Microbiology Research in India: An Analysis of publications output during 1999-2013

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ABSTRACT

The study analyses the mapping of Indian microbiology research output on several parameters including its growth and share in the world's research output, pattern of research communication in core domestic and international journals, geographical distribution of publications, share of international collaborative publications at the national level as well as across subjects and characteristics of high productivity institutions, authors and cited papers. The Web of Science database has been used to retrieve the publications data for 15 years. Concludes that India needs to increase its output and bring about improvement in the quality of its research efforts.

Keywords: Bibliometrics, Microbiology, Web of Science, Relative Growth Rate, Doubling Time, Impact Factor and Activity Index.

Introduction

The enormous growth of scientific literature, increased cost of written communication and shrinking library budget have made it difficult for the library professionals to cater to the information needs of scientists. The situation demands for an effective means of measurement of the growth of scientific literature, recognition of scientists who have major impact in their discipline, recognition of core journals in the discipline and identification of trends in the discipline etc. for framing effective library policies by the professionals. Results of such studies also help the policy makers to decide priorities in resource allocation for scientific activities. At present, Bibliometrics has established itself as a viable and distinctive research technique for studying the science of science based on bibliographical and citation data.

The field of Bibliometrics has grown in close association with its applications. The basic parameters used in bibliometric studies vary widely from field to field based on the purpose of the study. The parameters used are the number of publications published over years in a discipline, the number of pages published over years, number of authors per publication, the journals most frequently cited, number of citations per publication, number of times a publication is cited etc. The sources used for collecting bibliometric data may be references given at the end of publications, indexing and abstracting serials, national bibliographies on various subjects, or the original documents themselves. In general, bibliometric techniques are applied to study the following aspects in any discipline; growth rate of literature;

scientific productivity of authors; collaborative trend among authors; and core journals (Parvathamma, 1993).

Methods and Materials

This study uses **Web of Science** *(www.isiknowledge.com)* database to extract relevant publications data of Indian Microbiology research output for the 15 year period (1999 to 2013). For analyzing the data, Excel and SPSS- statistical software has been used. The Relative Growth Rate (RGR), Doubling Time (Dt) and Activity Index (AI) has been calculated.

Results and Discussion

Growth of Publications of World and India in Microbiology Literature

One of the obvious features of scientific literature in recent years has been its rate of growth. A number of growth models have been proposed regarding the rate of growth. Price (1963) proposed an exponential rate of growth of scientific literature. He predicted a regular exponential growth with doubling period of ten to fifteen years.

Table 1 depicts the microbiology research output of World and India, Average Citations per Papers and global publications share of India. India has produced 26,114 papers, and received 2,35,667 citations during the period 1999-2013, Average Citations per Paper is 9.02. As per the web of science data, cumulative publications growth, the cumulative microbiology publications output of India had increased from 4,557 publications during 1999-2003 to 7,752 publications during 2004-2008, and 13,805 publications during 2009-2013. India's publications are gradually increased year by year. The global publications share of India during 1999-2013 was 3.74%, which has increased from 2.62 in 1999 to 4.74 in 2013. This analysis proves that there is an increasing trend in the Indian microbiology research.

The global research output in microbiology research has increased from 1,75,616 in 1999 to 2,97,486 in 2013. The trend shows a steady and significant increase in the publications. In the same manner, the Indian research output in microbiology too has increased from 4,557 in 1999 to 13,805 by 2013. The trend shows a higher steepness, indicating a faster increase in research output vis-à-vis global research output (Table 1).

Table – 1: Growth of Publications of World and India in Microbiology Literature

Year	World (TP)	India (TP)	%TP Share	ACPP
1999	32433	851	2.62	14.06
2000	34049	868	2.55	17.05
2001	36026	904	2.51	17.80
2002	33514	962	2.87	18.61
2003	39594	972	2.45	18.42
2004	40519	1025	2.53	14.89
2005	41266	1211	2.93	15.79
2006	44453	1495	3.36	14.39
2007	49457	1675	3.39	13.02
2008	49929	2346	4.70	9.79
2009	56684	2455	4.33	8.05
2010	56541	2429	4.30	6.42
2011	59118	2931	4.96	4.00
2012	61574	2978	4.84	2.35
2013	63569	3012	4.74	0.76

