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# Technological Ecosystems for the Management of Hazardous Waste in E-Waste

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**Abstract**

*A documentary review was carried out on the production and publication of research papers related to the study of the variables Technological Ecosystems and E-waste. The purpose of the bibliometric analysis proposed in this document was to know the main characteristics of the volume of publications registered in the Scopus database during the period 2015-2022, achieving the identification of 16 publications. The information provided by this platform was organized through graphs and figures, categorizing the information by Year of Publication, Country of Origin, Area of Knowledge and Type of Publication. Once these characteristics have been described, the position of different authors on the proposed topic is referenced through a qualitative analysis. Among the main findings made through this research, it is found that China and India, with 4 publications, were the countries with the highest scientific production registered in the name of authors affiliated with institutions of these nations. The Area of Knowledge that made the greatest contribution to the construction of bibliographic material referring to the study of the variables Technological Ecosystems in the management of waste as E-waste was Environmental Sciences with 10 published documents, and the most used Publication Type during the period indicated above were Journal Articles with 50% of the total scientific production.*

***Keywords:*** *Technological Ecosystems. Waste Management, E-garbage.*

## 1. Introduction

Solid waste management, and in particular hazardous waste management, has become a topic of international interest. As globalization has evolved, communities have structured their structure, their productivity and consumption schemes. Nowadays, economic entities have become more competitive in order to be at the forefront of the constant demand for goods and consumption. This has led to an increase in the volume of waste and a large increase in hazardous substances. Proper management of hazardous waste, particularly in E-garbage, has become a first in recent years, characterized by technological advances and with the aim of creating an environmental awareness of technological waste.

At the international level, the enormous challenge that currently exists is to minimize the production of technological waste and avoid the toxic effects from technological devices, since these effects can have effects on the environment and human health. The implementation of technological ecosystems for the treatment of harmful and hazardous

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waste from technological devices is divided into several main sectors. By first promoting and determining the reduction and prevention generated by these devices, we also design collection models and new methods of effective recycling of obsolete equipment, ensuring an effective recovery of valuable materials.

The development of more effective techniques for the disassembly and separation of components, the sustainable extraction of precious metals, and the adoption of safer processes for the treatment of toxic substances are just a few examples of the innovations that technology has generated in these ecosystems. Similar to how consumption patterns can be determined and collection and recycling methods improved using artificial intelligence and data analytics.

But key players in the tech ecosystem – manufacturers, recyclers, governments and consumers – also need to work closely together. In addition to raising public awareness of the value of properly disposing of electronic devices, effective policies and regulations must be put in place to ensure responsible management of electronic waste. In conclusion, technological ecosystems for hazardous waste management represent a promising approach to address environmental and human health issues caused by the rapid depreciation of electronic products. To ensure a sustainable and healthy future for future generations, these end-to-end solutions based on innovation and collaboration are crucial. For this reason, this article seeks to describe the main characteristics of the compendium of publications indexed in the Scopus database related to the variables Technological Ecosystems and E-basura, as well. Such as the description of the position of certain authors affiliated with institutions, during the period between 2015 and 2022.

## 2. General Objective

To analyze, from a bibliometric and bibliographic perspective, the preparation and publication of research papers in high-impact journals indexed in the Scopus database on the variables Technological Ecosystems and E-trash during the period 2015-2022.

## 3. Methodology

This article is carried out through a research with a mixed orientation that combines the quantitative and qualitative method.

On the one hand, a quantitative analysis of the information selected in Scopus is carried out under a bibliometric approach of the scientific production corresponding to the study of the Technological and E-waste variables. On the other hand, examples of some research works published in the area of study mentioned above are analyzed from a qualitative perspective, based on a bibliographic approach that allows describing the position of different authors on the proposed topic. It is important to note that the entire search was carried out through Scopus, managing to establish the parameters referenced in Figure 1.

