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CARBON NANOMATERIALS IN WATER PURIFICATION

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Summary
A documentary review was carried out on the production and publication of research papers related to the study of the variables Carbon Nanomaterials, Water Purification. 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 201 7-2022 and to identify the current situation in Ecuadorian institutions with respect to the study of the aforementioned variables, achieving the identification of 333 Publications in total. The information provided by this platform was organized through graphs and figures categorizing the information by the 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 theme is referenced through a qualitative analysis. Among the main findings made through this research, it is found that China with 105 publications, was the country with the highest scientific production registered on behalf of authors affiliated with institutions of dichto nation. The Area of Knowledge that made the greatest contribution to the construction of bibliographic material referring to the study of Carbon Nanomaterials and Water Purification was Environmental Sciences with 152 published documents, and the Type of Publication that was most used during the period indicated above was the Journal Article that represents 44% of the total scientific production.

Keywords: Carbon Nanomaterials, Water Purification.

1. Introduction

At present, one of the most latent problems at a global level, in relation to environmental conditions, is water pollution, which has worsened thanks to the growth of the world population and industry(Ahmed, et al., 2022). Among the contaminants found most frequently within the studies carried out to know the conditions of the water, are the Dyes, which come from the textile industry, paints, food, polymers, among others, which when entering the body can generate diseases such as Cancer. Similarly, Heavy Metals from mining, among which it is common to find Cadmium, Mercury, Lead, Arsenic, Zinc, Copper, Iron, among others, which when entering the digestive system can cause health conditions for people, such as gastrointestinal complications, cancer, neurodegenerative diseases, among others(Baby, Saifullah, & Hussein, 2019). Currently, technological advances have made it possible to achieve treatments of the precious liquid, such as the use of nanotechnology, which is the area that studies particles whose size is equal to 1 x 10-9 meters, compared to a size smaller than that of a virus "In this area we study, design and manufacture materials at nanoscopic scales and use them for some practical application"(Baby, Saifullah, & Hussein, 2019) . Therefore, it has been discovered that through the adsorption of contaminants present in water through nanotechnology and the incorporation of one of the most common elements in nature such as carbon, which although they are known to be macroscopic, there are graphite derivatives that meet the ideal size to be implemented within nanotechnological strategies. for water decontamination. It has been shown that the implementation of carbon nanomaterials in water decontamination processes achieve rapid and very positive results for this purpose, and their behavior with different pollutants turns out to be successful within their adsorption.

Figure 1. Carbon structures and their affinity for types of pollutants.
Fountain: (Ramírez & de la Luz Asunción, 2022)

Therefore, it is possible to affirm that the use of this type of carbon nanomaterials can be of great help in the search for water decontamination, so the development of this article is proposed, hoping to know the current status of the bibliographic resources registered in Scopus, referring to the study of carbon nanomaterials in water purification.

2. General objective

Analyze from a bibliometric and bibliographic perspective, the production of research papers on the variables Carbon Nanomaterials, Water Purification registered in Scopus during period 201 7-2022.

3. Methodology

Quantitative analysis of the information provided by Scopus is carried out under a bibliometric approach on the scientific production referring to the study of the variables Carbon Nanomaterials, Water Purification. Likewise, it is analyzed from a qualitative perspective, examples of some research works published in the area of study indicated above, from a bibliographic approach to describe the position of different authors regarding the proposed topic.

The search is carried out through the tool supplied by Scopus and parameters referenced in Figure 2 are established.

3.1 Methodological design

Figure 2. Methodological design
Source: Authors.

3.1.1 Phase 1: Data collection

Data collection is carried out through the Search tool on the Scopus website, through which a total of 333 publications are identified. For this purpose, search filters were established consisting of: TITLE-ABS-KEY (carbon AND nanomaterials, AND water AND purification) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017))

- ✓ Published documents whose study variables are related to the study of the variables Carbon Nanomaterials and Water Purification
- ✓ Without distinction of country of origin.
- ✓ Without distinction of area of knowledge.
- ✓ Without distinction of type of publication.

3.1.2 Phase 2: Construction of analytical material

The information identified in the previous phase is organized. The classification will be made by means of graphs, figures and tables from data provided by Scopus.

- ✓ 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

After the analysis carried out in the previous phase, we proceed to the drafting of the conclusions and preparation of the final document.

4. Results

4.1 Co-occurrence of words

Figure 3 shows the Co-occurrence of keywords within the publications identifiedin the Scopus database.