1999-2003	175616	4557	2.59	17.26
2004-2008	225624	7752	3.44	12.99
2009-2013	297486	13805	4.64	4.08
1999-2013	**698726**	**26114**	**3.74**	**9.02**

TP=Total Publications

Indian's research output, relative growth and doubling time of Microbiology

The growth of Indian publications were analysed by Relative Growth Rate (RGR) and Doubling time (Dt). RGR is a measure to study the increase in number of articles of time (Mahapatra 1985) and the Dt is directly related to RGR. It is the time required for articles to become double of the existing amount. The table shows that the relative growth rate of Indian research output decreases gradually from 0.70 to 0.12 in fifteen year's period (1999-2013). The doubling time (Dt) correspondingly increases from 0.99 to 5.65 in this period. The mean growth rate & doubling time for the India is 0.115 and 0.848 respectively.

Table 2 represents the RGR, Dt, and mean of RGR and Dt of Indian publications in the field of microbiology during the period 1999–2013. From the Table 2 it is observed that the mean RGR for the first seven years is 0.100 and the Dt is 0.141 for the second eight years it is 0.015 and 0.707 respectively. Dt is the period of time required for a quantity to double in size or value. Hence it can be seen that the Dt is doubled during the second eight years. When the RGR is constant, the quantity undergoes exponential growth and has a constant Dt or period which can be calculated directly from the growth rate.

RGR decreased from 0.70 in 2000 to 0.12 in 2013. The mean relative growth for the first 7 years (1999-2005) showed a growth rate of 0.100 whereas the mean RGR for the last 8 years (2006-2013) reduced to 0.105. The corresponding Dt for different years gradually increased from 0.99 in 1999 to 5.65 in 2013. The mean Dt for the first 7 years was only 0.141 which was increased to 0.707 during the last 8 years. Thus the rate of growth of publication was decreased, the corresponding Dt was increased (Table 2).

Table – 2: Indian's research output and relative growth and doubling time of Microbiology

Year	No. of publications	Cumulative	Log 1	Log 2	RGR	Mean RGR	Dt.	Mean Dt.
1999	851	851		6.75				
2000	868	1719	6.75	7.45	0.70	0.100	0.99	0.141
2001	904	2623	7.45	7.87	0.42		1.64	
2002	962	3585	7.87	8.18	0.31		2.22	
2003	972	4557	8.18	8.42	0.24		2.89	
2004	1025	5582	8.42	8.63	0.20		3.42	
2005	1211	6793	8.63	8.82	0.20		3.53	
2006	1495	8288	8.82	9.02	0.20		3.48	
2007	1675	9963	9.02	9.21	0.18		3.76	
2008	2346	12309	9.21	9.42	0.21		3.28	
2009	2455	14764	9.42	9.60	0.18		3.81	
2010	2429	17193	9.60	9.75	0.15		4.55	
2011	2931	20124	9.75	9.91	1.00		0.69	
2012	2978	23102	9.91	10.05	0.14		5.02	
2013	3012	26114	10.05	10.17	0.12	0.015	5.65	0.707

RGR= Relative Growth Rate, Dt= Doubling Time

Sub-fields of research priority in Microbiology research in India

Out of 10 sub-fields identified, only five sub-fields witnessed increase in their activities from 1999–2006 to 2007–2013. Out of 10 sub-fields of microbiology the two domains published more than 4000 publications, three domains published more than 2000 articles and other subjects produced 1000 and less than 1000 publications (Table 3).

As per the sub-fields cumulative output in Indian Microbiology research during 1999–2013, the maximum research priority (14,431 publications, 55.26% share) is assigned to Biotechnology Applied Microbiology in India during 1999–2013, followed by Biochemistry Molecular Biology (2,758 publications, 10.56% share), Agriculture (1,753 publications, 6.71% share), Energy Fuels (1,531 publications, 5.86% share), Engineering (1,339 publications, 5.13% share), Immunology (1,162 publications, 4.45% share), Infectious Diseases (1,029 publications, 3.94% share), Genetics Heredity (904 publications, 3.46% share) and Plant Sciences (647 publications, 2.48% share), Pharmacology Pharmacy (560 publications, 2.14% share).

