DESIDOC Journal of Library & Information Technology, Vol. 28, No. 6, November 2008, pp. 11-20
© 2008, DESIDOC

Bibliometric Analysis of Research Output of Biotechnology Faculties in Some Indian Central Universities

R. Sevukan and Jaideep Sharma

Faculty of Library and Information Science,
Indira Gandhi National Open University, New Delhi -110 068
E-mail: sevukan2002@yahoo.com; j_sharma2002@yahoo.com

ABSTRACT

The study presents a detailed analysis of research performance of biotechnology faculties in central universities of India from 1997-2006. The data used for the study were retrieved from two database sources, namely, PubMed, NCBI (National Centre for Biotechnology Information); and ISI *Web of Science* database—Science Citation Index Expanded (SCIE). Bibliometric techniques have been employed to analyse the data. The results indicate that the growth of literature in biotechnology has steadily increased from 15 articles in 1997 to 43 articles in 2006; two-authored publications predominate amongst the pattern of authorship; applicability of Lotka's law is validated from the values n = 2.12, C = 0.669, and D = 0.027 obtained using least square method. However, the application of Bradford's law does not fit to the literature analysed.

Keywords: Bibliometrics, biotechnology, biotechnology faculties, Universities, India, Lotka's law, Bradford's law

1. INTRODUCTION

During the last two decades, biotechnology, as one of the important disciplines of life sciences, is being offered and gaining momentum among higher educational institutions, viz., universities, colleges of science and engineering, research institutes, etc. in India. The development of biotechnology is making visible impact in varied areas such as biology, medicine, agriculture, and environment[1]. According to Confederation of Indian Industry (CII) estimates[2], India produces roughly 2.5 million graduates in information technology, engineering and life sciences, 650,000 post graduates and nearly 1500 PhDs in biosciences and engineering each year. Qualitative research provides a pedestal to any university. It speaks of the fertile minds and an environment of intellectual interaction in the university[3].

India, with a population of more than a billion, has a huge market for biotechnology products and services. Hence, Indian situation demands R&D in biotechnology. The Indian subcontinent, which occupies only 2.4 per cent of the total global surface area, has the most varied species of flora and fauna. India has about 7.6 per cent of total mammal species, 12.6 per cent of bird species, 11.7 per cent of fishes, and roughly 6 per cent of total flowering plants that are present in the world[3]. Patra and Chand[4] summarised the growth of biotechnology literature from 1 article in 1982 to more than 300 articles in 2003. They have also stated that there is a growth in R&D output over the years, but for the period of 22 years, both the number of manpower devoted to it and the number of institutions, it looks low.

Arunachalam[5,6] clarifies that universities are still in the lead in contributing biotechnology publications. He also specified that the reason for greater volume of work at the higher educational institutes, compared to better endowed national laboratories, is the presence of a large number of doctoral students.

Received 12 May 2008

Keeping in view the above, an attempt has been made to analyse the research performance of faculties of biotechnology in 20 Indian central universities. Bibliometric techniques have been employed to conduct the research as it is especially useful when studying a research-intensive subject field such as biotechnology where the industry is likely to have close relations with public research organisations (e.g., universities). As far as the number of universities is concerned, India has prospered starting with 28 universities in 1950–51 to 350 universities[7] of different kinds—central, state, open, deemed, and so on—registering a manifold increase. Growth in numbers is expected to cater to the increasing number of students.

At the same time, it is important to assess the performance of faculty in terms of research contribution in their respective fields of study. Present study aims to ascertain the growth of literature; sources of publications; identification of prolific authors; institutions, core journals and related impact factor, etc. in the field of biotechnology by faculty in central universities of India for the period 1997–2006. Applicability of Lotka's law and Bradford's law has also been tested.

2. DATA SOURCE AND METHODOLOGY

The data for the present study was retrieved from two sources namely, NCBI (National Centre for Biotechnology Information) PubMed; and *ISI Web of Science* database– *Science Citation Index Expanded* (SCIE). PubMed is the NLM's (National Library of Medicine, USA) premier online bibliographic database which is freely accessible, and covers the subject fields such as medicine, nursing, dentistry, veterinary medicine, health care system and the preclinical sciences. *Web of Science* is a product of ISI that provides access to current and retrospective multidisciplinary information from approximately 8500 research journals all over the world. The search strategy used for collecting data for Aligarh Muslim university was as follows: "Topic=Biotechnology OR Biotech*; DocType=All Documents; Time Span=1997-2006; Institution or University=Aligarh Muslim Univ". The same strategy was used to collect data for 10 other universities only by changing name of the university.