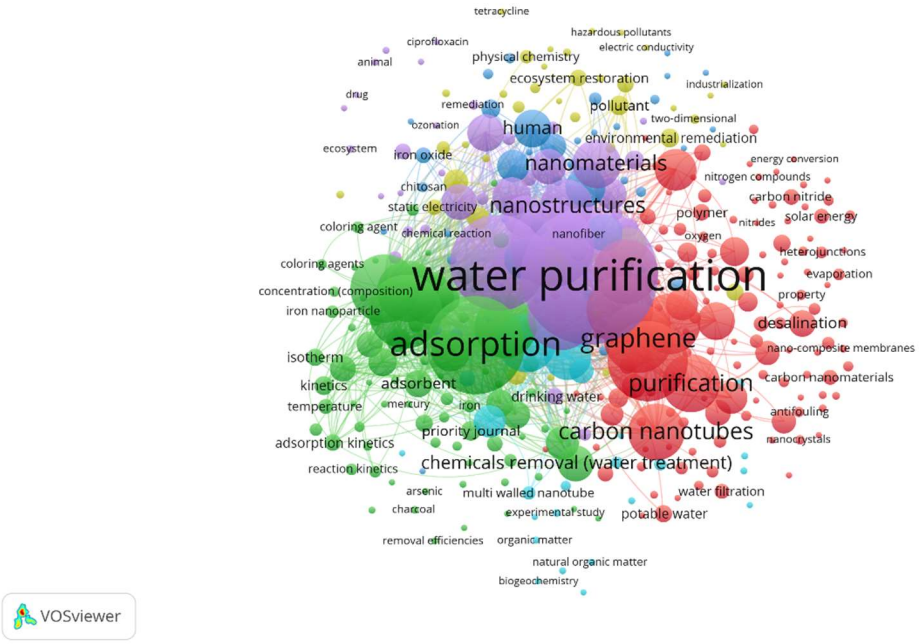

Figure 3. Co-occurrence of words
Source: Authors. (2023); based on data provided by Scopus.

Water purification was the study variable most frequently used within the investigations identified through the application of the search filter referenced in Phase 1 of the methodological design proposed for the development of this article, being directly related to variables such as Adsorption, Graphene, Nanomaterials, Human, Nanofibers, Ecosystems, which allow inferring that the authors of the articles analyzed, They have structured theories that prove the success in the search for

water purification and the reduction of water pollution due to agents such as heavy metals, dyes, organic waste, among others. The analysis of variables such as Polymers, Desalination, Chemical Waste, Damage to the Ecosystem is highlighted, so it is assumed that in the same way the different pollutants of the water are studied as well as the consequences that this entails to the balance of the environment. For this reason, it is possible to confirm the relevance of the studies analyzed here, with the objective set for the development of this document.

4.2 Distribution of scientific production by year of publication.

Figure 4 shows how the scientific production is distributed according to the year of publication, taking into account that the period between the years 2017 and 2022 is taken

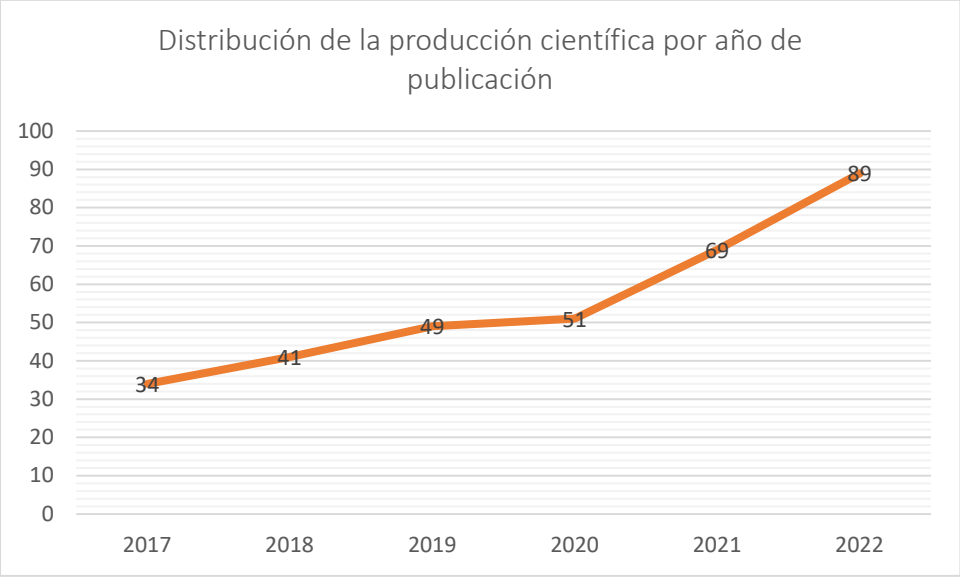

Figure 4. Distribution of scientific production by year of publication.
Source: Authors. (2023); based on data provided by Scopus.