Table – 3: Sub-fields of research priority in Microbiology research in India

Sl. No.	Subject	No. of Publications	%	Cumulative	Cum.%
1	Biotechnology Applied Microbiology	14431	55.26	14431	55.26
2	Biochemistry Molecular Biology	2758	10.56	17189	65.82
3	Agriculture	1753	6.71	18942	72.54
4	Energy Fuels	1531	5.86	20473	78.40
5	Engineering	1339	5.13	21812	83.53
6	Immunology	1162	4.45	22974	87.98
7	Infectious Diseases	1029	3.94	24003	91.92
8	Genetics Heredity	904	3.46	24907	95.38
9	Plant Sciences	647	2.48	25554	97.86
10	Pharmacology Pharmacy	560	2.14	26114	100.00
		26114	100		

Impact of journals of Indian contributions with more than 100 publications in Microbiology

One of the most important bibliometric techniques used in identifying core journals in a discipline has been Citation Analysis. "Citations are the formal explicit linkages between publications that have particular points in common (Garfield, 1979). Impact factor of the agriculture journals of Indian contributions with more than 100 publications in microbiology has been shown in the table 4. The major leading journals preferred by the scientists are *Bioresource Technology* with 1282 papers, *World Journal of Microbiology Biotechnology* with 780 papers, *Journal of Pure and Applied Microbiology* with 677 papers, *Applied Biochemistry and Biotechnology* with 645 papers and *African Journal of Biotechnology* with 531 papers.

Based on the average citations per paper the Applied Microbiology and Biotechnology, Germany holds the first position (29.25), followed by Research Journal of Biotechnology, Netherlands (23.75), Bioresource Technology, Netherlands (23.67), Biochemical Engineering Journal, Netherlands (20.15), Biomass Bioenergy, Netherlands (18.13), Journal of Clinical Microbiology, USA (17.94), and FEMS Microbiology Letters, USA (13.54).

Table – 4: Impact of journals of Indian contributions in the journals

Sl. No.	Source/ Journal	Country	TP	TC	ACP	Impact Factor
1	Bioresource Technology	Netherlands	1282	30340	23.67	4.365
2	World Journal of Microbiology Biotechnology	India	780	6834	8.76	1.353
3	Journal of Pure and Applied Microbiology	USA	677	97	0.14	0.073
4	Applied Biochemistry and Biotechnology	Germany	645	3660	5.67	1.239
5	African Journal of Biotechnology	Kenya	531	2231	4.20	0.57
6	Process Biochemistry	Netherlands	481	11425	23.75	2.524
7	Research Journal of Biotechnology	Egypt	417	148	0.35	0.29
8	Indian Journal of Biotechnology	India	410	614	1.5	0.510
9	Indian Journal of Microbiology	India	358	906	2.53	0.832
10	Plant Cell Tissue and Organ Culture	India	330	3745	11.35	2.612
11	Current Microbiology	India	310	3152	10.17	1.359
12	Journal of Clinical Microbiology	USA	289	5186	17.94	4.232
13	Applied Microbiology and Biotechnology	Germany	266	7780	29.25	3.811
14	International Journal of Systematic and Evolutionary Microbiology	England	265	2763	10.43	2.798
15	Journal of Chemical Technology and Biotechnology	USA	261	2784	10.67	2.494
16	Journal of Medical Microbiology	England	253	2426	9.59	2.297
17	Biotechnology Letters	India	250	2626	10.5	1.736
18	Biomass Bioenergy	Netherlands	230	4171	18.13	3.411
19	Biochemical Engineering Journal	Netherlands	217	4372	20.15	2.368
20	FEMS Microbiology Letters	USA	209	2830	13.54	2.723

TP=Total Publications, TC=Total Citations, ACP=Average Citations per Papers

Indian institutions contribution and the various indices in the field of Microbiology

Based on the publications output for India in microbiology, total of 20 institutions were identified as high productive between 235 and 3493 publications, with an average output 548 publication per institution during 1999-2013. These top 20 institutions together contributed 11,522 publications total research output by India in agriculture during 1999-2013. Of these 20 institutions, 7 institutions contributed publications output each above 20 institutions publications average (548 publications per institution) during 1999-2013. Institutions along with their publications outputs are: Council of Scientific Industrial Research (CSIR), Delhi (3493 publications), Indian Institute of Technology (IIT), Delhi (1566 publications), University of Delhi, Delhi (791 publications), Banaras Hindu University. Varanasi (540 publications), Indian Institute of Technology (IIT), Kharagpur (439 publications), Central Food Technological Research Institute (CFTRI), Mysore, Karnataka (400 publications), Institute of Microbial Technology (IMTECH), Chandigarh (394 publications).