A total of 345 records were retrieved from PubMed and SCIE. From the total records collected, 16 records were found duplicate and were eliminated. Finally, a total of 329 unique records of various types, viz., articles (303), reviews (18), correction (4), letters (3), and editorial material (1) was considered for analysis. MS–Excel Spreadsheet and MS–Word were used to analyse the final data collected in order to generate tables, charts, graphs, etc.

3. LIMITATIONS OF THE STUDY

Though there are 20 central universities in India, the present study is confined to only 10 universities (Table 1) as there were no records found from the databases for other universities. The literature analysed were published during a period of 10 years from 1997–2006. Data collection was limited to two empirical databases namely PubMed and ISI *Web of Science*– SCIE which are more comprehensive and widely used for conducting research.

4. BIBLIOMETRIC INDICATORS

Some of the bibliometric models and indicators employed for the study to analyse the collected data, based on PubMed and SCIE were:

4.1 Collaborative Coefficient

Collaborative coefficient (CC), suggested by Ajiferuke[8] and used by Karki and Garg[9] has been used to measure the extent and strength of collaboration among the faculties of biotechnology in central universities of India. It can be expressed mathematically as:

$$CC = 1 - \sum_{j=1}^{j=k} (1/J) f_j / N \qquad (1)$$

where f_j is the number of *J* authored papers published in a discipline during a certain period of time

N is the total number of research papers published in a discipline during a certain period of time and

k is the greatest number of authors per paper in a discipline.

4.2 Lotka's Law

Lotka's law is a classical method used to test the regularity in the publication activity of authors of scientific literature. It describes the frequency of publication by authors in a given field. It states that the number of authors making *n* contributions is about $1/n^2$ of those making one; and the proportion of all contributors that make a single contribution is in the region of 60 per cent. This means that out of all the authors in a given field, 60 per cent will have just one publication; 15 percent will have two publications ($1/2^2$ times 60); 7 per cent will have three publications ($1/3^2$ times 60), and so on[10-13]. This law can be expressed as:

$$y = C \times x^{-n} \quad (2)$$

where *x* is the number of publications of interest (1,2, etc.); *n* is an exponent that is constant for a given set of data; *y* is the expected percentage of authors with frequency *x* of publications, and *C* is a constant

The productivity corresponds not to the number of articles published by an author but to its logarithm; it seems that a multiplicative, rather than simply additive, model provides a better fit to this measure or counting method.

The exponent *n* is often fixed at 2, in which case the law is known as the *inverse square law of scientific productivity.* However, given that the exponent *n* predicts the relative number of authors at each productivity level it would seem useful to calculate it. In the present study, least square method has been used. It can be expressed as:

$$n = \frac{N\sum XY - \sum X \sum Y}{N\sum X^2 - (\sum X)^2} \quad (3)$$

where *N* is the number of data pairs considered

X is the logarithm of *x* (*x*=number of articles) and

Y is the logarithm of *y* (*y*=number of authors)

The constant *C* is calculated using the formula:

$$C = \frac{1}{\sum 1/x^n} \quad (4)$$

To verify that the observed distribution of author productivity fits the estimated distribution, Pao (1985) suggested applying the non-parametric Kolmolgorov-Smirnov (K-S) goodness-of-fit test. To this end, the maximum difference between the real and estimated accumulated frequencies was calculated, and this value was then compared with the critical value (c.v.) obtained from the following equation:

$$c.v. = \frac{1.63}{\left(\sum y_X + (\sum y_X / 10)^{1/2}\right)^{1/2}} \quad (5)$$

4.3 Bradford's Law

To identify the core journals of a particular discipline, Bradford's law[14] has been tested. This law describes studying the extent to which literature in a particular discipline is scattered over a range of journals. It states that "if scientific journals are arranged in order of decreasing productivity on a given subject, they may be divided into a nucleus of journals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus when the number of periodicals in the nucleus and the succeeding zones will be as *1:n:n²…".* In addition to the above bibliometric methods, some common statistical tools such as Mean, Standard Deviation and Coefficient of Variance have also been used.

