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# Analysis of scientific production on environmental risk assessment in ecosystems with a circular economy

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Received: June 3rd, 2024. Received in revised form: November 8th, 2024. Accepted: November 18th, 2024.

**Abstract**
Ecosystems are currently at risk, and scientific methods have been developed to assess these impacts. In this scenario, the circular economy makes it possible to reuse raw materials and reduce waste. The objective of the research is to analyze the scientific production related to the evaluation of environmental risks in ecosystems with a circular economy approach. Quantitative research was carried out, with a retrospective and descriptive approach, from a bibliometric study in the SCOPUS database in the period 2014 - 2024. The peak of research was 4, where research articles predominated with 7 in 12 areas of knowledge. The most producing country was the United States. The most producing journal was Thunderbird International Business Review with 159. four research lines and their gaps were identified. Environmental risk assessment is much more than a legal requirement; it is an opportunity to demonstrate an organization's commitment to sustainability.

*Keywords*: bibliometric analysis; circular economy; ecosystems; quantitative research; environmental risks.

# Análisis de la producción científica sobre la evaluación de riesgos ambientales en ecosistemas con enfoque de economía circular

**Resumen**
Los ecosistemas en la actualidad se encuentran en riesgo, por lo que se han desarrollado métodos científicos para evaluar estos impactos. En este escenario, la economía circular permite reutilizar materias primas y reducir los residuos. El objetivo de la investigación es analizar la producción científica relacionada con la evaluación de riesgos ambientales en ecosistemas con enfoque de economía circular. Se llevó a cabo una investigación cuantitativa, con un enfoque retrospectivo y descriptivo, a partir de un estudio bibliométrico en la base de datos SCOPUS en el período 2014 – 2024. El pico de investigaciones fue 4, donde predominaron los artículos de investigación con 7 en 12 áreas del conocimiento. El país más productor fue Estados Unidos. La revista más productora fue Thunderbird International Business Review con 159. Se identificaron 4 líneas de investigación y sus brechas. La evaluación de riesgos ambientales es mucho más que un requisito legal; constituye una oportunidad para demostrar el compromiso de una organización con la sostenibilidad.

*Palabras clave*: análisis bibliométrico; economía circular; ecosistemas; investigación cuantitativa; riesgos ambientales.

## 1 Introduction

The evolution and formation of diverse ecosystems on our planet was due to its physical, geological and geographical conditions [1]. An ecosystem is a functional unit of nature [2], which includes living organisms (biocenosis) [3] and their physical environment (biotope) [4], interacting as a closed system [5]. The main characteristics of an ecosystem

**How to cite:** Sánchez-Suárez, Y., Armando Pancorbo-Sandoval, J.A., Leyva-Ricardo, S.E., Sánchez-Castillo, V., Analysis of scientific production on environmental risk assessment in ecosystems with a circular economy. DYNA, 91(234), pp. 116-125, October - December, 2024.

include species diversity [6], trophic structure [7], nutrient [8] and energy cycling [9], and interactions between species and their environment [10].

Ecosystems are dynamic and subject to constant change due to internal and external factors [11]. They are classified into terrestrial of various types, including forests, grasslands, deserts, tundra's, mountains and aquatic ecosystems are divided into freshwater (rivers, lakes, marshes and wetlands) [12] and marine (oceans, seas, coral reefs and estuaries) ecosystems, these cover more than 70% of the earth's surface and harbor a great diversity of marine life [13].

All ecosystems play a crucial role in climate regulation [14] and habitats for a wide range of species [15]. They have unique characteristics in terms of climate, soil, flora and fauna [16]. For example, forests are rich in biodiversity and act as carbon sinks [17], deserts are extreme ecosystems with arid conditions and a diversity of life adapted to such conditions [18], while seas contain high dissolved salt content, with producer, consumer and decomposer organisms forming food chains [19].

Environmental risks are factors that can damage the natural environment [20], either by natural phenomena or by human action. These risks can be of various kinds, from air, water and soil pollution (depending on the type of ecosystem and its characteristics) [21], to the generation of hazardous waste. Environmental risks can be classified into natural and anthropogenic [22]. Natural environmental risks are caused by natural phenomena that are beyond our control, but that cause great damage to the ecosystem [23], while anthropogenic environmental risks are those caused by human action [24].