The average citation received per publications by total publications of these 20 top institutions varies from 8.7 to 28.32 with a average citation per publication during 1999-2013 was 15.76. Only eight institutions registered higher average citations per publication than the average of 20 institutions. These are: National Institute Interdisciplinary Science Technology (NIIST), Thiruvananthapuram, Kerala 28.32 citations per publication, followed by Indian Institute of Technology(IIT), Madras (20.98 citations per publication), Institute of Microbial Technology (IMTECH), Chandigarh (19.01 citations per publication), National Institute of Cholera Enteric Diseases (NICED), Kolkata (18.07 citations per publication), Centre For

Cellular Molecular Biology , Hyderabad, Telangana (16.72 citations per publication), University of Delhi, Delhi (16.6 citations per publication (Table 5).

The average *h*-index of 20 institutions varies from 21 to 84, with the average value of *h*-index during 1999- 2013. Only 16 out of 20 institutions had scored higher *h*-index values than the average values 0f 20 institutions. These are Council of Scientific Industrial Research (CSIR), New Delhi with *h*-index 84, followed by Indian Institute of Technology (IIT), Delhi (64), University of Delhi, Delhi (52), National Institute Interdisciplinary Science Technology (NIIST), Thiruvananthapuram, Kerala (44), Institute of Microbial Technology (IMTECH), Chandigarh (43), Banaras Hindu University. Varanasi (40 Indian Institute of Technology (IIT), Kharagpur (40), Indian Institute of Technology(IIT), Madras (39), Central Food Technological Research Institute (CFTRI), Mysore, Karnataka (36), Indian Institute of Science (IISC), Bangalore (34), All India Institute of Medical Sciences (AIIMSes), Delhi (34), Bhabha Atomic Research Center(BARC), Mumbai (34) (Table 5).

Table-5: Indian institutions contribution and the various indices in the field of Microbiology

Rank by TP	Research /Academic Institution	TP	TC	ACP	H-Index
1	Council of Scientific Industrial Research (CSIR), Delhi	3493	55436	15.87	84
2	Indian Institute of Technology (IIT), Delhi	1566	23584	15.06	64
3	University of Delhi, Delhi	791	13127	16.6	52
4	Banaras Hindu University. Varanasi	540	7784	14.41	40
5	Indian Institute of Technology (IIT), Kharagpur	439	7199	16.4	40
6	Central Food Technological Research Institute (CFTRI), Mysore, Karnataka	400	5466	13.66	36
7	Institute of Microbial Technology (IMTECH), Chandigarh	394	7489	19.01	43
8	Indian Institute of Science (IISC), Bangalore	387	4909	12.68	34
9	Indian Agricultural Research Institute (IARI), Delhi	324	3149	9.72	26
10	All India Institute of Medical Sciences (AIIMSes), Delhi	309	4762	15.41	34
11	Indian Institute of Technology(IIT), Madras	307	6442	20.98	39
12	National Chemistry Laboratory, Pune	301	4962	16.49	33
12	Bhabha Atomic Research Center(BARC), Mumbai	301	4693	15.59	34
13	National Institute Interdisciplinary Science Technology (NIIST), Thiruvananthapuram, Kerala	267	7562	28.32	44
14	Jawaharlal Nehru University, New Delhi	252	3513	13.94	31
15	Indian Institute Of Technology (IIT), Bombay	248	3527	14.22	31
16	PGIMER Chandigarh, Chandigarh	247	3316	13.43	30
17	National Institute of Cholera Enteric Diseases (NICED), Kolkata	246	4444	18.07	33
18	University of Hyderabad , Hyderabad, Telangana	238	2070	8.7	21
19	Centre For Cellular Molecular Biology , Hyderabad, Telangana	237	3963	16.72	33
20	Panjab University, Chandigarh, Punjab	235	3722	15.84	29

