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A Bibliometric Analysis on the Application of Biopolymers in Water Purification

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1.1 Introduction

Biopolymers are macromolecules that are biologically synthesized from living organisms [1]. Biopolymers come from animals, microbes, plants, and algae. Their abundance, low cost, expandability, and chemical structure make them promising materials for water treatment applications [2].

It is known that for the sustainable progress and development of human society in the twenty-first century, freshwater is essential, and its scarcity has been a terrible threat [3]. So, biopolymers emerge as ideal candidates for water treatment, besides being widely used in the literature in wastewater treatment. Other applications in the field of water and wastewater treatment are the removal of heavy metals,environmental remediation, among many others.

Bibliometric analysis is a powerful tool to provide an outline and to summarize results of an issue, subject, or field based on the available literature (by using quantitative methods), including the trends, information about authors, and sources, among many others. Several research areas take advantage of this approach, proving that this analysis is relevant and interdisciplinary. Some recent examples of using bibliometric analysis are in the analysis of human–wildlife conflict [4], aerobic digestion technology [5], consumer awareness of plastics [6], plastic effects on marine and freshwater environments [7], open innovation and tourism relationship [8], and multicriteria decision making [9], among many others.

In the present work, a bibliometric analysis of the use of biopolymers in water purification was performed using Bibliometrix R-package. The analysis was focused on the discussion of the sources, authors, affiliations, countries, publications, and keywords, mainly showing an overview of the research area.

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1.2 Methodology

The Scopus search was performed on 6th December 2021 by using the keywords biopolymer* AND (water purification* OR water treatment*), and resulted initially in 2562 publications (from 1972 to 2022). All the *h*-index values were calculated by Bibliometrix.

The initial result was limited to articles and reviews in English from 2002 to 2021, resulting in 2017 publications: 1802 articles and 215 reviews. The first 2000 publications were exported to a .bib file and analyzed using Bibliometrix, an R-package.

1.3 Results

1.3.1 Bibliometric Analysis

The annual scientific production from 2002 and the subject area of the publications are shown in Figure 1.1.

The results show that the area is interdisciplinary, with a predominance of publications in the environmental science area. Concerning the annual scientific production, the increase in the number of publications during the period with an annual growth rate of 19.26% can be observed. These results depict the relevance of biopolymers in the water purification research field. The discussion of results will be divided into sources, authors, affiliations, countries, publications, and keywords, which will be discussed in sequence.

1.3.1.1 Sources

The five most relevant sources concerning the number of publications are (number of publications in parenthesis). Water Research (130), Bioresource Technology (127), Journal of Applied Polymer Science (64), Carbohydrate Polymers (61), and Journal of Membrane Science (54). The dynamics of the number of publications of these most relevant sources in the last 10 years are shown in Figure 1.2.

On the other hand, the most locally cited sources, i.e. the ones most cited from the reference lists of the 2000 analyzed publications, are (number of citations in parenthesis): Water Research (4987), Bioresource Technology (2669), Carbohydrate Polymers (2288), Environmental Science and Technology (2020), and Journal of Membrane Science (1912).

In Figure 1.2, the two most important journals in the research field of biopolymers in water purification point to an increase in the annual number of publications between 2013 and 2014, with a reduction and a tendency to stabilize by the year 2021. The other journals show greater stability regarding the annual number of publications within the analyzed period.

All the mentioned sources are relevant in the field of biopolymers for water purification. These journals are peer-reviewed and of high quality, providing the authors the confidence to publish their works in these journals [10].