Environmental risk assessment is a critical process used to estimate the probability of an adverse outcome from environmental changes caused by natural and human activities [25]. This process follows the scientific method of determining the hazard and risks to the health and welfare of species associated with exposure to pollution [26]. There are several methodologies for conducting environmental risk assessments, including:

- Failure Mode and Effects Analysis (FMEA) [27],
- Fault Tree Analysis (FTA) [28],
- Checklists [29],
- Functional Analysis of Operability (FAO) [30],
- Layer of Protection Analysis (LOPA) [31],
- Ishikawa Diagram or Cause and Effect Diagram [32],
- Theory of Constraints [33].

Environmental risk assessment has a significant impact on business management today [34]. It allows organizations to identify and assess the impacts of their activities on the environment, in turn facilitating informed decision making to minimize their environmental footprint [35]. In addition, it is considered crucial to comply with government regulations and improve the company's reputation in order to achieve greater competitiveness [36,37].

In this scenario, and with the aim of reducing the consumption of raw materials that affect ecosystems through a change in the current model (linear model of production and consumption), the circular economy paradigm [38-40] arises in order to promote the generation of environmental impacts [39] and sustainable spaces based on cultural diversity [41].

Among the objectives of this management approach are: to generate economic prosperity, protect the environment and prevent pollution [42]. This economic model, while proposing the reuse of waste and its utilization as new resources, focuses on an innovative change in the design of each phase of the process, which allows the adoption of new ideas that enhance regeneration and eco-design [43].

It is a method that seeks not only sustainable production, but also responsible consumption, which implies creating environmental quality, economic prosperity and social equity, for the benefit of current and future generations [42]. In this sense, the assimilation of this management philosophy by the different business systems in terms of expanding their responsible practices and respect for the environment, will increasingly reduce ecosystemic risks directly or indirectly, and will become a competitive advantage due to its alignment with the objectives of sustainable development.

Consequently, the objective of this research is to analyze the scientific production related to the evaluation of environmental risks in ecosystems with a circular economy approach.

## 2 Methodology

Research was conducted under the quantitative paradigm [44,45], with a retrospective and descriptive approach, based on a bibliometric study with the aim of analyzing indicators that allow describing science and its triangulation in order to identify lines of research and possible future work agendas [46,47].

### *2.1 Selection and exclusion criteria*

For the selection of the documents, a set of criteria were established with the aim of ensuring the impact, relevance and quality of the research found [48]. Inclusion criteria focused on the identification and collection of the most relevant articles in English and Portuguese language in the period 2014 - 2024 (last 10 years), in the databases: SCOPUS (https://www.scopus.com/), for its impact at international level grouping mainstream journals and Lens (https://www.lens.org/) for its extensive library of research.

The exclusion criteria were to eliminate all those studies that did not address environmental risks in ecosystems and that in turn these analyses did not have a focus on the circular economy, as well as all those articles that were duplicated after the integration of both databases in the EndNote X8 bibliographic manager. This review was carried out independently by two researchers, who initially applied the strategies, presented and discussed the results together as feedback until reaching the final version.

### *2.2 Search strategy*

The main thematic descriptors identified for the search strategy were: "environmental risks", "ecosystems" and "circular economy". The search formula was: TITLE-ABS-KEY (("environmental risks" OR "environmental griess") AND ("ecosystems" OR "ecosystems") AND ("circular economy" OR "economic circular")).

Table 1
Search results

| Parameters | Quantity |
|---|---|
| SCOPUS | 15 |
| Lens | 152 |
| **Total** | 167 |
| Duplicates | 0 |

Source: Own elaboration.

It was conducted on April 4, 2024. Table 1 shows a summary of the search results. The information was downloaded in a ".RIS" format for analysis and processing.

### *2.3 Bibliometric indicators*

In the analysis of bibliometric indicators, the source of information was combined between both databases and is described below:

2.3.1. Trend indicators

- Scientific production per year: the behavior of the research was studied, its frequency over time, and the trend line adjusted to the highest R2 value was plotted to determine the confidence level of the function.

2.3.2. Production indicators

- Scientific production by type of document: documents were classified according to their type (articles, books, etc.) and quantified.
- Scientific production by area of knowledge: the amount of research by area of knowledge was quantified.
- Scientific production by country: the amount of research by country was quantified.
- Scientific production by institutional affiliation: the amount of research by institutional affiliation was quantified, these were related to countries based on a binary matrix (affiliation versus country), which was processed in the UCINET for Windows - Version 6 software and a network of institutional affiliation and its frequency was created.