Highly Productive Scientists in India

"Scientific productivity" is frequently measured in terms of the published output, mostly because the data on the n umber of publications by authors can be easily collected and are quite reliable. Lotka (1926) proposed his 'Inverse square law of scientific productivity' for measuring the scientific productivity of authors in a given discipline. It is one of the earliest studies in the direction of measuring scientific productivity using the number of publications of an author as a measure. Apart from studying the scientific productivity of authors, another aspect of authorship which has gained importance is the study of collaborative trend of authors in a given discipline.

The table 6 shows the top highly productive scientists based on the number of publications irrespective of their disciplines during 1999-2013 appeared in Web of Science. These authors have together published 3251 publications and received 45677 citations with an average citation per paper of 14.05. Kumar, A. is the highly productive author, he contributed 319 publications and received 3377 citations, and average citation per paper is 10.59. Kumar, S. contributed 300 articles and received 2428 citations with 8.09 average citations per paper, Pandey A. contributed 243 articles and received 7837 citations with 32.25 average citations per paper. Singh S. contributed 203 articles and received 2156 citations.

Table - 6: Highly Productive Scientists in India

Sl. No.	Authors	Publications	TC	ACP	H-Index
1	Kumar A	319	3377	10.59	30
2	Kumar S	300	2428	8.09	23
3	Pandey A	243	7837	32.25	43
4	Singh S	203	2156	10.62	21
5	Sharma S	202	2810	13.91	27
6	Kumar R	173	2124	12.28	21
7	Sharma A	153	1598	10.44	21
8	Singh A	140	1756	12.54	22
9	Gupta R	130	4317	33.21	34
10	Singh R	129	1516	11.75	19
11	Kumar V	120	842	7.02	15
12	Nair, G.B.	118	2554	21.64	27
13	Ghosh S	115	1265	11	18
14	Sharma P	111	1273	11.47	20
15	Kumar P	103	866	8.41	15
16	Kumar M	102	937	9.19	17
17	Singh A. K	101	1051	10.41	18
17	Sharma R	101	2081	20.6	19
17	Gupta S	101	1165	11.53	17
18	Srivastava A. K	97	1201	12.38	18
19	Das S	96	994	10.35	18
20	Shivaji S	94	1529	16.27	23

International collaboration

Collaboration has become a well established feature in the field of microbiology literature. It is observed that there is a consistently increasing trend towards collaboration among various branches microbiology literature which leads o collaborative authorship in literature.

Table 7 depicts the international collaborative papers of India with top 20 countries during 1999- 2013. The share international publications in the Indian microbiology literature research output was among the different collaborative countries the USA ranked first with 1296 publications and 25,978 citations (20.04 ACP and 71 H-index), followed by Germany which ranked second with 409 publications and 9,201 citations (22.5 ACP and 47 H-index), South Korea ranked third with 368 publications and 5,177 citations. Japan 341 and England 296 publications ranked fourth and fifth respectively.

Table- 7: International collaboration

Rank by collaborative papers	Country	Total Publication (TP)	Total Citations (TC)	Average Citations per Publication (ACP)	H-Index
1	USA	1296	25978	20.04	71
2	Germany	409	9201	22.5	47
3	South Korea	368	5177	14.07	33
4	Japan	341	8781	25.75	47
5	England	296	8431	28.48	46
6	France	228	5954	26.11	39
7	Australia	172	2961	17.22	30
8	Peoples R China	170	3789	22.29	31
9	Canada	152	3757	24.72	32
10	Brazil	138	5250	38.04	34
11	Taiwan	116	1932	16.66	22
12	Switzerland	113	3568	31.58	30
13	Netherlands	111	3367	30.33	30
14	Italy	101	2896	28.67	26
15	Saudi Arabia	96	1135	11.82	11
16	Malaysia	95	1820	19.16	17
17	Sweden	93	1870	20.11	24
18	Bangladesh	86	2369	27.55	26
19	Belgium	80	3342	41.78	23
20	Spain	77	2886	37.48	24