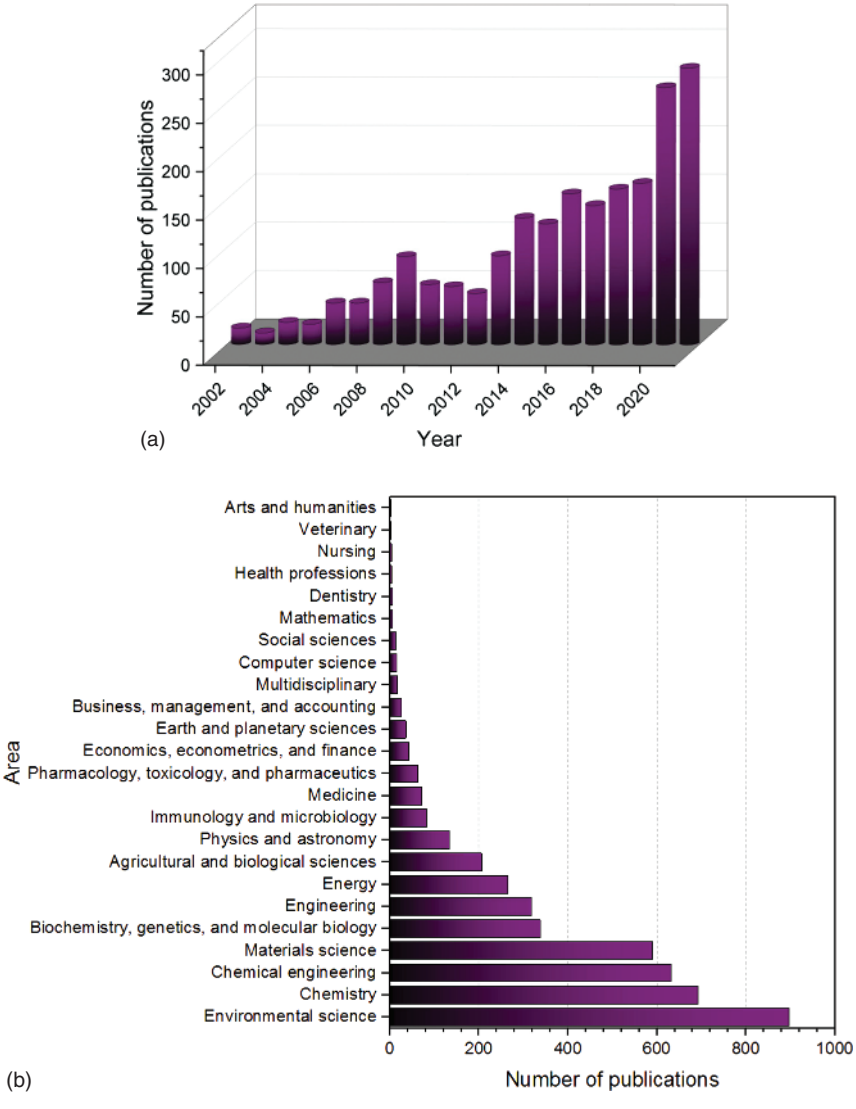

Figure 1.1 (a) Annual scientific production from 2002, and (b) subject area of the publications.

1.3.1.2 Authors, Affiliations, and Countries

The most relevant authors of the research field according to their *h*-index are presented in Table 1.1.

In the list of the most important authors, Zhang W. is the one with the highest *h*-index and number of publications. However, the author with the highest local citations is Wang J. (from the reference lists of 2000 analyzed publications). The largest number of publications of the author deals with sludge and correlated

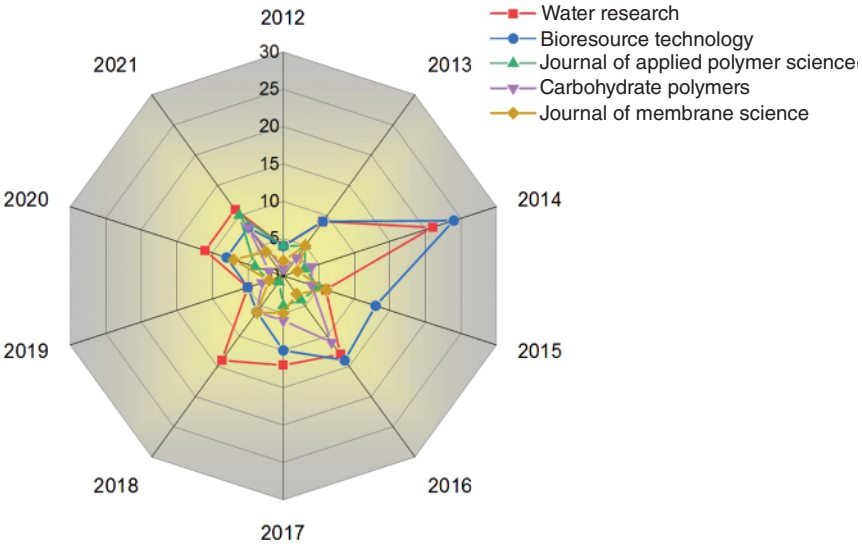

Figure 1.2 Dynamics of the number of publications of the most relevant sources in last 10 years.

Table 1.1 Most relevant authors of the research field of biopolymers for water purification, with their number of publications and local citations.

Author	*h*-Index	Number of publications	Local citations
Zhang W.	16	28	38
Jekel M.	13	16	5
Wang J.	13	20	46
Wang Z.	13	21	14
Chang I.	11	14	8
Vigneswaran S.	11	13	4
Wang Y.	11	18	6
Zhang L.	11	21	22
Zhang Y.	11	18	15
Zhang Z.	11	17	14

aspects. The second most important author based on Bibliometrix, Jekel M., studies the purification of wastewater by using membrane filtration and ultrafiltration. No consensus is shown in the literature about which of the measures is more effective for analyzing the importance of a certain author in a given research area (the number of publications/citations or the *h*-index) [11]. An inaccurate interpretation of the measure of the author's influence may occur when the number of publications