5. RESULTS AND DISCUSSION

5.1 Central Universities

Out of the 20 central universities in India data from only 10 universities were available, therefore, rest of the universities were not considered for the study. Table 1 gives the list of universities considered for the present study.

5.2 Growth of Literature

Table 2 depicts the year-wise distribution of total research output of central universities in India in biotechnology. It is observed that the output of 10 central universities has grown steadily during the period of study from 16 in 1997 to 46 in 2006. However, there was a sudden increase in the output in the years 1998, 2002 and 2006 producing 31, 45 and 46 records, respectively while a decreasing trend was observed in the years 2000 and 2004.

5.3 Type of Publications

Biotechnology literature in India has been published in different types of publications. The majority of the literature has been published in journals. Table 3

Table 1. List of central universities in India considered for the study

Name of the University	Abbreviation
Babasaheb Bhimrao Ambedkar University, Agra	BBAU
Aligarh Muslim University, Aligarh, Uttar Pradesh	AMU
Banaras Hindu University, Varanasi, Uttar Pradesh	BHU
Jamia Millia Islamia, New Delhi	JMI
Jawaharlal Nehru University, New Delhi	JNU
Nagaland University, Nagaland	NU
Pondicherry University, Pondicherry	PU
Tezpur University, Assam	TU
University of Delhi, Delhi	DU
Visva Bharati Santiniketan, West Bengal	VBS

Table 2. Year-wise distribution of biotechnology literature during 1997-2006

Year	Output	Per cent	Cum. per cent
1997	16	4.86	4.86
1998	31	9.42	14.28
1999	31	9.42	23.70
2000	26	7.90	31.61
2001	29	8.81	40.42
2002	45	13.68	54.10
2003	35	10.64	64.74
2004	34	10.33	75.07
2005	36	10.94	86.02
2006	46	13.98	**100.00**
Total	**329**	**100.00**	

shows that journal articles form the majority of the literature output (92.10 per cent) followed the reviews 5.47 per cent, corrections 1.22 per cent, letters 0.91 per cent, and editorial material 0.30 per cent. It is observed that the articles being a prominent source constantly increased during the period of study except for the years 2000 and 2003.

5.4 University-wise Performance

Table 4 summarises year-wise performance of central universities in relation to their contribution in biotechnology research during the period 1997–2006. BHU that contributed 42.55 per cent is placed first. The level of variation in research output is 36.42 per cent which is the least amongst all the universities. The lowest coefficient of variance, in case of BHU, speaks of the consistent performance of its Faculties throughout the period of study.

The share of JNU comes to 25.53 per cent of the total research output of Indian universities during the period of study. It is placed second in order. Encouraging performance is noted in the years 1998, 1999, 2002, and 2004, which amounted to more than 50 per cent of output, and resulted in 47.69 per cent of year-wise variation in biotechnology research output. AMU ranks third in order contributing 15.50 per cent of contribution. Year-wise analysis indicates 70.67 per cent of variation in the output performance.

The Faculty in PU contributed 7.60 per cent of the literature of the total biotechnology research output and is placed fourth. The year-wise variation is 110.35 per cent in the level of research output by this university during the period of study. This variation is mainly due to zero output in the years 1997-2000 and less output in the years 2003 and 2006.

VBS, DU, and TU occupied the next three positions contributing 3.34 per cent, 2.43 per cent and 1.82 per cent, respectively. The year-wise variation in the performance output of such universities is 100.05 per cent, 129.10 per cent and 140.55 per cent, respectively. A high level of variation of these universities speaks of the poor performance of research in biotechnology during the period of study.

The contribution of remaining three universities namely JMI, NU, and BBAU was less than one per cent of total research output. The share of JMI is 0.61 per cent while NU and BBAU got only 0.30 per cent each.