3.1. Methodological design


Figure 1. Methodological design

Source: Authors' own creation

3.1.1 Phase 1: Data collection

Data collection was carried out from the Search tool on the Scopus website, where 16 publications were obtained from the following filters:

TITLE-ABS-KEY ( technological AND ecosystems, AND e-waste ) AND PUBYEAR > 2011 AND PUBYEAR < 2023

- Published documents whose study variables are related to the study of variables, Technological Ecosystems and E-waste.
- Limited to the years 2015-2022.
- Without distinction of country of origin.
- Without distinction of area of knowledge.
- No distinction of type of publication.

3.1.2 Phase 2: Construction of analytical material

The information collected in Scopus during the previous phase is organized and then classified by graphs, figures and tables as follows:

- Co-occurrence of words.
- Year of publication.
- Country of origin of the publication.
- Area of knowledge.
- Type of publication.

3.1.3 Phase 3: Drafting of conclusions and outcome document

In this phase, the results of the previous results are analysed, resulting in the determination of conclusions and, consequently, the obtaining of the final document.

## 4. Results

4.1 Co-occurrence of words

Figure 2 shows the co-occurrence of keywords found in the publications identified in the Scopus database.

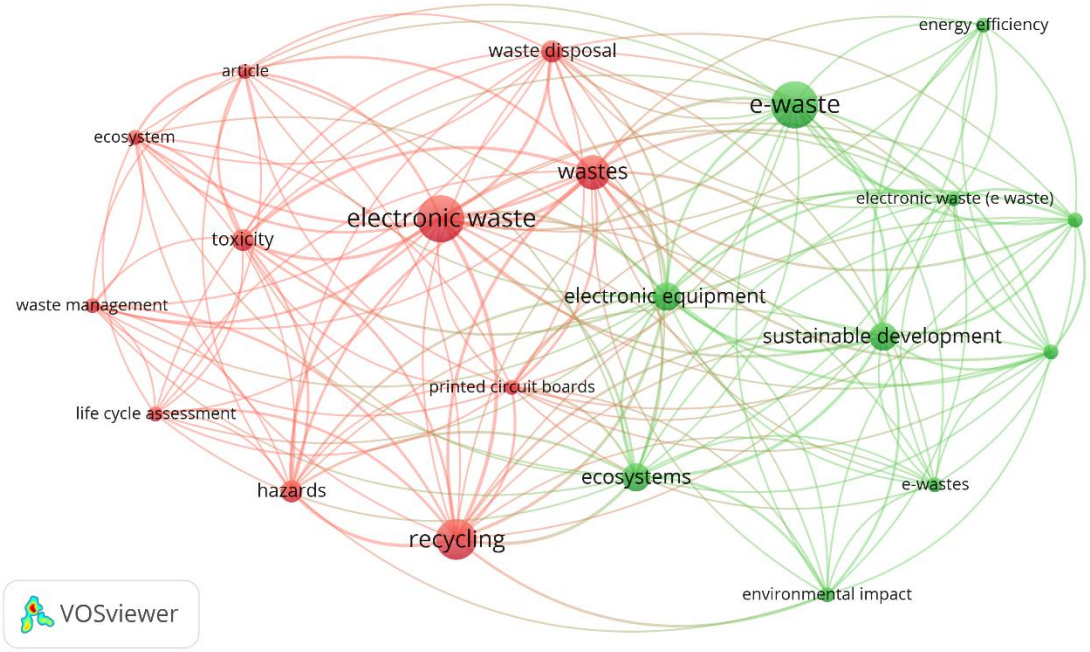


Figure 2. Co-occurrence of words

Source: Authors' own elaboration (2023); based on data exported from Scopus.

