificuldades de apresentação da rotulagem ambiental tipo III ao consumidor final, tomando como base as teorias da comunicação e da ciência da informação.

Palavras Chave:

comunicação pública, declaração ambiental, rotulagem ambiental

RESUMEN:

La ecoetiqueta consiste en la concesión de um sello a um producto que responde a determinados critérios ambientales. Este sello informa al consumidor sobre el desempeño ambiental del produto. Actualmente existen tres tipos de ecoetiquetas: I- Certificación que utiliza consideraciones y pensamientos enfocados en el ciclo de vida del produto; II- Autodeclaración por el propio fabricante; III-Declaración que utiliza informaciones del Análisis del Ciclo de Vida según la ABNT NBR ISSO 14040.La ecoetiqueta tipo III trae beneficios ambientales, económicos y sociales, tales como mejora del perfil ambiental del produto, aumento de la competitividad industrial, visibilidad del fabricante, entre otros. A pesar que su uso presenta diversos benefícios, y es un deber por parte de las organizaciones ofrecer información clara y confiable a la sociedade, muchas empresas encuentran dificultades a la hora de presentar dichas informaciones de forma eficiente al consumidor.La presentación de la ecoetiqueta al consumidor final es un proceso de comunicación que involucra emabalaje, rotulos, propaganda, marketing. De esta forma, el consumidor tiene acceso a informaciones que direccionan su elección, fomenta el consumo consciente y aumenta el valor agregado del produto. El objetivo de este artículo es discutir sobre las dificultades en la presentación de la ecoetiqueta tipo III para el consumidor final, a partir de las Teorias de la Comunicación y de la Ciencia de la Información.

Palabras clave:

comunicación pública, declaración ambiental, ecoetiqueta

1| INTRODUÇÃO

A etimologia da palavra comunicação vem do latim "Communicare", que significa tornar algo comum, o ato de partilhar informações. O processo de comunicação consiste na transmissão de uma mensagem entre um emissor e um receptor. A mensagem pode ser codificada através de sons, gestos, símbolos e/ou imagens que tem que ser suficientemente clara e precisa para facilitar a interpretação e compreensão do receptor. A apresentação de informações inerentes a um produto para o consumidor é um processo de comunicação como outro qualquer, realizado por meio da embalagem, do rótulo, da propaganda, do marketing impresso ou digital. Neste caso, por meio das informações na embalagem, o consumidor tem acesso a uma diversidade de informações que direcionam sua escolha de compra ou não do produto.

Segundo Scatolim (2008) o usuário reconhece o produto por meio do rótulo, que traz informações como ingredientes, composição, finalidade e modo de uso. Além do aspecto informacional, o rótulo também traz apelo estético. Desta forma os rótulos desempenham um papel importante, sendo um instrumento de informação e, ao mesmo, publicitário. Na área da gestão ambiental chamamos de rotulagem ambiental as declarações dos fabricantes de que o produto segue critérios ambientais específicos.

Essa "marca" ou "selo", localizado na embalagem, informa o consumidor sobre o desempenho ambiental do produto. Tais declarações ambientais podem vir em forma de textos, símbolos, tabelas, material suplementar, boletins técnicos, propaganda, entre outros meios, mas o mais comum ainda é o rótulo ou a embalagem do produto (ABNT, 2006).

A família de normas ISO 14020 (ISO 14020, 14021, 14024, 14025) define três tipos de declarações ambientais: a tipo I é uma certificação que utiliza considerações e pensamentos com foco no ciclo de vida do produto. A Tipo II normaliza como devem ser realizadas as autodeclarações feitas pelo próprio fabricante do produto. E finalmente a rotulagem Tipo III que é a declaração ambiental que necessita um estudo de Avaliação do Ciclo de Vida, conforme a norma ABNT NBR ISO 14040.

Segundo Kohlrausch (2003) os tipos de rotulagem definidos pela família de normas 14020 são de carácter voluntário, e fornecem os princípios orientadores para a criação dos rótulos ambientais desde as autodeclarações até as certificações de terceira parte (Rotulagem tipo III).

A Rotulagem tipo III, também conhecida como Declaração Ambiental de Produto – DAP, se difere das demais declarações por necessitar de uma verificação de terceira parte, isto é, carece de uma validação por uma entidade que não tenha tido envolvimento com o estudo ACV, tampouco com o fabricante do produto. Esta certificação legitima o estudo e garante a veracidade das informações apresentadas.

A DAP é apresentada na forma de um documento com uma série de informações sobre as categorias de impacto ambiental avaliadas no estudo de ACV. Desta forma, sua leitura pode ser um pouco complexa se o consumidor final não estiver familiarizado com o assunto. Tendo isto em vista, este trabalho tem como finalidade levantar como a rotulagem tipo III (DAP) é apresentada para o grande público e como é feita a divulgação dos produtos certificados para o consumidor final.