**Source of information:** Obtained from the SCOPUS database. The .XLSX files were downloaded in Excel format and further processed using Microsoft Excel software. The country map was generated with the Lens platform, the density corresponds to the introduction and assimilation of results.

2.3.3. Impact indicators

The impact analysis was focused on indicators of quality and positioning of the journals in which the research was published; only SCOPUS journals were taken into account, as they were the ones with the highest impact during the period. Table 2 summarizes the main impact indicators analyzed.

**Source of information:** The QC are obtained from the file in ".RIS" format processed in the EndNote X8 bibliographic manager in the "Notes" section, where the sum of the number of citations of the articles of a journal, are the total citations. The IF, Q and H-index indicators were obtained from the SCImago Journal & Country Rank site (https://www.scimagojr.com/).

Table 2
Journal impact indicators

| | Acronym | Description |
|---|---|---|
| **Journal rankings** | QC | Number of citations (QC): evaluates the number of citations received by the journal in the period analyzed. |
| | IF | Impact Factor (IF): analyzes the ratio between the number of citations received by a journal's articles during the previous two years and the number of articles published in those years. |
| | Q | Quartile (Q): analyzes the relevance of a journal within all journals in the area of knowledge, divided into four quartiles Q1, Q2, Q3 and Q4. |
| | H-index | Measures the productivity of a journal in correlation with the citation impact of publications. |

Source: Own elaboration.

### *2.4 Building knowledge maps*

- Keyword co-occurrence analysis: network, overlay and word cloud knowledge maps were constructed to compare the results in both databases, the most predominant terms and the clusters in which they are grouped. From the cluster analysis, possible lines of research are determined.

Specifications of each of the maps according to the analysis:

Network bibliometric map: an analysis of the relationship of keywords was performed based on the network study and the identification of main clusters.

Bibliometric overlay map: the temporal evolution of keywords was studied in order to identify the most recent and novel terms.

Word cloud map: the frequency of occurrence of keywords and those of greater relevance in the Lens database were analyzed for comparative analysis.

- Analysis of collaboration between countries: knowledge maps were constructed with the objective of analyzing collaboration or not between countries, alliances or clusters on the subject and possible inferences of knowledge transfer between regions, with emphasis on the role of Latin America.
- Author relationship analysis: the relationships or not between authors were studied based on the study of co-citations and alliances in publications through inter-institutional collaboration.
- Citation analysis: an analysis of the level of citations per author / publications was made, where the level of citations per period and the possibility of access (open access) or not were contrasted to compare these citation levels.

Table 3.
Sources of knowledge maps

| Analysis - Maps | Sources of procurement |
|---|---|
| Keyword co-occurrence analysis | |
| Network bibliometric map<br>Overlay bibliometric map | Vosviewer |
| Word cloud map | Lens |
| Analysis of cross-country collaboration | |
| Network bibliometric map | Vosviewer |
| Author relationship analysis | |
| Overlay bibliometric map | Vosviewer |
| Citation analysis | |
| Citation map | Lens |

Source: Own elaboration.

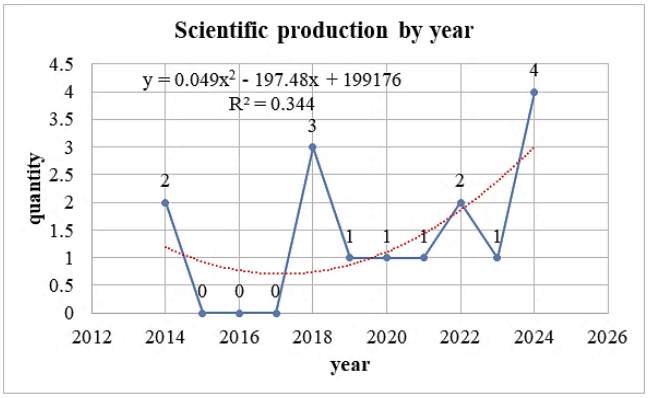


Figure 1. Scientific production by year.
Source: Own elaboration.

