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Bibliometric analysis of Life Cycle Assessment articles visible in Scopus and Web of Science

Análisis bibliométrico de artículos de Life Cycle Assessment visibles en Scopus y Web of Science

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ABSTRACT

The interest and concern generated in recent years about the environment has increased. Countries have signed treaties and agreements in search of sustainable development with the goal of an environmental, social, and economic balance. Life Cycle Assessment (LCA) has been established in this context as an international tool of great utility in different areas to identify and quantify the environmental loads of a process or product. In this article, a bibliometric analysis is carried out using the Web of Science (WoS) and Scopus databases about LCA, indicating the values of scientific production in the period 2000-2020, by country, organization, and subject. Finally, a mapping for the keywords was performed using the VosViewer software.

Descriptors: Documentary analysis; decision making; environmental impact; life cycle assessment; sustainable development. (UNESCO Thesaurus).

RESUMEN

El interés y la preocupación generados en los últimos años por el medio ambiente ha aumentado. Los países han firmado tratados y convenios en busca del desarrollo sostenible con el objetivo de lograr un equilibrio ambiental, social y económico. Life Cycle Assessment (LCA) se ha establecido en este contexto como una herramienta internacional de gran utilidad en diferentes áreas para identificar y cuantificar las cargas ambientales de un proceso o producto. En este artículo se realiza un análisis bibliométrico utilizando las bases de datos Web of Science (WoS) y Scopus sobre LCA, indicando los valores de la producción científica en el período 2000-2020, por país, organización y temática. Finalmente, se realizó un mapeo de las palabras clave utilizando el software VosViewer.

Descriptores: Análisis documental; toma de decisiones; impacto ambiental; ciclo de vida; desarrollo sostenible. (Tesoro UNESCO).

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INTRODUCTION

Life Cycle Assessment (LCA) is a tool for environmental management that allows companies and organisations to identify and quantify the environmental burdens associated with their processes by establishing the inputs and outputs of matter and energy throughout the entire life cycle of the product or a part of it depending on the object of the study and the system delimitations. ISO 14001 standardises the elaboration of an LCA by containing the requirements and guidelines together with standards 14040 to 14044 (Aristizábal Alzate et al., 2020).

This method has been used for the waste management systems analysis (Bovea et al., 2017; Sharma & Shandel, 2021), wind farms (Li et al., 2021), comparison of wheat straw treatment (Deng & Adams II, 2020), steel manufacturing exhaust gas utilisation methods (Cheng, *et al.* 2020), biofuel production from forest biomass (Ringsred et al., 2021), biofuels (Chiriboga et al., 2020), energy consumption environmental comparison of transport means (Wang et al., 2021) environmental impacts associated with products such as cross-insulated wood panels (Santos et al., 2021), AA alkaline batteries (Hamade et al., 2020), windows (Saadatian et al., 2021) comparison of power generation scenarios and photovoltaic systems among others existing (Sierra et al., 2020; Hadi & Heidari, 2021).

In recent years, interest in the LCA method has been increasing and this is reflected in the number of publications generated on this topic in different scientific journals. The progress study and state of research on this topic can be carried out using bibliometric studies. Bibliometrics uses statistics and quantitative studies to analyse the characteristics of the use and production of documents by reflecting how bibliographic sources are distributed with respect to a sector and the trend they follow (Spinak, 1998). Thus, bibliometric analysis is very useful to evaluate the scientific production generated around a particular topic of interest. As part of this analysis type, indicators such as the productivity of publications, authors, publishing institutions, countries, analysis by subject, citations and impact indices are used (Solano López et al., 2009). In this article a bibliometric analysis of LCA is elaborated to represent the real status of this topic of great interest in the scientific area and wide application in companies,

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organisations, and institutions due to the benefits it can provide such as cost reduction in energy, water, fuel, environmental costs, and competitive advantage for their commitment to the transition towards more circular and sustainable processes and economy. This document is a Microsoft Word template. Please do not use other templates. The author(s) must strictly follow instructions to maintain the journal's high standard.

METHOD

In a first phase, the Scopus and Web of Science databases were consulted in April 2021 using the search algorithm: LCA and bibliometric in the category Title for WoS, and LCA or Life and cycle and assessment and bibliometric in the categories title, abstract, keywords in Scopus.