From the above analysis, it can be deduced that BHU shares 42.55 per cent of total biotechnology research output over the period of study. The other ranked universities are JNU 25.53 per cent, AMU 15.50 per cent, and PU 7.60 per cent, respectively. NU, and BBAU share the last position of research productivity. Highest level of variation 316.23 is found in NU and BBAU.

5.5 Authorship Pattern

It is a well known fact that nowadays, research is carried out by group of researchers rather than by a single researcher. Therefore, the data were analysed to know the authorship pattern in biotechnology. Through collaboration, researchers share and exchange knowledge and techniques, that bring in a mixture of positive scientific thoughts and decrease cost at the same time.[15] Bibliometricians have paid due attention to these phenomena ever since. Intensifying

Table 3. Source-wise distribution of Biotechnology literature during 1997–2006

Source/Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total	Per cent
Article	15	30	28	24	27	44	30	31	31	43	303	**92.10**
Review	1		2	2	1		4	3	3	2	18	**5.47**
Corrections			1		1	1			1		4	**1.22**
Letter		1							1	1	3	**0.91**
Editorial material							1				1	**0.30**
Total	**16**	**31**	**31**	**26**	**29**	**45**	**35**	**34**	**36**	**46**	**329**	**100**

Table 4. University-wise distribution of biotechnology literature during 1997-2006

Univ/ Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total	Per cent	SD	Mean	CV
BHU	7	14	16	17	15	17	13	8	9	24	140	42.55	5.10	14.00	36.42
JNU	3	13	11	3	5	11	6	14	10	8	84	25.53	4.01	8.40	47.69
AMU	3	1	2	5	3	8	12	2	6	9	51	15.50	3.60	5.10	70.67
PU	0	0	0	0	5	4	1	7	6	2	25	7.60	2.76	2.50	110.35
VBS	1	1	2	0	0	2	0	0	2	3	11	3.34	1.10	1.10	100.05
DU	0	0	0	0	1	1	3	2	1	0	8	2.43	1.03	0.80	129.10
TU	2	2	0	1	0	0	0	0	1	0	6	1.82	0.84	0.60	140.55
JMI	0	0	0	0	0	0	0	1	1	0	2	0.61	0.42	0.20	210.82
BBAU	0	0	0	0	0	1	0	0	0	0	1	0.30	0.32	0.10	316.23
NU	0	0	0	0	0	1	0	0	0	0	1	0.30	0.32	0.10	316.23
Total	**16**	**31**	**31**	**26**	**29**	**45**	**35**	**34**	**36**	**46**	**329**	**100.00**	**8.75**	**32.90**	**26.59**

SD=Standard Deviation CV=Coefficient of Variance

Table 5. Distribution of authorship pattern

Authorship pattern	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total	%
1	2	---	---	1	---	---	1	1	---	---	5	1.52
2	6	11	11	10	9	17	12	8	5	22	111	33.74
3	4	7	7	5	11	9	8	4	17	10	82	24.92
4	3	8	7	7	3	11	5	9	7	3	63	19.15
5	1	5	3	---	4	6	6	7	3	3	38	11.55
6	---	---	3	1	---	2	2	4	2	3	17	5.17
7	---	---	---	1	---	---	1	---	2	3	7	2.13
8	---	---	---	---	---	---	---	---	---	1	1	0.30
9	---	---	---	1	2	---	---	---	---	1	4	1.22
>10	---	---	---	---	---	---	---	1	---	---	1	0.30
Total	**16**	**31**	**31**	**26**	**29**	**45**	**35**	**34**	**36**	**46**	**329**	100.00
***CC**	**0.54**	**0.65**	**0.66**	**0.62**	**0.66**	**0.65**	**0.64**	**0.68**	**0.69**	**0.63**	**0.65**	

** Collaboration coefficient*

co-author relationship has been reported for all fields and at practically all levels of aggregations, for instance, by Glanzel[16] for the macro level, by Gomez[17] for the meso level, and Ding[18] and Glanzel[19] for the micro level. As a result, multi-authorship necessarily increases productivity and always results in high citation impact[20].