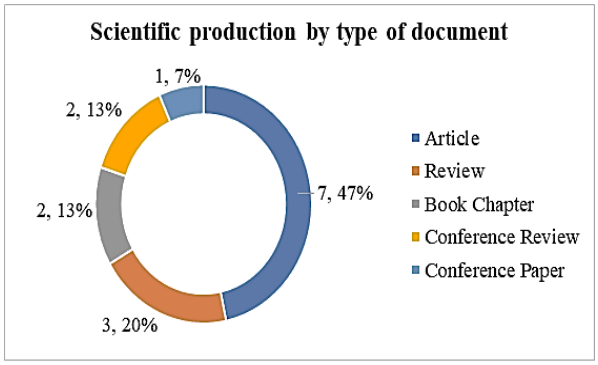


Figure 2. Scientific production by type of document.
Source: Own elaboration.

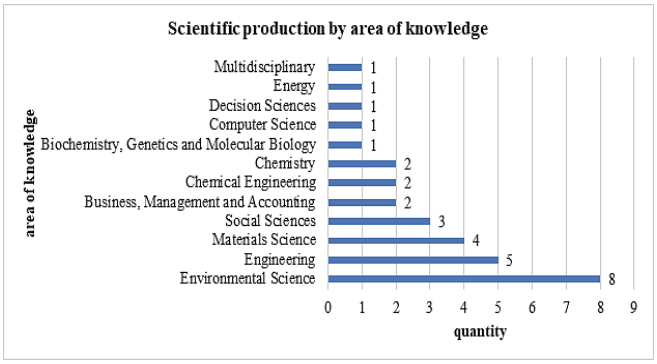


Figure 3. Scientific production by area of knowledge.
Source: Own elaboration.

Table 3 shows the relationship between the analyses and knowledge maps described and the platforms or ways of obtaining them.

## 3 Discussion of results

The behavior of the investigations was heterogeneous (Fig. 1), its behavior was between zero and four investigations, in the period 2015 - 2017 no investigations were found, while the trend is towards increase characterized by a polynomial function with a confidence level of 34.4 % with a maximum peak of four investigations in the year 2024.

Fig. 2 shows the distribution by type of research documents, where research articles predominated, representing 47 % of the total, followed by research papers with 20 %. Two book chapters and three events were found, two at the 2013 International Conference on Manufacture Engineering and Environment Engineering, MEEE 2013 and one at the 2022 8th International Engineering, Sciences and Technology Conference, IESTEC 2022, both with emphasis on environmental policies and their assimilation in industrial processes [49,50].

Research was identified in 12 areas of knowledge (Fig. 3), with a predominance of environmental sciences with eight investigations, followed by engineering and materials science with five and four investigations, respectively, where innovations related to the reuse of resources and water treatment to reduce environmental risks in ecosystems stood out [51-53].

Fig. 4 shows the analysis of scientific production by country, initially analyzing the amount of research by region, in the Americas the most productive country was the United States, with two studies, followed by Panama and Brazil, both with one study. The region with the highest results was Europe, where Spain and France led with two publications. In Asia, India was the country with the highest number of publications, with three articles.

On the other hand, when analyzing the assimilation and introduction of the results in the area of knowledge, it became evident that the most representative country was China through the creation of capacities to carry out an efficient transfer of this knowledge in terms of sustainable development and the adoption of social responsibility strategies in its actions for the protection of the environment [54,55]. Countries such as the United Kingdom, the United States, Australia and Russia also stood out.

Research was identified in 35 institutional affiliations, all on an equal footing with one research each; these were associated with their countries of origin by means of affinity diagrams that resulted in the preparation of the binary matrix and from its processing the institutional affiliation network was obtained (Fig. 5). The countries with the highest production by institutional affiliation were India and the United States with seven and six investigations, respectively, while in Latin America, Panama stood out with three institutions.