The articles were limited to the period between 2000 and 2021. In this phase, articles were identified in which a bibliometric analysis on LCA had been carried out on a specific topic or, as in the present article, a review of the scientific production on this topic was carried out. The algorithm used was: LCA and bibliometric in the category Title for WoS, and LCA or Life and cycle and assessment and bibliometric in the categories title, abstract, keywords for Scopus. In Scopus, a subsequent reading of the articles abstracts was carried out to identify whether the article really had a bibliometric analysis on LCA purpose or whether, on the contrary, it did not fulfil the objective of this article as it was, for example, a key word for another analysed topic or a topic of greater scientific production within the bibliometric analysis carried out for another topic.

RESULTS

This bibliometric analysis seeks to show whether there is an increase in scientific production on this topic and to identify the organisations or universities with the greatest contribution, areas, and topics with highest number of publications in Scopus and Web of Science (WoS) databases.

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In the Web of Science database, two bibliometric analyses were found in 2016 and 2019 prior to this article focusing on the scientific production around LCA in Brazil (Zanghelini et al., 2016) and conventional and prefabricated construction (Kushima Ramos et al., 2019) using the algorithm: LCA and bibliometric in the Title category. In the Scopus database, 56 results were initially found using the logarithm: LCA or Life and cycle and assessment and bibliometric in the categories title, abstract, keywords. Subsequently, the articles abstracts were read to filter those that were bibliometric analyses on LCA, finding related articles on the following topics: biorefineries (Lima et al., 2021) ecosystem services (VanderWilde & Newell, 2021) carbon capture, storage and use technologies LCA, solar photovoltaics, environmental footprint, architecture and construction bioenergy as well as bibliometric analyses on LCA scientific production (Tobias da Cruz et al., 2021; He & Yu, 2020; de Paula Teixeira, 2020; Martínez Delgado et al., 2019; Hu, 2019; Li et al., 2018; Visentin et al., 2019; Chen et al., 2014).

Bibliometric analysis of similar documents

Table 1 contains background information on documents in which a bibliometric analysis on LCA or on a topic using LCA has been carried out. This table shows that the bibliometric analyses on LCA from a general perspective, either globally or in a specific country, are the documents with the highest number of citations, demonstrating the interest in the subject; however, LCA is a constantly growing topic in terms of scientific production, as shown in Figure 1, which is why this author considers it important to keep this type of analysis updated so that the information provided and the topics of interest and trends are more in line with describing the topic status in scientific production.

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Table 1.

Papers conducting bibliometric analysis on LCA.

Reference	Topic	Database	Timespan	Number of citations
Zanghelini et al. (2016)	LCA in Brazil	Publications indexed in the Institute for Scientific Information	1993-2015	14
Kushima Ramos et al. (2019)	Conventional and prefabricated construction	Google Scholar, Science Direct, WoS e Periódicos CAPES	2013-2017	0
Lima et al. (2021)	Biorefinery database systems	WoS y Scopus	2008 - 2018	1
VanderWilde & Newell (2021)	Ecosystem services and LCA	WoS	1900 - 2019	0
	Carbon capture, storage and use technologies	Scopus	1995-2018	0
Tobias da Cruz, et al. (2021)	LCA trends	WoS	1990-2018	1
Martínez Delgado et al. (2019)	Photovoltaic Solar Energy	Scopus	1998-2020	0
de Paula Teixeira (2020),	Environmental footprint	WoS	1992- 2018	14

Source: The authors.

LCA bibliometric analysis

Table 2 and Figure 1, below show the number of publications on LCA in the databases consulted. Scopus contains the largest number of publications and, as in WoS, in the last 10 years, there has been an increase in production on this topic. This behaviour has been observed in other similar studies such as in (Li et al., 2018), where a bibliometric analysis is carried out between 2000 and 2014 and in which the authors indicate a marked growth from 2010 onwards, also visible in Figure 1, and which continues until 2020. Based on the results, the Scopus database provides a greater variety of documents on this topic compared to WoS.

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Table 2.

Number of annual publications in Scopus and WoS (2000-2021).

Year	Scopus	WoS	Year	Scopus	WoS
2000	509	134	2011	2370	680
2001	570	161	2012	2835	807
2002	526	174	2013	3146	970
2003	781	216	2014	3465	1118
2004	845	220	2015	3535	1289
2005	1057	327	2016	3833	1419
2006	1210	304	2017	4347	1577
2007	1295	356	2018	4664	1842
2008	1452	340	2019	5025	1961
2009	1681	487	2020	5170	2213
2010	2037	608	2021	1947	619

Source: The authors.