2| METODOLOGIA

A presente pesquisa foi realizada com produtos brasileiros que foram avaliados segundo a apresentação das informações ambientais geradas pela DAP, doravante tratada por EPD (Environmental Product Declaration). Duas formas de EPD foram consideradas no estudo: as contidas no sistema International EPD® System e as verificadas pela Fundação Vanzolini. Ambos os casos são EPDs de produtos do setor de construção civil.

Após a definição dos objetos de estudo, buscou-se verificar como as informações contidas nas respectivas EPDs eram apresentadas para o consumidor, analisando informações apresentadas no site oficial da empresa, nos sites de varejo e nas notícias encontradas na internet sobre o produto.

A segunda etapa contou com a aplicação de um questionário semiestruturado. A pesquisa focou na presença (ou ausência) de qualquer informação das EPDs nas embalagens. Também foi questionado aos fabricantes qual a percepção destes em relação aos benefícios gerados pelas EPDs. Nos casos em que não havia qualquer menção nas embalagens, foi questionado o motivo de não ter incluído estas informações e como o fabricante difunde a existência da EPD daqueles produtos.

A partir dos resultados obtidos através das pesquisas nos sites e da entrevista com os fabricantes foi realizada uma análise crítica para melhor compreensão das dificuldades específicas de apresentação de resultados das EPDs.

3| RESULTADOS E DISCUSSÃO

O sistema EPD® é um programa global para declarações ambientais baseadas na ISO 14025 e na norma europeia EN 15804. A EPD® possui uma base de dados com mais de 650 DAPs dos mais diversos tipos de produtos e de vários países. Os produtos brasileiros contidos neste programa são produzidos por duas empresas (Votorantim Cimentos e ISOVER). Uma contém EPDs de três produtos de base na construção civil: cimento, argamassa e concreto. A segunda empresa possui seis EPDs de produtos de acabamento interno: forros (2) e feltros (3). A tabela 1 resume as informações das EPDs brasileiras.

Empresa	Produto	Certificação
Votorantim Cimentos	Cimento (CP II E 40, CP III-40 RS E CP V-ARI)	EPD Environmental Product Declaration
	Concreto (FCK 30 MPA BR.1 ABAT 10+-2)	
	Argamassa (2202 matrix revestimento fachada)	
ISOVER Saint-Gobain do Brasil	Forro (Prisma Plus)	
	Forro (Forrovid Boreal)	
	Feltro (Feltro Facefelt Br)	
	Feltro (Feltro Isoflex 4+)	
	Feltro (Feltro Wallfelt Pop 4+)	
Indústria e Comércio de Molduras Santa Luzia	Rodapé de poliestireno reciclado	RGMAT Fundação Vanzolini
Vidro Real Revestimentos	Pastilhas de vidro reciclado	

Tabela 1 – *Produtos brasileiros com declaração ambiental de produto no sistema EPD®*

A Fundação Vanzolini, além de outras atividades, desenvolve projetos de certificação ambiental de produtos da construção civil. Para tanto, a fundação criou o RGMAT, uma certificação que é uma DAP e também um selo ambiental. A instituição se responsabiliza pelas Regras de Categoria de Produto (PCRs na sigla em inglês) e pelos critérios para emissão do selo. Segundo Felipe Queiroz da diretoria de certificação da Fundação, o RGMAT é um programa criado conforme a norma ISO 21930 e ISO 14025, para o desenvolvimento de know-how em um programa de EPD, para tal o processo foi simplificado e foi dado um maior enfoque para a ISO 21930.
Após a realização do estudo de ACV por terceiros, é elaborada a EPD e a fundação faz o processo de verificação para emissão do selo. Os aspectos técnicos são baseados nas ISO 14025 e na ISO 21930. No momento, dois produtos de acabamento têm o selo RGMAT: pastilhas de vidro e rodapé de poliestireno, ambos reciclados.
Para verificar como é realizada a divulgação das informações referentes a EPD nos debruçamos sobre a comunicação de dois produtos, rodapé de poliestireno reciclado da Indústria e Comércio de Molduras Santa Luzia e o cimento certificado pela EPD Brasil da Votorantim Cimentos.

3.1. Rodapé de poliestireno (eps) reciclado

3.1.1. Informações no site oficial da empresa e em outras fontes

O site oficial da empresa não conta com informação sobre a EPD, e nenhuma menção à certificação. Na ficha técnica podemos encontrar informações sobre a composição do produto: 96% de EPS Reciclado e 4% de EPS Virgem.
1Na data desta pesquisa a DAP das pastilhas da Vidro Real Revestimentos estava expirada e ISOVER Saint-Gobain não respondeu ao nosso contato.
Os sites de varejo enfatizam as características ecológicas do produto com termos como "Produto ecologicamente correto", "Proveniente da reciclagem de EPS", mas não foram encontradas informações sobre a certificação do produto em nenhuma fonte.