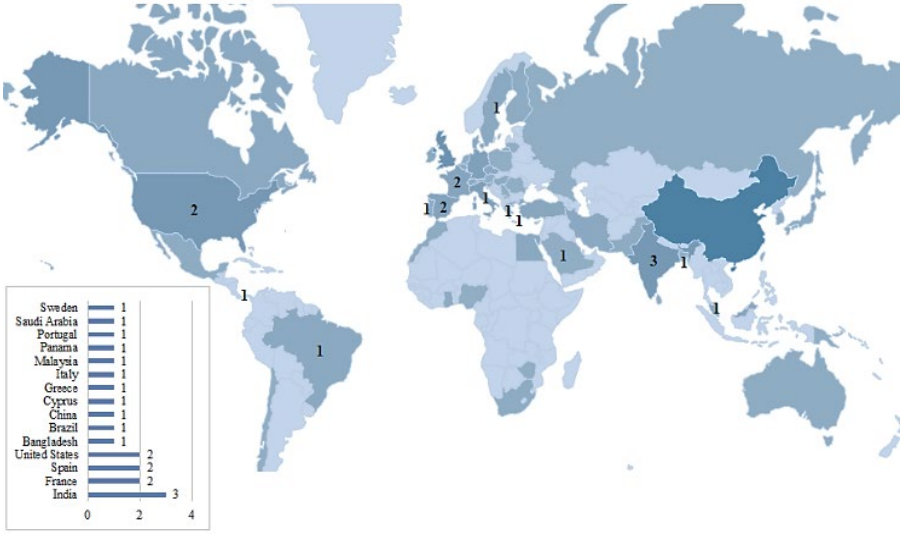


Figure 4. Scientific production by country.
Source: Own elaboration.

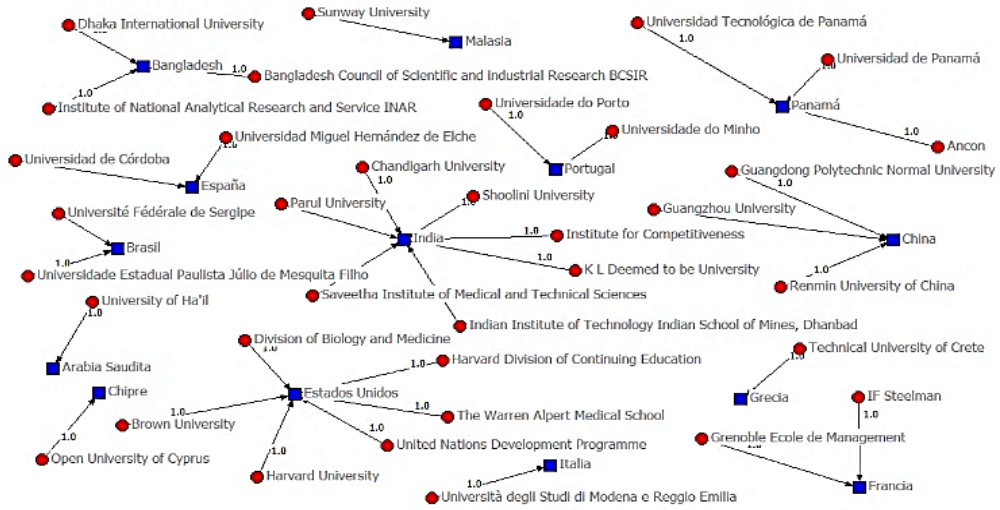


Figure 5. Institutional affiliation network.
Source: Own elaboration.

Research was identified in 14 journals, including one that published two papers resulting from events, the journal WIT Transactions on Engineering Sciences. Table 4 shows the ranking of the seven most cited journals, where the one that accumulated the highest number of citations during the period analyzed was Thunderbird International Business Review with 159 (n = 159) corresponding to the article "Circular economy business models in developing economies: Lessons from India on reduce, recycle, and reuse paradigms".

Journal of Hazardous Materials was the journal with the highest impact factor and h-index with a value of 2.95 (IF = 2.95) and 352 (H-index = 352) respectively. Regarding the quartile of the seven journals analyzed, one is not in any quartile, five are in quartile 1 (Q1) representing 71.43 % of the total and one is in quartile 3 (Q3).

Table 4
Journals ranking.

| Journal | QC | IF | Q | H-index |
|---|---|---|---|---|
| 1. Thunderbird International Business Review | 159 | 0.51 | Q1 | 51 |
| 2. Journal of Hazardous Materials | 73 | 2.95 | Q1 | 352 |
| 3. Environmental Science and Pollution Research | 26 | - | - | - |
| 4. Water Alternatives | 15 | 0.71 | Q1 | 53 |
| 5. Sustainability (Switzerland) | 5 | 0.67 | Q1 | 169 |
| 6. Materiaux et Techniques | 4 | 0.29 | Q3 | 13 |
| 7. International Journal of Biological Macromolecules | 3 | 1.25 | Q1 | 191 |

Source: Own elaboration.