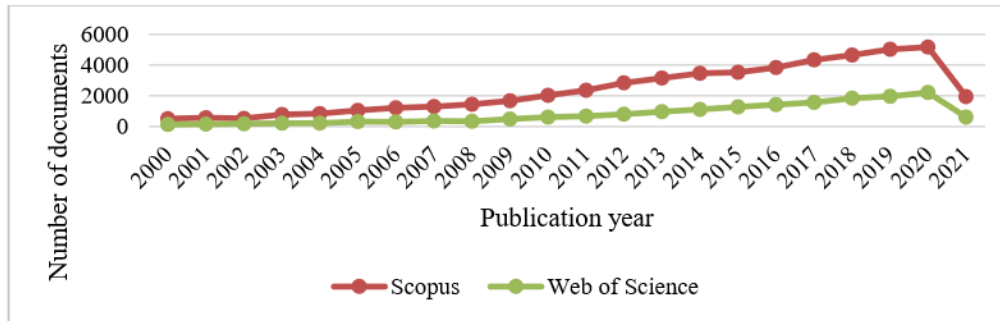


Figure 1. Papers published by year from 2000 to 2021 on LCA-related topics.

Source: The authors.

LCA bibliometric analysis

Table 3 shows the list of the most productive countries in Scopus and WoS. The 10 countries with the highest number of published papers were consulted and although the positions may vary according to the base consulted, the list remains the same except for Sweden which is only in the top 10 in Scopus and Australia in WoS. The United States and China continue to be the leading countries in LCA with respect to the number of publications and the countries in the top 5 are the same as those presented by He & Yu (2020). Table 4 shows that the top 5 organisations are from these two countries, justifying their leadership in the subject. In the table, Mexico's

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position in terms of production is added due to this article origin, demonstrating a need to generate scientific production on this topic by occupying places above number thirty.

Table 3.

Countries with the highest production of LCA documents (2000-2021).

Country	Scopus		WoS	
	Ranking position	Number of documents	Ranking position	WoS
United States	1	12089	1	3950
China	2	5270	2	1840
United Kingdom	3	4354	6	1173
Italy	4	4145	3	1603
Germany	5	4129	5	1308
Spain	6	2834	4	1427
Canada	7	2584	8	927
France	8	2573	7	943
Australia	9	2156	Not in top 10	668
Netherlands	10	2083	9	889
Mexico	32	134	317	37
Sweden	Not in the top 10	1694		795

Source: The authors.

Table 4.

Organisations with the highest scientific production in LCA.

Organization	Country	WoS		Scopus	
		Ranking position	Number of documents	Ranking position	Number of documents
European Commission		1	1109	1	2208
U.S. Department of Health and Human Services	USA	2	885	3	877
National Institutes of Health (USA)	USA	3	869	4	867
National Nature Science Foundation of China	China	4	783	2	1502
National Science Foundation	USA	5	398	5	860

Source: The authors.

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Publications by topic

Table 5, shows the topics with the highest production. Environmental sciences and engineering are two predominant areas, which is consistent with the interest that has been generated in recent years in seeking a balance between social, economic, and environmental aspects in industrial processes and products. LCA is a decision-making tool for studying alternatives, which makes it very attractive for presenting options to a problem.

Table 5.

Publications by subject in WoS and Scopus.

Area	WoS		Area	Scopus	
	Number of documents	Participation (%)		Number of documents	Participation (%)
Environmental sciences	8083	45,3	Engineering	20294	20,4
Engineering	7581	42,5	Environmental sciences	19996	20,1
Science technology and other topics	4328	24,2	Energy	11315	11,4
Energy fuels	2165	12,1	Medicine	7155	7,2
Agriculture	750	4,2	Business, administration, and accounting	4691	4,7
Chemistry	687	3,8	Social sciences	4284	4,3
Building constructor technology	625	3,5	Agriculture and life sciences	3886	3,9
Material science	601	3,3	Computer science	3881	3,9
Applied biotechnology and microbiology	559	3,1	Material science	3825	3,9
Psychology	415	2,3	Chemical engineering	2936	3

Source: The authors.

