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# Thirty Years of Global Literature on Bioleaching: A Scientometric Analysis

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# Thirty Years of Global Literature on Bioremediation: A Scientometric Analysis

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## ABSTRACT

The study deals with the Scientometric analysis of thirty years publication on 'Bioremediation' collected from Web of Science Databases for the period of 1989 – 2018. A total of 2477 papers were identified. The study reveals that most of the researchers preferred to publish their research results in the form of journal articles. 2050 (82.8%) articles were published in journals. The authorship trend shows, 95% of the publications were published under the joint authorship. Central South University with 268 (10.8%) publication tops in the institutional wise publications. This study also identifies Relative growth rate, Doubling Time, Degree of Collaboration, the Bibliographic Coupling of the institution, document wise distribution and prominent keyword.

**Keywords:** Scientometric, Bioremediation, Relative Growth Rate, Doubling Time, Authorship, Institutional Bibliographic Coupling.

## INTRODUCTION

(Hess. D.J, 1997, [7]). Scientometric can be defined as the “quantitative study of science, communication in science, and science policy”. This paper studies the global level productivity of research published in the Bioremediation from 1989 to 2018. Scientometric involves quantitative studies of scientific activities. The major focus of the study is to apply the scientometric analysis with a view to analyzing the growth and development of research output in Bioremediation at the global level. (Bioremediation, Wikipedia, [6]). Bioremediation is a process used to treat contaminated media, including water, soil and subsurface material, by altering environmental conditions to stimulate the growth of microorganisms and degrade the target pollutants. In many

cases, bioremediation is less expensive and more sustainable than other remediation alternatives. . (Bioleaching, Wikipedia, [1]). Bioleaching is one type of bioremediation, which involves the extraction of metals from their ores through the use of living organisms

## **REVIEW OF LITERATURE**

(C. Baskaran, 2016, [5]). Examines the relative growth rate and doubling time of Bioinformatics Publication during 1999-2013. The mean relative growth was measured and doubling time observed from the analysis. Total number 20577 of records on bioinformatics publication during the study. The Maximum of Publication 2234 in 2012 was published compare to the rest of the years. The highest publication published in Bioinformatics journal and Harvard University scientists contributed the highest number of publication in the study. RGR and DT are exhibiting that fluctuating trend happening whole period of study. (C. Baskaran, 2013, [2]). Analysis the author productivity, discipline-wise, institution-wide collaboration and ranking of authors in the research contribution of Alagappa University during 1999-2011. Relative Growth Rate (RGR) was found to be a fluctuating trend during the study period. The Doubling time (Dt) was found to be increased and decreased trend in this study. The degree of collaboration and its means value is found to be 0.963. The top three institutions with Alagappa University is Central Electro Chemical Research Institute, National Cheng King University and Anna University. (C. Baskaran, 2014, [3]). Analysis the quantitative analysis of the productivity and characteristics of citations of Library and Information Science (LIS) publications during 2003-2012. A Total of 1942 contributions published and 12502 citations received in the LIS journals indexed in SSCI. 21.36% of citations were received in 2012. The top-ranked authors, Bawden, B and Hjørland, B contributed 0.72% of papers out of which Hjørland, B cited 1.93% of articles, The USA contributed 4.38% of papers and also received 24.85% of citations. It is followed by UK which contributed 9.99% of LIS research papers out of 9.68% of citations were received. Year-wise authors' productivity, Institution-wise position and ranking of journals with citations references are listed to indicate their productivity and degree of involvement in their publications of Library and