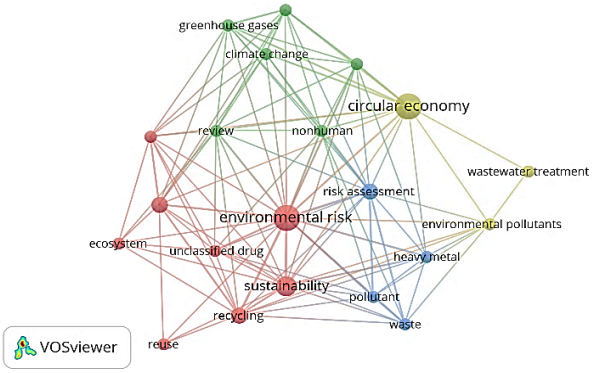


Figure 6. Word concurrency network map.
Source: Own elaboration.

Fig. 6 shows the map of cooccurrence of key words network, where four clusters and 21 items were identified, from the analysis of the interrelation between the items, four possible lines of research were identified:

- Cluster 1 (8 items) colored red focused on environmental risk assessment from a sustainable approach to ecosystems affected by misuse and deficient recycling strategies for unclassified drugs.
- Cluster 2 (6 items) in green focused on comprehensive reviews of existing studies on the impact of greenhouse gases on climate change, with a particular focus on non-human perspectives. How climate change affects non-human species, ecosystems and biodiversity in general will be investigated.
- Cluster 3 (4 items) in blue focused on environmental risk assessment and heavy metal waste management from an integrated approach to pollution mitigation in ecosystems.
- Cluster 4 (3 items) in yellow focused on the use of innovative strategies for the elimination of environmental pollutants with a circular economy approach for wastewater treatment.

An analysis of the most recently used keywords in the literature was carried out based on the study of the overlay keyword cooccurrence map (Fig. 7). The most recent research focused their studies on wastewater treatment from governance strategies focused on environmental management at local, regional and global levels [56], on applications in agriculture in support of germination [57,58], focus on sustainable innovation in water use [59] and strategies for water desalination and obtaining energy from chemical reactions [60].

On the other hand, research has also focused on fertilizer applications in agriculture [61], in addition to other research focused on the challenges and potentials in new precision agriculture systems [62].

Fig. 8 shows the keyword cloud map, with the objective of contrasting the results obtained from the network keyword co-occurrence map and the frequency of occurrence in the Lens database. The keyword with the highest frequency was environmental sciences with a frequency equal to 65 (n = 65), followed by biology with 63 (n = 63) and, ecology and business both with a frequency of 57 (n = 57).

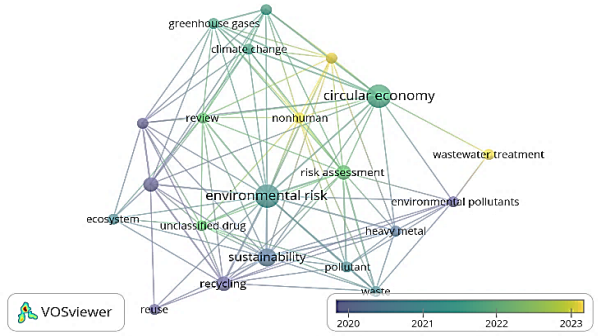


Figure 7. Word concurrency overlay map.
Source: Own elaboration.

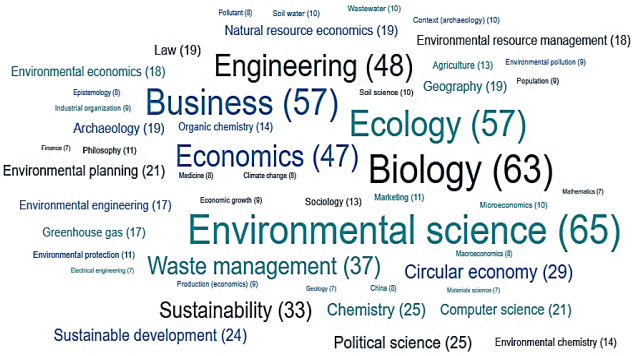


Figure 8. Word cloud map.
Source: Own elaboration.

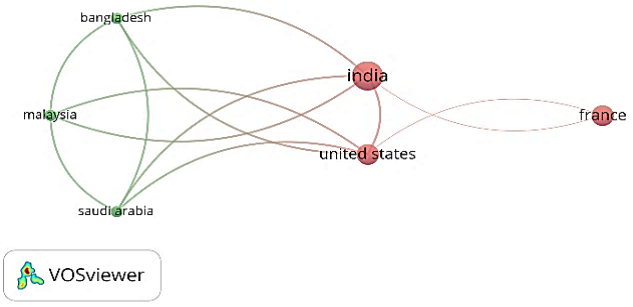


Figure 9. Country network.
Source: Own elaboration.