3.1.2. Entrevista com fabricante

Na tabela 2 estão compiladas as respostas do fabricante sobre como os resultados da EPD do rodapé de poliestireno são divulgados ao público consumidor e quais os benefícios percebidos.

Tópicos	Respostas
DIFUSÃO PARA O GRANDE PÚBLICO	*"Em termos gerais é difundida, mas geralmente enviamos aos clientes que solicitam para especificar o produto. A declaração está disponível no site http://vanzolini.org.br/rgmat/produtos-rg-mat/"*
INFORMAÇÕES NA EMBALAGEM	*"Sim, temos o selo RGMAT em toda nossa comunicação e embalagens (caixas, etiquetas)"*
BENEFÍCIOS DA EPD	*"Com uma EPD, é possível controlar e gerenciar os impactos ambientais atrelados ao produto. Tendo uma EPD, temos também um compromisso de evolução contínua nas questões ambientais, sociais e econômicas da organização, do processo e do produto. Na realidade brasileira essa mentalidade de valor agregado ainda está muito recente, mas acreditamos que é um mercado que não tem volta. Nossa intenção é investir fortemente na transparência"*
DIFICULDADES NA DIVULGAÇÃO	*"Sim, nossa maior dificuldade foi e está sendo transformar informações técnicas provenientes da ACV/EPD em informações "palpáveis" aos clientes e público em geral. Convenhamos que é difícil imaginar e mensurar x kg de CO_2-eq. que um determinado produto emite ao longo do seu ciclo de vida"*

Tabela 2 – *Questionário sobre a divulgação da EPD do rodapé de poliestireno reciclado ao consumidor.*

3.2. Cimento votorantim

3.2.1. Informações no site oficial da empresa e em outras fontes

Na área do site oficial da empresa dedicada ao produto não existe informações a respeito da certificação, mas a obtenção da Declaração Ambiental de produto foi divulgada em vários sites de notícia (especializados na temática de ACV como também na grande mídia).

3.2.2. Entrevista com fabricante

Na tabela 3 estão compiladas as respostas do fabricante sobre como os resultados da EPD do cimento Votorantim são divulgados ao público consumidor e quais os benefícios percebidos.

Tópicos	Respostas
DIFUSÃO PARA O GRANDE PUBLICO	*"Temos falado dos EPDs em fóruns de sustentabilidade especialmente relacionados a construção sustentável, temos também um material informativo que foi distribuído a alguns clientes e também via site de hospedagem dos EPDs"*
INFORMAÇÕES NA EMBALAGEM	*"Ainda não temos essa informação nas embalagens, acreditamos que hoje o EPD é mais relevante para as grandes construtoras que possuem sustentabilidade como um diferencial de mercado e que tenham também interesse na obtenção de um selo LEED. (Construção Sustentável)"*
BENEFÍCIOS DA EPD	*"Os EPDs ajudam a empresa a se diferenciar, no caso da Votorantim ela é a primeira empresa do setor de cimentos a publicar essa informação. Inclusive ganhamos bastante destaque em mídia. Porém a grande expectativa que temos é a de que o EPD seja um diferencial na escolha do cimento quando se pretende obter um selo LEED, já que ele ajuda a somar pontos nesse sistema de certificação"*
DIFICULDADES NA DIVULGAÇÃO	*"Como decidimos focar no mercado a granel, nosso foco não foi o grande público, portanto não tivemos tanta dificuldade na comunicação"*

Tabela 3 – *Questionário sobre a divulgação da EPD do rodapé de poliestireno reciclado ao consumidor.*

4| CONCLUSÃO

A presente pesquisa constatou que ainda há poucos produtos nacionais com DAPs baseadas em estudos de ACV. Estas poucas declarações são, em sua totalidade, representativas de produtos da construção civil, seja de acabamento interno (rodapé) ou insumos básicos (cimento).

No que tange à informação ao grande público, a forma de apresentar os resultados das EPDs é distinta. No caso dos produtos de acabamento interno, estes possuem embalagens com um selo impresso que remete à declaração. Já no caso do cimento, o foco da empresa é no mercado a granel, portanto não há uma preocupação com embalagens. O contato com o público se dá através de participação em fóruns sobre construção sustentável ou envio direto aos clientes, portanto, a comunicação é bastante direcionada, não atingindo o consumidor comum.

As empresas que responderam o questionário entendem a EPD como benéfica aos processos internos da empresa e também para diferenciação no mercado. Há uma percepção clara da importância das EPDs como vantagem à obtenção de outras certificações ambientais

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