Information Science research. (C. Baskaran, 2015, [4]). Analysis the total enzymes publications records of 4962 from 1999-2013. Relative Growth rate (RGR) and doubling time of publication were found RGR has been increasing from 2001, 2002 (0.001) to 2013 (0.023). This study and it confront the publications output trend among USA scientists; Wang Y has secured top level as measured by 0.226%. USA scientists have contributed totally 15832 (30.815%) items and include 87.947% per cent appear as journal articles. Harvard University scientists are much attention in a produced large number of research papers and they hold top level among research collaboration in enzyme research. (Liang Zhang et, all, 2010, [9]). Reviewed wetland research, 1991–2008: Ecological engineering and ecosystem restoration. The results showed the significant wetland research issues in the SCI database. From 1991 to 2008, the annual number of journal articles published and the number of articles cited to wetland research increased more than six-fold and nine fold respectively. The USA produced the most single-country articles and international collaborative articles, followed by Canada and UK. (Kirti Joshi, Avinash Kshitij, Garg, 2010, [8]). Studied the field of forest mycology indicates that the number of publications has increased significantly during the year 2004-2008. A total of 3313 publications scattered 619 journals title from 50 countries and 839 institutions highest rate of annual growth of published articles. (Subramaniyam K, 1983, [10]). Bibliometric Studies of Research Collaboration, Published in A review, Journal of Information Science. In this paper, several types of collaboration have been identified, and earlier research on collaboration has been reviewed. Further research is needed to refine the methods of defining and assessing collaboration and its impact on the organization of research and communication in science.

## **OBJECTIVES OF THE STUDY**

The main purpose of this study was to analyze the 30 years of scientometric features of Bioleaching research activities at global level and to identify the year wise distribution of Bioleaching research output, the rate of growth of Bioleaching research productivity by calculating relative growth rate and doubling time of publications, Authorship pattern, degree of collaboration, ranking of authors

based on publications, journal wise distribution of publications, institution wise research concentration and bibliographic coupling, country wise distribution, language-wise distribution, document wise distribution and main Keywords on global bioleaching research output.

## **METHODOLOGY**

The data for the study of Bioleaching research output on a global level were downloaded from the web of science database in September 2018. The Publications were retrieved by using the keyword “BIOLEACHING” in the title field and cover the period from 1989 to 2018. Further, the researcher has downloaded the bibliographical data in the form of plain text files. Then, the bibliographical details are converted using Histcite software (developed by Thomson Reuter). VOSviewer (developed by Universiteit Leiden, Netherlands) is also used for bibliographic coupling analysis.

## **ANALYSIS AND DISCUSSIONS:**

### **Year wise Distribution of Publications:**

Total of 2477 publications was published on Bioleaching during 1989 – 2018 globally. Table 1 shows the year-wise distribution of publication on Bioleaching research. The maximum number of publications 183 (7.4%) were recorded in 2015 with a Total Local Citation Scores (TLCS) 555 and Total Global Citation Scores (TGCS) 1358. The minimum number of publications 6 (0.2%) were recorded in 1989 with 51 TLCS and 98 TGCS. The maximum TLCS 1784 were recorded in 2008 and minimum 17 in 2018. The maximum TGCS 4267 were recorded in 2008 and minimum 38 in 2018. It also indicates that all these 2477 publications have 83544 cited references, which indicates a healthy trend in citing reference found among the global researcher of bioleaching area of study.

**Table 1: Year wise Distribution of Publications**

<b>S.No</b>	<b>Year</b>	<b>Publications</b>	<b>%</b>	<b>TLCS</b>	<b>TGCS</b>
<b>1</b>	1989	6	0.2	51	98
<b>2</b>	1990	15	0.6	67	128
<b>3</b>	1991	16	0.6	110	271
<b>4</b>	1992	31	1.3	350	750
<b>5</b>	1993	46	1.9	384	818
<b>6</b>	1994	27	1.1	263	891
<b>7</b>	1995	36	1.5	340	804
<b>8</b>	1996	32	1.3	343	790

<b>9</b>	1997	43	1.7	545	1112
<b>10</b>	1998	39	1.6	513	1353
<b>11</b>	1999	39	1.6	508	1111
<b>12</b>	2000	38	1.5	607	1359
<b>13</b>	2001	66	2.7	1300	3318
<b>14</b>	2002	49	2	341	1475
<b>15</b>	2003	63	2.5	1164	2991
<b>16</b>	2004	56	2.3	783	1492
<b>17</b>	2005	55	2.2	774	1477
<b>18</b>	2006	88	3.6	1204	2663
<b>19</b>	2007	72	2.9	805	1818
<b>20</b>	2008	152	6.1	1784	4267
<b>21</b>	2009	133	5.4	1284	3091
<b>22</b>	2010	131	5.3	1063	2356
<b>23</b>	2011	125	5	878	1878
<b>24</b>	2012	134	5.4	690	1742
<b>25</b>	2013	173	7	1063	2272
<b>26</b>	2014	163	6.6	650	1520
<b>27</b>	2015	183	7.4	555	1358
<b>28</b>	2016	165	6.7	267	787
<b>29</b>	2017	159	6.4	137	396
<b>30</b>	2018	142	5.7	17	38
<b>Total</b>		<b>2477</b>	<b>100</b>	<b>18840</b>	<b>44424</b>