Subject-wise productivity in India

Table 8 and figure 1 indicate the subject-wise productivity of India in microbiology research. Biotechnology Applied Microbiology, Biochemistry Molecular Biology, Agriculture, Energy Fuels, Engineering, Immunology, Infectious Diseases, Genetics Heredity, Plant Sciences, Pharmacology Pharmacy, were considered on the basis of the total number of publications. During 1999-2013 Biotechnology Applied Microbiology (ranked first) with 14431 publications, Biochemistry Molecular Biology ranked second with 2758 publications other subject's productivity in given table 10 India's contribution in the field of Genetics Heredity ranked eighth 904 publications to the World's literature on the subject. Similarly India's contribution in the field of Infectious Diseases 1029 publications to the overall World's literature. Similarly the table 11 and figure 2 shows subject wise productivity of world microbiology literature.

Table – 8: Subject wise productivity in India

		YEAR														
Subject	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Biotechnology Applied Microbiology	426	449	456	491	492	485	608	771	899	1301	1438	1454	1700	1693	1768	**14431**
Biochemistry Molecular Biology	94	91	116	130	112	126	153	151	160	198	274	241	253	320	339	**2758**
Agriculture	50	41	62	64	68	77	59	118	138	210	137	151	211	190	177	**1753**
Energy Fuels	39	36	49	56	53	52	47	106	123	202	121	136	191	174	146	**1531**
Engineering	94	98	63	41	75	59	115	101	80	102	95	76	102	121	117	**1339**
Immunology	43	42	42	50	41	55	73	68	78	81	112	91	141	128	117	**1162**
Infectious Diseases	35	36	36	43	37	63	61	55	63	83	100	98	104	114	101	**1029**
Genetics Heredity	31	29	28	40	37	30	35	59	55	65	81	75	107	116	116	**904**
Plant Sciences	26	32	31	33	40	45	31	40	38	50	40	58	62	58	63	**647**
Pharmacology Pharmacy	13	14	21	14	17	33	29	26	41	54	57	49	60	64	68	**560**
Total	**851**	**868**	**904**	**962**	**972**	**1025**	**1211**	**1495**	**1675**	**2346**	**2455**	**2429**	**2931**	**2978**	**3012**	**26114**

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Table – 9: Subject wise productivity in World

Subject	YEAR															
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Biotechnology Applied Microbiology	15156	15073	15675	15650	18633	18618	19369	22036	22612	24883	28520	29332	30131	30280	32550	**338518**
Biochemistry Molecular Biology	4511	4404	5030	4580	5832	5164	5767	5947	5935	6010	7153	6919	7214	6694	7445	**88605**
Agriculture	512	449	479	516	513	694	671	762	934	1784	1720	2135	2708	2531	2642	**19050**
Energy Fuels	255	278	294	318	331	342	364	464	671	1493	1393	1845	2441	2279	2689	**15457**
Engineering	676	707	554	711	643	786	1026	1042	857	995	1030	1078	1119	2890	1342	**15456**
Immunology	3106	3755	3984	3004	3050	2969	3406	3211	3341	3517	3611	3437	3723	4050	3711	**51875**
Infectious Diseases	2909	3921	4417	3246	3487	4132	4235	3730	6051	3985	4213	3945	4154	4361	4490	**61276**
Genetics Heredity	3238	3197	3263	3066	4512	4515	3260	4615	4060	4291	5686	4599	4266	5109	4863	**62540**
Plant Sciences	396	395	395	389	423	470	483	483	510	613	630	651	699	677	646	**7860**
Pharmacology Pharmacy	1674	1870	1935	2034	2170	2829	2685	2163	4486	2358	2728	2600	2663	2703	3191	**38089**
Total	**32433**	**34049**	**36026**	**33514**	**39594**	**40519**	**41266**	**44453**	**49457**	**49929**	**56684**	**56541**	**59118**	**61574**	**63569**	**698726**

Activity Index

In the present context, Activity Index (AI) for India has been calculated for different years to see how India's performance gradually changed during different years. For this the author has used the Activity Index 2000-20123.