Technological Waste was the most frequently used keyword within the studies identified through the execution of Phase 1 of the Methodological Design proposed for the development of this article. Electronic equipment is also among the most frequently used variables, associated with variables such as Ecosystems, Recycling, Environmental Impact, E-waste, Sustainable Development, Garbage Deposit. It is striking that, in the current state of astonishing technological progress and growing environmental awareness, there is an urgent need to address the challenges posed by the management of hazardous waste from obsolete electronic products (commonly referred to as "e-waste"). This topic concerns not only the final disposal of obsolete devices, but also their potential negative impact on our environment and human health due to the toxic substances they contain. In this context, technology ecosystems have emerged as an innovative and important approach to address this dilemma effectively and sustainably. These ecosystems are the result of a confluence of technologies, interdisciplinary collaboration, and accountability that offer promising solutions to mitigate the negative impacts of e-waste and move toward a more balanced future for the environment and human well-being.

4.2 Distribution of scientific production by year of publication

Figure 3 shows how scientific production is distributed according to the year of publication.

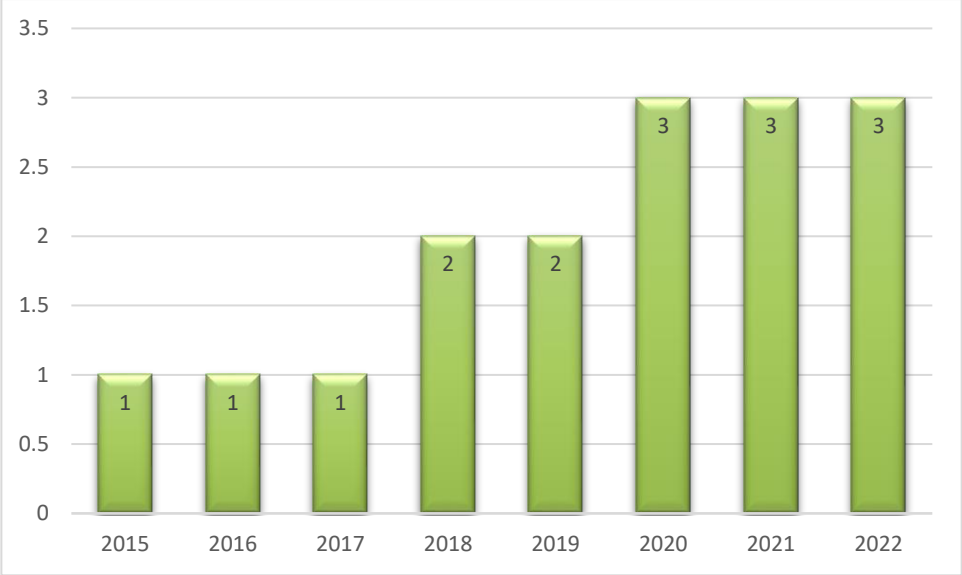


Figure 3. Distribution of scientific production by year of publication.

Source: Authors' own elaboration (2023); based on data exported from Scopus

Among the main characteristics evidenced through the distribution of scientific production by year of publication, the number of publications registered in Scopus was in the years 2020-2022, reaching a total of 4 documents published in journals indexed on this platform. This article aims to demonstrate the implications of the growth of e-waste, within the traditional conception of the Linear Economy, over time, and to deduce the potential reaction of society. by defining the pattern of his time of impatience. Method: For the development of the research, the logistic model of differential equations (Verhulst, 1838) and a theoretical model of finite difference equations associated with an empirical log-linear regression model were used to analyze the growth prospects of electronic waste, over time, when technological advances are estimated, as well as the potential reaction of society. Main results: The results show that there is a point of impatience in society that can be measured, as long as the specificities of each type of e-waste are known; and that the volume of e-waste grows exponentially over time, being influenced, in part, by the evolution of technology, considering the electronic products made available to society as a proxy, which is driven to consume, among other motivations, by functional obsolescence.(Porto, 2021)

4.3 Distribution of scientific output by country of origin

Figure 4 shows how scientific production is distributed according to the country of origin of the institutions to which the authors are affiliated.