### Relative Growth Rate and Doubling Time

Relative growth rates of bioleaching literature and also the doubling time for publications is analyzed in Table -2. It could be observed that the relative growth rates for all sources of bioleaching research output have decreased from 0.916 in 1990 to -0.113 in 2018. The mean relative growth rates for the periods are divided into three blocks of 10 years each and they were 0.871, 0.136 and 0.006 respectively. The overall study period has witnessed a mean relative growth rate of 0.337. Contradictory to this, the doubling time for publication of all sources of bioleaching research output has increased from 0.76 in 1990 to 6.13 in 2018. The mean doubling time for publications for the periods of three blocks of 10 years each is found to be 0.47, 7.03 and 9.02 years respectively. The whole study period has witnessed a doubling time for publications at 5.50 years. In general, bioleaching research output has shown a declining trend as far as the publications are concerned; inversely doubling time for publications has increased progressively.

**Table 2: Relative Growth Rate and Doubling Time of Bioleaching Publications**

Year	Publications	W1	W2	R(a)= (W2-W1)	Mean R(a)	Dt = 0.693/R(a)	Mean Dt(a)
1989	6	-	1.792	-		-	
1990	15	1.792	2.708	0.916		0.76	
1991	16	2.708	2.773	0.065		10.74	
1992	31	2.773	3.434	0.661		1.05	
1993	46	3.434	3.829	0.395		1.76	
1994	27	3.829	3.296	-0.533	0.871	1.30	0.47 Years
1995	36	3.296	3.584	0.288		2.41	
1996	32	3.584	3.466	-0.118		5.88	
1997	43	3.466	3.761	0.295		2.35	
1998	39	3.761	3.664	-0.098		7.10	
1999	39	3.664	3.664	0.000		0.00	
2000	38	3.664	3.638	-0.026		26.68	
2001	66	3.638	4.190	0.552		1.26	
2002	49	4.190	3.892	-0.298		2.33	
2003	63	3.892	4.143	0.251	0.136	2.76	7.03 Years
2004	56	4.143	4.025	-0.118		5.88	
2005	55	4.025	4.007	-0.018		38.46	
2006	88	4.007	4.477	0.470		1.47	
2007	72	4.477	4.277	-0.201		3.45	
2008	152	4.277	5.024	0.747		0.93	
2009	133	5.024	4.890	-0.134		5.19	
2010	131	4.890	4.875	-0.015		45.74	
2011	125	4.875	4.828	-0.047		14.78	
2012	134	4.828	4.898	0.070		9.97	
2013	173	4.898	5.153	0.255		2.71	9.02 Years
2014	163	5.153	5.094	-0.060	0.006	11.64	
2015	183	5.094	5.209	0.116		5.99	
2016	165	5.209	5.106	-0.104		6.69	
2017	159	5.106	5.069	-0.037		18.71	
2018	142	5.069	4.956	-0.113		6.13	
	<b>2477</b>			<b>3.164</b>	<b>0.337</b>		<b>5.50 Years</b>

**Authorship Pattern and Degree of Collaboration in Bioleaching Research**

Table 3 shows the authorship pattern, there were 4172 authors contributed 2477 publications. 504 (20.35%) publications were contributed by four authors, followed by 490 (19.78%) publications were contributed by three authors, whereas single author publications were 107 (4.32%) only.

**Table 3: Authorship Pattern in Bioleaching Research**

Authorship Pattern	Publications	Percentage %
Single Authors	107	4.32
Two Authors	357	14.41
Three Authors	490	19.78
Four Authors	504	20.35
Five Authors	402	16.23
Six Authors	268	10.82
Seven Authors	124	5.01
Eight Authors	102	4.12
Nine Authors	52	2.10
Ten and More Authors	71	2.87
	<b>2477</b>	<b>100.0</b>

### The Degree of Collaborations:

The Degree of Collaboration (DC) is measured by the proportion of multiple authored papers derived by Subramanian (1983), based on this, the result of the degree of collaboration (DC) = **0.956 i.e.**, 95 per cent of collaborative authors articles published during the study periods.