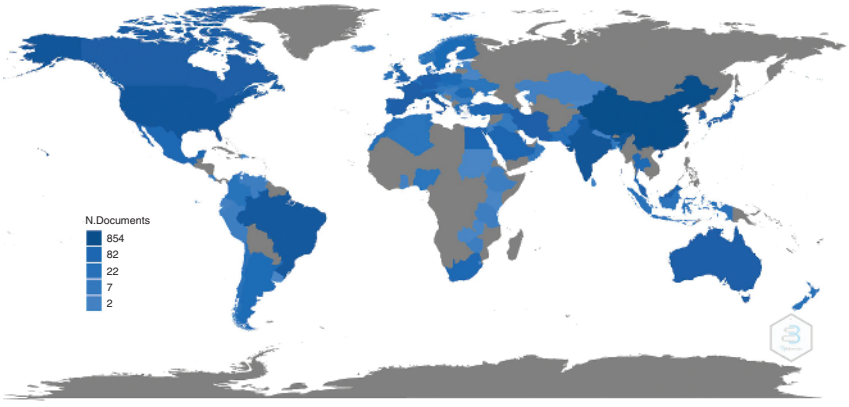

Figure 1.3 Country's scientific production.

is analyzed, since in some cases the author can be at the beginning of career, whose scientific trajectory is in growth stage [12].

The most relevant affiliations according to the number of publications are (number of publications in parenthesis). Tsinghua University (40), China University of Geosciences (31), Tongji University (31), Nanyang Technological University (27), Chinese Academy of Sciences (25), and Delft University of Technology (25). Nanyang Technological University is from Singapore, Delft University of Technology is from the Netherlands, and all the others are Chinese.

The country's scientific production is shown in Figure 1.3.

In Figure 1.3, the chart shows the scientific production which is presented on a scale of shades of blue, in which the darkest blue in the chart represents the most productive, and gray represents the countries with no publications. Through this general overview, it can be observed that the subject is studied across the globe, given its importance, showing that this issue is an international concern [11, 13]. The most productive countries are (number of publications in parenthesis). China (854), the USA (394), India (381), Brazil (283), Italy (211), South Korea (195), Canada (171), Australia (170), Spain (165), and France (162). However, when the most cited countries are presented, the scenario changes (number of citations in parenthesis): China (12502), the USA (7574), France (6511), India (5183), Canada (3512), Malaysia (3327), Italy (2580), Korea (2535), Australia (2083), and Germany (2073), being the countries with the highest average citations per publication France (155), Serbia (109), Switzerland (89), Hong Kong (81), Malaysia (70), Greece (69), Ethiopia (69), Egypt (63), the USA (54), and Singapore (53). These results depict the importance of countries such as China, the USA, and France in the literature about biopolymers for water purification, even knowing that each country, no matter the number of publications, plays an important role in the construction of the whole literature.

The results of the most prominent countries are in accordance with the most important authors since the most relevant authors in the field of biopolymers for water purification are Chinese.

1.3.1.3 Publications

Table 1.2 brings the 10 most relevant publications (top 10) concerning the total number of local citation scores (LCS), and 10 more relevant publications according to the total number of global citation scores (GCS). LCS refers to the documents resulting from the Scopus search (the number of citations of publications in the local data set). The higher the LCS, the more important the publication about biopolymers for water purification. GCS denotes the total number of citations of publications in the Scopus database, but the cited publications may be from fields different than biopolymers for water purification. The analysis allows benchmark studies in the research field of biopolymers for water purification to be identified [31].

Among the 2000 analyzed publications, the most globally cited one is Azizi Samir et al. [14] with 1897 citations, and the most locally cited is Sheng et al. [15] with 40 citations. According to Farrukh et al. [32], the citation analysis provides the value of the publication.

Among the top 10 GCS publications, most of them are reviews. The subjects addressed by the authors differ greatly – Azizi Samir et al. [14] reviewed recent

Table 1.2 Citation scores of the most relevant publications.

Group	Publication	GCS	LCS
Top 10 GCS	Azizi Samir et al. [14]	1897	5
	Sheng et al. [15]	1750	40
	Crini [16]	1578	19
	Wan Ngah et al. [17]	1460	30
	Kenawy et al. [18]	1178	4
	Leenheer and Croué [19]	1008	6
	Renault et al. [20]	572	5
	McSwain et al. [21]	567	17
	Wang et al. [22]	527	1
	Meng et al. [23]	517	11
Top 10 LCS	Sheng et al. [15]	1750	40
	Hallé et al. [24]	125	36
	Tian et al. [25]	151	32
	Kimura et al. [26]	132	30
	Wan Ngah et al. [17]	1460	30
	Zheng et al. [27]	126	24
	Bala Subramanian et al. [28]	247	21
	Baghoth et al. [29]	354	19
	Haberkamp et al. [30]	152	19
	Crini [16]	1578	19

LCS, local citation score and GCS, global citation score.