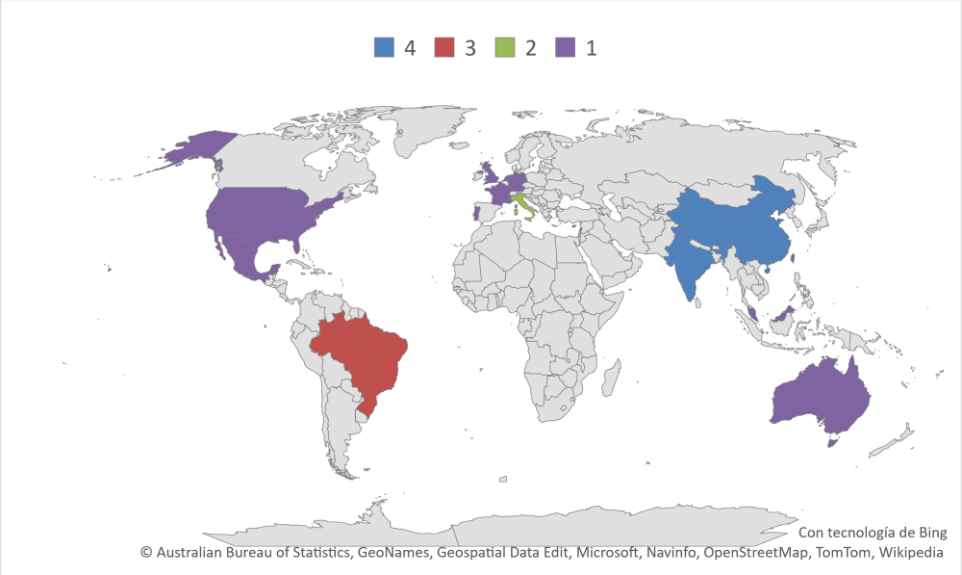


Figure 4. Distribution of scientific production by country of origin.

Source: Authors' own elaboration (2023); based on data provided by Scopus.

Within the distribution of scientific production by country of origin, the registrations from institutions were taken into account, establishing China and India as the country of this community, with the highest number of publications indexed in Scopus during the period 2015-2022, with a total of 4 publications in total. In second place, Brazil with 3 scientific papers, and Italy occupying the third place presenting to the scientific community, with a total of 2 documents among which is the article entitled "Green Route for the Beneficiation of Metallic Materials from Electronic Waste for the Selective Reduction of CO2" In this context, we demonstrate an easily scalable green route for the benefit and effective use of metal materials from e-waste by Cryogenic temperature grinding with the main objective of recovering almost complete metal waste from e-waste using an energy process. efficient and eco-friendly approach. The metal nanoparticles thus obtained are subsequently used for the selective reduction of CO2 in different gaseous products by electrochemical means, leading to the evolution of CH4, H2 and CO as major gaseous products at neutral pH and CO as the majority product at basic pH. . In a nutshell, the current approach can provide useful means to obtain significant metal waste from e-waste, which can be further used for green energy production in an eco-friendly way, making the process sustainable.(Sharma, 2022)

4.4 Distribution of scientific production by area of knowledge

Figure 5 shows the distribution of the  elaboration of scientific publications based on the area of knowledge through which the different research methodologies are implemented.