### Most Productive Authors in Bioleaching Research

Table 4 shows the top five most productive authors. There were 4712 authors contributed 2477 publications in bioleaching research globally. Out of these 4712 authors, Qiu GZ contributed 145 (5.85%) publications and secured the first position with 989 TLCS and 1 TGCS, followed by three authors namely Liu XD, Qin WQ and Wang J Pereira, contributing 52 (2.10%) publications respectively with different Local and Global citation for their publications. Mousavi SM comes third with 45 (1.82%) publications with 711GCS.

**Table 4: Most Productive Authors in Bioleaching Research**

S.No	Author	No. of Contribution	Percentage %	TLCS	TGCS
1	Qiu GZ	145	5.85	989	1585
2	Liu XD	52	2.10	275	506
3	Qin WQ	52	2.10	291	450
4	Wang J	52	2.10	251	438
5	Mousavi SM	45	1.82	419	711

### Journal Wise Distribution of Publications in Bioleaching Research



Table 5 shows the top five most productive journals. There were 425 journals published 2477 publications. Out of these 425 journals, HYDROMETALLURGY were contributed 364 (14.71%) publications with 4926 TLCS and 9089 TGCS and secured the first position, followed by MINERALS ENGINEERING contributed 237 (9.6%) with 1861 TLCS and 4152 TGCS, TRANSACTIONS OF NONFERROUS METALS SOCIETY OF CHINA contributed 105 (4.2%) with 487 TLCS and 825TGCS and scored the third position respectively.

**Table 5: Top Five Highly Contributing Journals in Bioleaching Research**

S.No	Name of the Journal	No. of Publications	Percent age %	TLCS	TGCS
1	HYDROMETALLURGY	364	14.7	4926	9089
2	MINERALS ENGINEERING	237	9.6	1861	4152
3	TRANSACTIONS OF NONFERROUS METALS SOCIETY OF CHINA	105	4.2	487	825
4	BIORESOURCE TECHNOLOGY	76	3.1	1035	1681
5	INTERNATIONAL JOURNAL OF MINERAL PROCESSING	47	1.9	487	1055

### **Institution Wise Distribution and Bibliographic Coupling**

The table-6 indicates top five Institution-wise research productivity. It is noted that 1439 institutions were contributed 2477 of the total research productivity. It is noted that Central South University contributed the highest number of research publications 268 (10.8%) with 1561 TLCS and 2585 TGCS. Chinese Academy of Sciences terms second in order 97 (3.9%) publications with Total Global Citation Source 1025 and the third in order is the University of Chile with 88 (3.6%) publication having the TGCS of 1617.

**Table 6: Institution Wise Distribution of Publications**

S.No	Name of the Institution	No. of Publications	Percentage %	TLCS	TGCS
1	Central South University	268	10.8	1561	2585
2	Chinese Academy of Sciences	97	3.9	514	1025
3	University of Chile	88	3.6	601	1617
4	Ministry Education	79	3.2	616	917
5	The University of Cape Town	65	2.6	633	1229

### **Bibliographic Coupling of Institution**



4	USA	174	7	1027	3596
5	Chile	145	5.9	966	2720

### Language-Wise distribution of Publications in Bioleaching Research

Table 8 shows the language-wise distribution. The total 2477 publication of study is distributed around 14 languages. English was the most preferred language for publication 2429 (98.1%) with 18777 TLCS and 44285 TGCS, followed by Spanish 12 (0.5%) and French 10 (0.4%) publications. Language such as Japanese, Malay, Rumanian and Turkish contribute single publication.