An analysis of the collaboration network between countries was carried out (Fig. 9), where two main clusters and six items were identified, three for each cluster:

- Cluster 1: green color with the countries Bangladesh, Malaysia and Saudi Arabia.
- Cluster 2: red color with the countries India, United States and France.

An analysis of authorial collaboration was performed (Fig. 10), where the overlay collaboration map was constructed to identify the authors who have published most recently in 2024, including: Trivedi, R., Upadhyay, T.K., Kha; Chang, K.F., Lin, C. and Bin, Y; Martins, M., Sousa, F and Soares, C and Olivera, R.V. and Maia, H.B. In isolation, 58 authors were found in the research, all with only one publication.

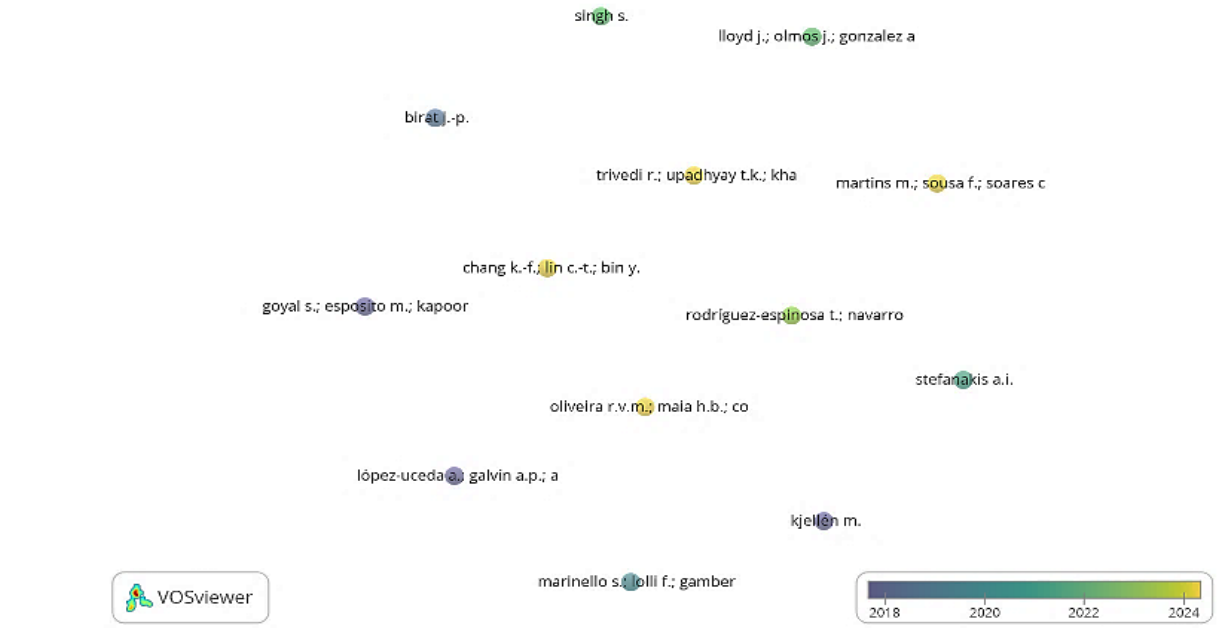


Figure 10. Author overlay network.
Source: Own elaboration.