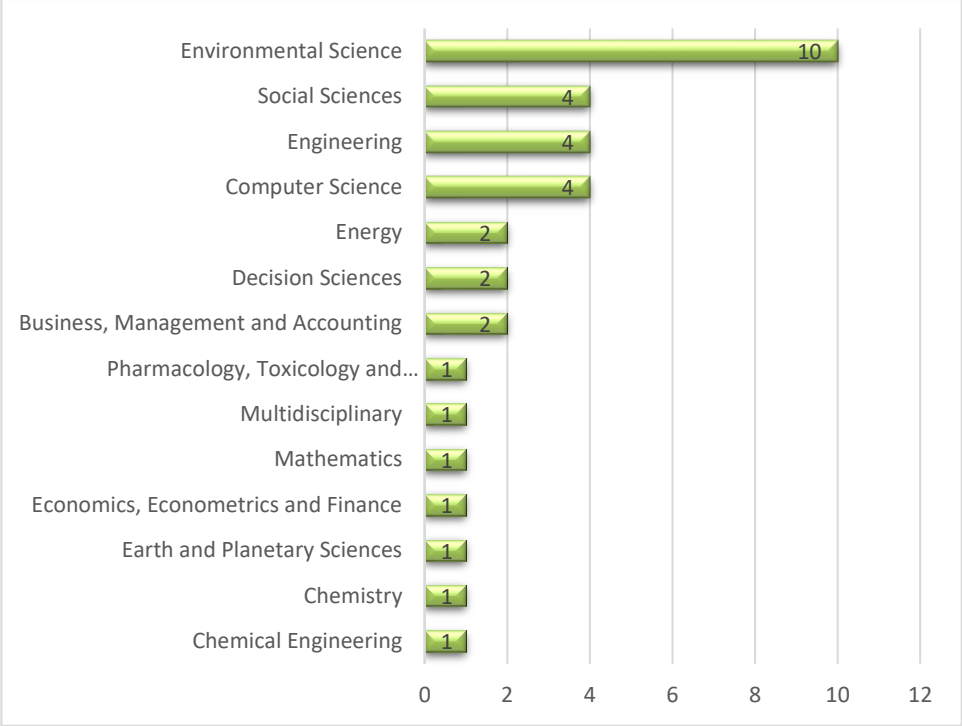


Figure 5. Distribution of scientific production by area of knowledge.

Source: Authors' own elaboration (2023); based on data provided by Scopus

Environmental Science was the area of knowledge with the highest number of publications registered in Scopus with a total of 10 documents that have been based on their variable methodologies Technological Ecosystems and E-waste. In second place, Social Sciences with 4 articles and Engineering in third place with 4. The above can be explained thanks to the contribution and study of different branches, the article with the greatest impact was registered by the Environmental Science area entitled "Impact of technological innovation and the development of regulations on the toxicity of electronic waste: a case study of discarded mobile phones" The document attempts to address the question: Have technological innovations and regulatory development had a positive impact on ecosystems and public health? We identified 36 Waste Mobile Phones (WMPs) manufactured between 2002 and 2013, assessed their metal concentration, leachability, and potential impact on the environment and human health using digestion, the Toxicity Characteristics Leaching Procedure (TCLP), and the USEtox model, respectively. The results highlight that regulations did not have a significant impact on the total metal content, except for some heavy metals, while technological innovation registered a stronger impact. WMPs should be classified as hazardous due to excessive lead content. Copper posed the most significant ecotoxicity risk, and chromium showed the most significant risk of cancerous and non-cancerous diseases. In addition, we showed that the toxicity of WMPs increased with technological innovation.(Chen, 2018)

4.5 Type of publication

In the following graph, you will see the distribution of the bibliographic finding according to the type of publication made by each of the authors found in Scopus.