The Activity Index (AI) characterizes the relative research effort of a country in given subjects. It is defined as:

$$AI = \frac{\textit{given field's share in the country' spublication output}}{\textit{given field's share in the world's spublication output}}$$

$$\text{Mathematically } AI = \frac{nij/nio}{noj/noo} *100$$

Where:

nij - Indian output of papers in particular field
nio - Total Indian output on all subjects
noj - World output of papers in particular field
noo - Total World output on all subjects

The Activity Index is used for Indian microbiology research output in Table 9. The table reveals the highest AI in various subject categories as follows: Biotechnology Applied Microbiology (117.39) in 2007, Biochemistry Molecular Biology (98.88) in 2002, Agriculture (539.95) in 2003, Energy Fuels (679.28) in 2006, Engineering (543.74) in 2000, Immunology (73.23) in 2004, Infectious Diseases (60.27) in 2004, Genetics Heredity (50.59) in 2011, Plant Sciences (385.20) in 2003, and Pharmacology Pharmacy (48.74) in 2008. It is observed from the data that it indicates India's research efforts in these subjects correspond to the world's average.

Table – 12: Activity Index of Various Subjects

Year	Biotechnology Applied Microbiology	Biochemistry Molecular Biology	Agriculture	Energy Fuels	Engineering	Immunology	Infectious Diseases	Genetics Heredity	Plant Sciences	Pharmacology Pharmacy
1999	107.12	79.42	372.18	582.88	529.95	52.76	45.85	36.49	250.23	29.6
2000	116.85	81.05	358.2	507.98	543.74	43.88	36.02	35.58	317.79	29.37
2001	115.93	91.9	515.83	664.2	453.19	42.01	32.48	34.2	312.76	43.25
2002	109.3	98.88	432.1	613.5	200.89	57.99	46.15	45.45	295.54	23.98
2003	107.56	78.23	539.95	652.25	475.13	54.76	43.22	33.4	385.2	31.91
2004	102.98	96.45	438.6	601.05	296.73	73.23	60.27	26.27	378.49	46.11
2005	106.97	90.4	299.62	439.99	381.94	73.03	49.08	36.58	218.71	36.8
2006	104.04	75.5	460.45	679.28	288.21	62.97	43.84	38.01	246.25	35.74
2007	117.39	79.6	436.26	541.25	275.63	68.93	30.74	40	220	26.99
2008	111.28	70.12	250.52	287.95	218.17	49.02	44.33	32.24	173.59	48.74
2009	116.42	88.44	183.91	200.56	212.96	71.61	54.8	32.89	146.6	48.24
2010	115.39	81.08	164.63	171.58	164.11	61.63	57.82	37.96	207.39	43.87
2011	113.8	70.74	157.16	157.82	183.85	76.39	50.5	50.59	178.9	45.44
2012	115.6	98.84	155.22	157.86	86.57	65.35	54.05	46.95	177.14	48.96
2013	114.64	96.1	141.39	114.59	184	66.54	47.48	50.34	205.83	44.98
Average AI	**111.68**	**85.12**	**327.07**	**424.85**	**299.67**	**61.34**	**46.44**	**38.46**	**247.63**	**38.93**

Conclusion

Bibliometrics depicts essential aspects of scientific activities by quantitative and statistical methods, and its output proved to be a valuable supplement to qualitative methods such as peer reviews has developed tools to quantify that part of research output, which is documented in the framework of scholarly communication. Research is a complicated process involving very often a large number of intricate issues. Evaluation is one of the key components of any research and development activity. There are many measures of scientific productivity of research output and impact.

India had contributed 26,114 papers in microbiology during the period 1999 to 2013 as reflected in Web of Science international database. The cumulative Indian research output in microbiology increased from 4,557 papers during 1999-2003 to 7,752 publications during 2004-2008, and 13,805 publications during 2009-2013. India's publications are gradually increased year by year. The global publications share of India during 1999-2013 was 3.74%, which has increased from 2.62 in 1999 to 4.74 in 2013. This analysis proves that there is an increasing trend in the Indian microbiology research.

Bibliometric techniques are very important tools for analyzing research performance. Citation analysis constitutes an important tool in quantitative studies of science and technology. To assess the quality of a given publication, the number of times it has been cited in the literature can be counted. Findings of the study are likely to be of some help in formulating policies regarding interlay budget allocation for different categories of bibliographic forms and subscription of periodicals.

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