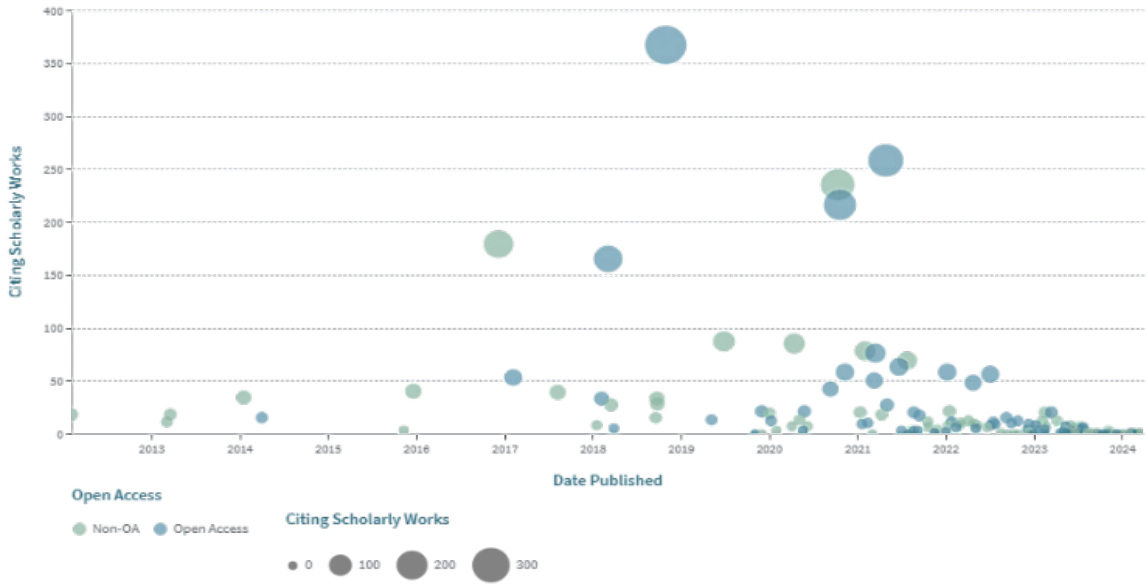


Figure 11. Citation map.
Source: Own elaboration.

Fig. 11 shows an analysis of the citation levels of the papers from the citation map generated in the Lens database, during the period 2013 - 2017 the citation levels did not exceed 50 citations and the papers that are not in open access predominated, while from 2017 these levels increased and the citations were balanced towards papers in open access, an element that demonstrates the transit of different publishers towards open science, with a maximum peak of more than 350 citations in the year 2019.

## 1 Conclusions

Environmental risk assessment is much more than a legal requirement; it is an opportunity to demonstrate an organization's commitment to sustainability and the well-being of the planet, through a focus on sustainable development and the fulfillment of the Sustainable Development Goals. In order to reduce environmental risks,

Table 5.
Agenda for future research.

| Research cluster | Future research objectives |
|---|---|
| **Cluster** 1 | • Identify and classify unclassified drugs that represent a significant environmental risk.<br>• Study the impact of these drugs on different ecosystems.<br>• Develop methods to measure and quantify this impact.<br>• Investigate reuse and recycling strategies for these medicines.<br>• Propose sustainable policies and practices for the management of unsorted drugs. |
| **Cluster** 2 | • Review and synthesize existing literature on greenhouse gases and climate change.<br>• Analyze the impact of climate change on non-human species and ecosystems.<br>• Identify gaps in current research and suggest areas for future research.<br>• Develop a framework for assessing the impact of climate change from a non-human perspective.<br>• Propose mitigation strategies based on the findings of the review. |
| **Cluster** 3 | • Develop methods to assess the risks associated with exposure to heavy metals in waste.<br>• Research on how heavy metals act as contaminants in different environments.<br>• Develop strategies and technologies for the safe and efficient management of waste containing heavy metals. |
| **Cluster** 4 | • Investigate how the principles of the circular economy can be applied to wastewater treatment.<br>• Study existing and emerging technologies for wastewater treatment.<br>• Research on the different types of pollutants present in wastewater, including their origin, their behavior in the environment and their effects on human and ecological health. |

Source: Own elaboration.

different initiatives have been developed, reflected in the 2030 agenda and the sustainable development goals; in this context, the circular economy plays an important role through the reuse of resources that optimizes the generation of waste to the environment.

The behavior of the research was heterogeneous with a maximum peak of four, research articles in the area of environmental sciences predominated. In the geographical area of the Americas, the main results were published in the United States, Panama and Brazil. The most productive journal was Thunderbird International Business Review with 159, while the Journal of Hazardous Materials had the highest impact with a value of 2.95.

From the keyword co-occurrence analysis, four lines of research were identified: environmental risk assessment from a sustainable ecosystem approach, the impact of greenhouse gases on climate change, environmental risk assessment and heavy metal waste management from an integrated approach, and the use of innovative strategies for the elimination of environmental pollutants.

### *1.1 Future research*

In future work, we recommend generalization to other databases such as Web of Science, Sciencedirect or Scielo, the development of other bibliometric indicators, including the Price index, as well as the analysis of collaboration maps between institutions. On the other hand, to develop research that analyzes the visibility indicators of research and journals to maximize their impact and that in turn constitute the starting point for conducting bibliographic or systematic reviews of the literature. In this sense, an agenda for future research is proposed where specific objectives are identified for each of the research clusters identified (Table 5).

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