Among the main characteristics referenced in the study of scientific production published in high impact journals indexed in Scopus database related to the analysis of the application of Carbon Nanomaterials in Water Purification, is the classification by year of publication, which demonstrates how the volume of articles registered on said platform has been, year after year. The period analyzed includes the years from 2017 to 2022, the latter being the year in which the largest number of publications were indexed in Scopus with a total of 89. Followed by 2021 with 69 and 2020 with 51. From the above, it is possible to affirm that the growth in terms of efforts by the scientific community to generate new knowledge around these variables has been significant considering that the volume of such production has increased year after year from 34 documents in 2017 to 89 registered in 2022. Within these, it is important to highlight the contribution identified in articles such as the one entitled "Classification of nanomaterials and the effect of graphene oxide (GO) and newly developed nanoparticles in the ultrafiltration membrane and its applications: a review" (Al-Maliki, et al., 2022) whose objective was to present a overview of the

effects of different hydrophilic nanomaterials, including mineral nanomaterials (silicon dioxide (SiO2) and zeolite), metal oxide (copper oxide (CuO), zirconium dioxide (ZrO2), zinc oxide (ZnO), antimony tin oxide (ATO), iron(III) oxide (Fe2O3) and tungsten oxide (WOX)), two-dimensional transition (e.g. MXene), metal-organic structure (MOF), Covalent organic structure (COF) and carbon based on nanomaterials (such as carbon nanotubes and graphene oxide (GO)), additionally presents the current progress of mixed matrix membranes, challenges affecting membrane performance and recent applications for wastewater treatment systems. Studies of this type represent a great contribution to the search for solutions to water pollution that currently augurs hundreds of communities and threatens to affect the balance of the ecosystem, so it is expected that based on this type of reviews, research around these variables will be encouraged and this environmental problem will be solved.

4.3 Distribution of scientific production by country of origin.

Figure 5 shows how scientific production is distributed according to the nationality of the authors.

Figure 5. Distribution of scientific production by country of origin.
Source: Authors. (2023); based on data provided by Scopus.

China was the country with thehighest number of publications with a total of 105 documents indexed in Scopus during the period 2017-2022, followed by India with 87, and the United States and South Korea with 36 and 26 publications respectively. From these first positions in the results of the search for publications referring to the study of Carbon Nanomaterials and their use in Water Purification, it is possible to highlight the dominance in this subject of Asian institutions, which demonstrate by volume of production, a broad leadership in research around the aforementioned variables . The Latin American country with the highest number of publications was Brazil with 9 documents registered in Scopus, occupying the fourteenth place. Within these it was possible to identify the article entitled "Functionalized nanometric graphene and its derivatives for the elimination of contamination and water treatment" (Kumar, Singh, Kumar, & Moshkalev, 2018) whose purpose was to highlight the qualities of Graphene and its contribution in the search for water purification. Chemically modified graphene containing several functional groups offers potential applications for water treatment due to the adsorption of various inorganic contaminants and organic dyes. Graphene derivatives have demonstrated outstanding performance for removing contaminants from water, as well as a good adsorbent of various types of inorganic contaminants such as cadmium, chromium, arsenic, mercury, antimony, lead, fluoride, zinc, copper, etc. and organic dyes such as methylene.

4.4 Distribution of scientific production by area of knowledge

Next, it is shown in Figure 6, how the production of scientific publications is distributed according to the area of knowledge through which the different research methodologies are executed.