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Furthermore, the history of international conventions, whether legally binding or not, encourages the use of these methodologies to ensure that their actions are in line with what has been subscribed to in the search for sustainable development. Both databases have areas related to industry, energy, environment, and technology in their categories with the highest participation. When relating the categories to the organisations with the highest production (Table 6), the participation of those focused on science is evident. Universities that generate information have also remained on the list and continue to produce documents on this topic.

Table 6

Universities with the highest scientific production.

Universities	Country	WoS		Scopus	
		Ranking position	Number of documents	Ranking position	Number of documents
University of California System	USA	1	423		
Technical University of Denmark	Denmark	2	385	1	699
INRAE- French National Research Institute for Agriculture, Food and the Environment	France	3	293		
ETH Zurich	Switzerland	4	269	2	539
Centre National de la Recherche Scientifique CNRS	Francia	5	254	7	370
Norwegian University of Science Technology NTNU	Norway	6	233	3	483
Chalmers University of Technology	Sweden	7	216	5	407
University of London	United Kingdom	8	212		
University of Santiago de Compostela	Spain	9	207		
Leiden University	Netherlands	10	207		
Chinese Academy of Sciences	China			4	413
Ministerio de Educación de China	China			6	402
University of Michigan	USA			8	364
Politecnico di milano	Italy			9	364
Tsinghua University	China			10	350

Source: The authors

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Figure 2, indicates the most frequently used words in the documents consulted for this bibliometric analysis. Life cycle is most associated with costs, decision-making, sustainability, and sustainable development. No major nodes are evident in the figure; however, it provides an idea of what specific topics LCA documents are being elaborated on including: greenhouse gases, climate change, carbon footprint, energy, emission control and gas emissions, global warming, recycling, environmental impact studies, among others. Table 1 shows bibliometric analyses on carbon footprint and energy and biofuel which have been cited 14 and 13 times respectively (Martínez-Delgado et al., 2019), (Li et al., 2018).

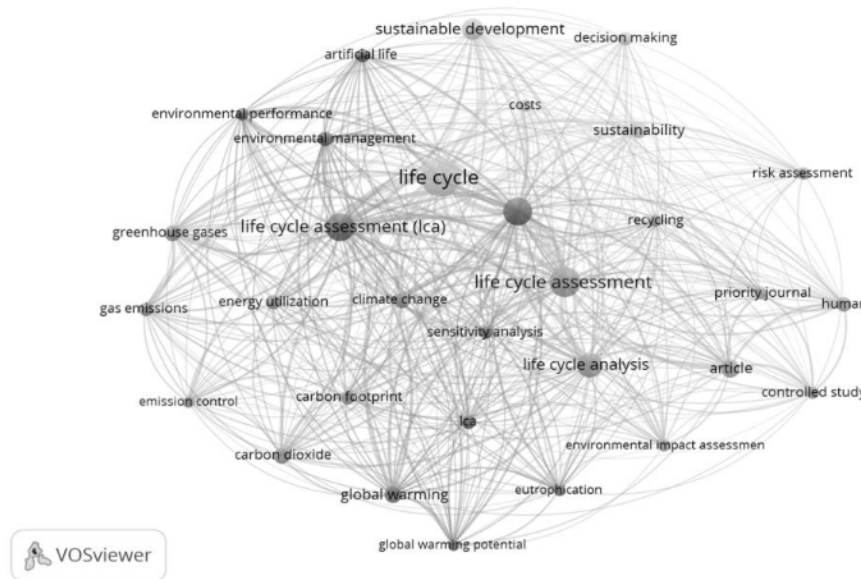


Figure 2. Keywords in LCA publications (2000-2021).

Source: The authors.

CONCLUSION

The scientific production on LCA has been increasing over the last 20 years and has become a useful tool for dissemination in organisations and institutions in different countries. The United States, China, Spain, Germany, and Italy have the highest production, while Mexico is between 32nd and 27th place according to the database consulted, which is why Mexican researchers and organisations are encouraged to

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generate more information on LCA. The topic with the most information is those corresponding to environmental sciences and engineering. There are bibliometric analyses on specific topics related to construction, energy, biofuels, carbon footprint, among others, for which bibliometric analyses have already been carried out. The keywords are varied and there is not yet a preponderance of any one of them, being a highly useful topic for different sectors.

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