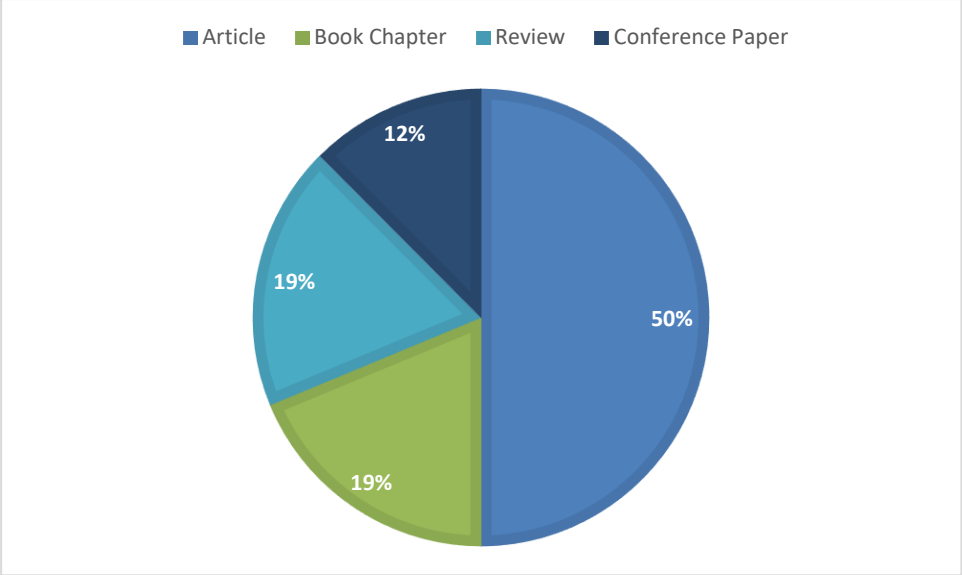


Figure 6. Type of publication.

Source: Authors' own elaboration (2023); based on data provided by Scopus.

The type of publication most frequently used by the researchers referenced in the body of this document was the one entitled Journal Articles with 50% of the total production identified for analysis, followed by Book Chapter with 19%. Journals are part of this classification, representing 19% of the research papers published during the period 2017-2022 in journals indexed in Scopus. In this last category, the one entitled "Mass balance as an economic and sustainable strategy in the WEEE sector" stands out. This article aims to provide an explanation of Waste Electrical and Electronic Equipment (WEEE), a concept associated with the disposal of large household appliances such as refrigerators. The importance of innovation and technological knowledge has led to the development of new industrial progress and has represented the main reason for the increase in the production of goods and services. The growth in the modernization of the high-tech sector has increased rapidly: in the IT industry, the upgrade of Electrical and Electronic Equipment (EEE) and its planned obsolescence have become two of the fastest-growing waste streams in a global context. By describing the large amounts of e-waste and the hazardous substances it contains (i.e. heavy metals, CFCs, pentane), the most virtuous companies are working to introduce new criteria in the assessment of environmental costs related to the economic degeneration of natural resources and the negative impact of economic activities on environmental pollution (e.g. $CO_2$ emissions). The project developed a perspective that focuses on sustainable accounting and the use of environmental accounting tools. It investigates the environmental and economic dimensions in the e-waste sector, considering the flows of materials recovered from the treatment plant of a Sicilian company. (Tuccio, 2017)

## 5. Conclusions

Through the bibliometric analysis carried out in this research work, it was possible to establish that China and India was the country with the highest number of records published in the Technological Ecosystems and E-waste variables. with a total of 4 publications in the Scopus database. In the same way, it was possible to establish that the application of theories framed in the area of Environmental Sciences, were used more frequently in the impact generated by the implementation of technological ecosystems to mitigate toxic effects on the environment, for this reason those topics of interest how complex it is in a modern society and the way in which they interact with technological resources, Digital ecosystems intervene in an interconnected and independent way in

order to mitigate the waste of those devices of the technological era such as: computers, mobile phones, tablets, communications services, among others. As a result of this article, we can highlight the management of these devices, since it is crucial to properly handle the toxic materials present in these devices and also to properly handle recycling to avoid damage and contamination in the environment. The unsustainable extraction of materials for the production of electronic devices also depletes natural resources and accelerates climate change.

To conclude, the technology and e-waste ecosystems are currently intertwined. Implementing sustainable design practices in device manufacturing, promoting the circular economy to maximize the reuse of materials and components, and encouraging education on the value of proper recycling are crucial to addressing these issues. To mitigate the negative effects of technology ecosystems and decrease the amount of e-waste produced, while also reaping the advantages offered by technology, it is essential that government regulations, public awareness campaigns, and industry, government, and the community collaborate. can provide sustainably.

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