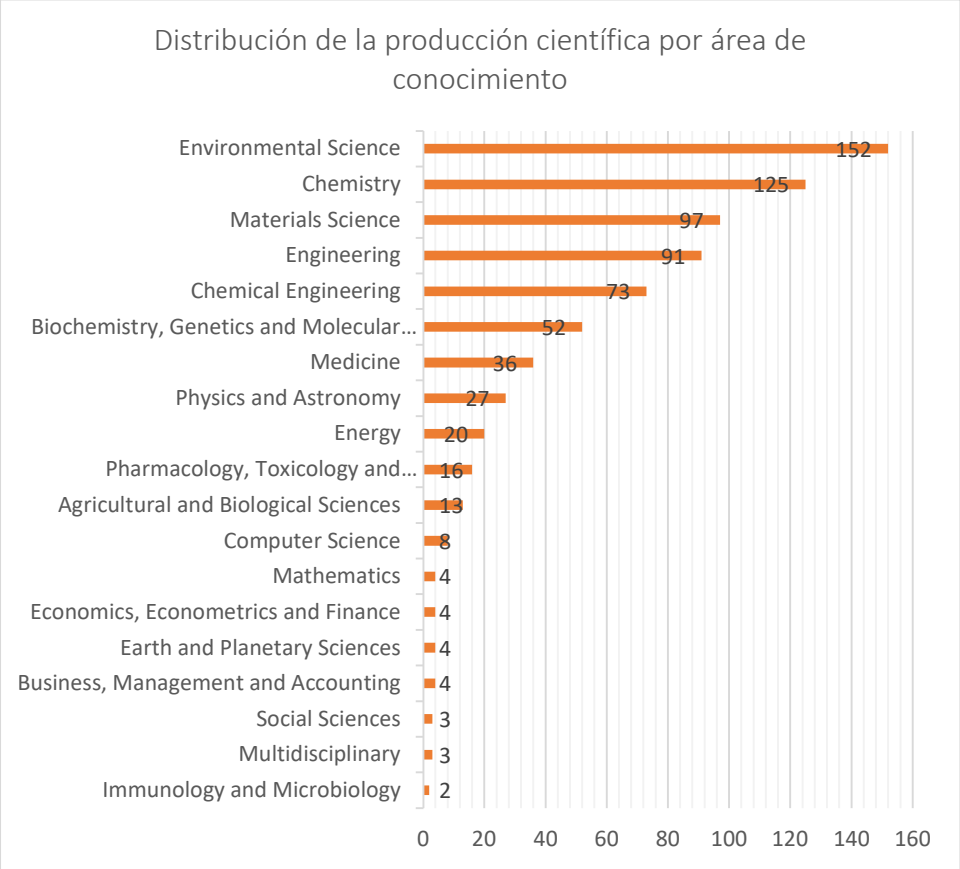

Figure 6. Distribution of scientific production by area of knowledge.
Source: Authors. (2023); based on data provided by Scopus.

Environmental Sciences was the area of knowledge with the highest number of publications registered in Scopus with a total of 152 documents that have based their methodologies on the impact of the variable Carbon Nanomaterials and Water Purification, followed by Chemistry with 125 and Materials Science with 97. It is important to know the contributions that are made from the area of Medicine since in this way you can get an overview of the implications that can lead to the intake of water contaminated by different agents such as heavy metals, pesticides, dyes, among others. Therefore, it is recorded that through the area of Medicine, a total of 36 documents are managed in Scopus, among which is the article entitled "Carbon nanomaterials treated by combination of oxidation and flash for a highly efficient solar evaporation of water" (Cong, et al., 2021) through which A carbon nanomaterial with higher light absorption and photothermal conversion efficiency than carbon black was obtained by combining carbon black with oxidation and flash illumination. Within the results of this experimental research, it is possible to highlight that its application is promising carbon nanomaterial treated as a photothermal agent in the field of seawater desalination and solar energy collector which would reduce the global crisis due to lack of water for human consumption.

4.5 Type of publication

Figure 7 shows how the bibliography production is distributed according to the type of publication chosen by the authors

Figure 7. Type of publication
Source: Authors. (2023); based on data provided by Scopus.

The type of publication most frequently used by researchers was the Journal Article with 44% followed by Reviews with 33% and Book Chapters with 18%. Within this last category, the article entitled "Self-assembled nanomaterials for cleaning and bioremediation" stands out, whose objective was to analyze (Kumar, et al., 2022)self-assembled nanomaterials, such as those based on metals, those based on biopolymers and others that have been studied for the purification and treatment of water and wastewater and the elimination of various pollutants such as heavy metals, dyes and pesticides.

5. Conclusions

The use of Carbon Nanomaterials in Water Purification turned out to be a topic of great interest within the scientific community, since after applying the search filters, it was possible to identify 333 documents globally that deal with this topic from different approaches or areas of knowledge. It is important to note that within the period between 2022 and 2023, China was the country with the highest scientific production around these variables and that within the classification of scientific production by country of origin, Asian countries lead research in this area. Among the main contributions that researchers have made to the different processes for water purification, it has been demonstrated through experimental research, how the use of Carbon Nanomaterials represent positive results in the adsorption of different pollutants such as dyes, heavy metals, among others. Therefore, it is expected that the scientific community will strengthen studies on water purification and desalination of it, in order to contribute to one of the most latent scourges in communities characterized by extreme poverty and is the difficulty in accessing water resources,

hindering the conditions for the development of a dignified life. In addition to the above, the controls exercised to mitigate the effects of water pollution by different agents, the reduction of environmental impact is achieved, which is one of the Sustainable Development Goals (SDGs) of the United Nations in search of balance in the different ecosystems in order to prolong the life of flora and fauna and of course of human life.

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