**Table 8: Language-Wise Distribution of Publications**

S.No	Language	No. of Publications	Percentage %	TLCS	TGCS
1	English	2429	98.1	18777	44285
2	Spanish	12	0.5	7	11
3	French	10	0.4	37	67
4	Chinese	5	0.2	5	35
5	German	4	0.2	4	8
6	Portuguese	4	0.2	1	4
7	Polish	3	0.1	1	3
8	Czech	2	0.1	5	8
9	Russian	2	0.1	0	0
10	Serbian	2	0.1	2	2
11	Japanese	1	0	1	1
12	Malay	1	0	0	0
13	Rumanian	1	0	0	0
14	Turkish	1	0	0	0

### Document Wise Distribution of Publications

Table-9 indicates the document wise distribution of research output in bioleaching research. This study has observed a total of 2477 publications in bioleaching during the period from 1989 to 2018. Out of various document of publications in bioleaching, journal articles that appeared in the journals have shown a predominant contribution (82.8%) with Total Global citation score of 30,285 and this occupies the first position. The document of Proceeding Papers; Articles comes second in order (9.9%) with total Global citation scores 7467 of sharing total research output in bioleaching during the period of analysis. The source of Review comes in the third position (5.1%) with total

global citation scores of 6495 with respect to total output in bioleaching research during the study period and the minimum sharing of document comes from correction, letter, discussion, news item, with less than 5 publications having no citations.

**Table 9: Document Wise Distribution of Publications**

S.No	Source Type	No. of Publications	Percentage %	TLCS	TGCS
1	Article	2050	82.8	13370	30285
2	Article; Proceedings Paper	246	9.9	3326	7467
3	Review	126	5.1	2091	6495
4	Meeting Abstract	28	1.1	5	9
5	Editorial Material	6	0.2	0	0
6	Note	6	0.2	22	36
7	Article; Book Chapter	3	0.1	24	94
8	Correction	3	0.1	0	0
9	Letter	3	0.1	0	2
10	Discussion	2	0.1	0	0
11	News Item	2	0.1	0	0
12	Review; Book Chapter	2	0.1	2	36

### Keywords Distribution in Bioleaching Research

The intensity of data focused on the titles of the papers is more than whatever remains of the segment of the papers. Consequently, if a word happens more every now and again than anticipated it to happen, at that point, it mirrors the accentuation given by the creators about the exploration field of their advantage. The essential words called '**Keyword**' are a standout amongst other pointers to comprehend and get a handle on quickly the idea substance of the papers. Table 10 reveals that the high-frequency keywords are "BIOLEACHING" topped with 1291 publications with the highest Global Citation Score of 21872, next "ACIDITHIOBACILLUS" with the Global Citation Score of 4592 respectively with 346 appearances.

**Table 11: Top Five Key Words Appeared in the Publications**

S.No	Keywords	Records	Percentage %	LCS	GCS
1	BIOLEACHING	1291	52.1	11689	21872
2	ACIDITHIOBACILLUS	346	14	2115	4592
3	FERROOXIDANS	339	13.7	2510	5797
4	COPPER	301	12.2	1932	3855
5	USING	285	11.5	2375	4745

## **CONCLUSION:**

A total of 2477 publications were published in Bioleaching research globally during the study period 1998 - 2018. The highest number of publications 183 (7.4%) was published in 2015. The highest Total Local Citation Scores (TLCS) and Total Global Citation Scores (TGCS) were recorded in 2008, 1784 and 4267 respectively. The mean relative growth is 0.337 and the average doubling time is 5.50. The collaborative research is predominant; the degree of collaboration is 0.956. 4712 authors contributed 2477 publications, Qiu GZ scores the first position with 145 contributions (5.85%). 1439 institutions contributed 2477 publications globally; Central South University contributed 268 (10.8%) publications and score first rank. Research articles were predominant (82.8%). 2477 publications published in 425 journals, Hydrometallurgy journal contributed 364 (14.7%) publications and score the first position. 78 countries contributed bioleaching research globally and Public R China rank first with 659 (26.6%) publications and India comes next with 204 (8.2%) publications. 14 languages were identified in global bioleaching publications. Central South University contributed 268 Publications with 226023 bibliographic coupling with other institutes. Bioleaching is a method of natural remediation to extract metals from their ores through the use of living organisms. Generally, results of this study revealed that the contribution of bioleaching research literature is on the gradual rise and the study on bioremediation is very much needed to minimize the chemical effect on the ecosystem in near future to make the earth a better place for humankind.

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