In the light of the above fact, an attempt has been made to identify the nature of authorship pattern in scientific research output made by the Faculties of Biotechnology in central universities of India. It is evident from Table 5 that two-authored papers rank first in order sharing 33.73 per cent of the total research output. The year-wise analysis shows that the performance of two-authored papers has been increasing in almost all the years except for 2000 and 2004. The three-authored papers follow second in order taking 24.92 per cent of the total research contributions followed by four- five- and six-authored contributions sharing 19.15 per cent, 11.55 per cent, and 5.17 per cent of the total scientific research output during the study period, respectively. It is interesting to note that single-authored papers occupy seventh position in order totaling five contributions which represent only 1.53 per cent while seven-, eight-, nine-, and ten- or more authored contributions record 2.13 per cent, 0.30 per cent, 1.22 per cent and 0.30 per cent, respectively.

Based on the data presented in Table 5, the CC using Eqn. (1) was calculated. The calculated value of CC (last row of Table 5) for the study period does not vary much for different years. The value of CC is lowest (0.54) for 1997 and highest (0.69) for 2005. This indicates that the biotechnology research among faculties of central universities in India is fairly collaborative.

5.6 Author Productivity

A total of 329 records of biotechnology literature of Indian central universities retrieved from PubMed and SCIE for 1997–2006 have been published by

Table 6. Distribution of author productivity

No. of articles	No. of authors	Observed per cent
1	409	66.72
2	112	18.27
3	35	5.71
4	19	3.10
5	11	1.79
6	8	1.31
7	6	0.98
8	1	0.16
9	1	0.16
11	2	0.33
12	4	0.65
13	3	0.49
14	1	0.16
21	1	0.16
Total	**613**	**100.00**

613 authors. The ratio of the number of authors to articles is about 1.86. It is very interesting to observe from Table 6 that 409 authors, which accounts for 66.72 published only one article whereas only 11 authors contributed more than 10 articles (1.79 per cent).

To validate the Lotka's law, a calculation was done using Eqns (2-5), (Table 7), to know the values of *n* and *C* to test whether application of Lotka's law fits the data or not. Thus, based on the data presented in Table 6, the calculated values of *n* and *C* are 2.12 and 0.669, respectively.

The critical value is 0.065 and the value of maximum difference (D) between the real and estimated accumulated frequencies is 0.027, which is less than the critical value 0.065. This resulted in fitting the application of Lotka's law to the data of biotechnology literature.

Table 8 depicts prolific authors who have produced more than five articles in biotechnology during the period of study. The findings of distribution of authors in terms of their number of contributions reveal the fact that R.Prasad from Jawaharlal Nehru University is in the First place with 21 different publications in biotechnology. The second place is taken by A.K.Tripathi from Banaras Hindu University, Varanasi with 14 publications; the third place is to three authors from Banaras Hindu University, namely A.Kumar, L.C.Rai and S.A. Abbasi , with 13 articles each; and so on. On an average, the high percentage of publication by individuals is given by BHU (120 articles) followed by JNU (57), PU (42), and AMU (25). Only one researcher of BBAU (7) takes the last place among the individual researchers who have produced more than five articles.

5.7 Identification of Core Journals

The literature in biotechnology covered in the present study (1997–2006) comprises a total of 303 articles published in 75 journals (Table 9). It is found that 33 journals published only one article each, 11 journals published two articles each, 6 journals published 3 articles each, 5 journals published 4 articles each and the rest of 20 journals published more than 5 articles each. Table 9 shows that 4 journals (3.28 per cent) published maximum segment of information with 32.01 percent of articles while the second larger group of 16 journals (21.33 percent) provided the next equal of 33.33 per cent articles.

The third largest of 55 (73.33 per cent) journals published the next 113 articles (37.29 per cent). According to Bradford's Law of distribution the relationship between the zones is $1:n:n^2$ (i.e. 1:5:25). But the relationship between the zones in the present study is contradictory in each as 4:16:55 which does not fit into Bradford's distribution. It is concluded that core distribution of articles were published by a very few journals. Based on the data presented in Table 9, the cumulative number of articles was plotted against the logarithm of ranking of journals according to Bradford's plot (Fig. 1).

The result reveals that the core journals are those whose points lie on the initial curved part of the 'S' until it tangentially becomes a straight line. As can be seen from Fig. 1, the slope of the curve decreases slightly after the fourth journal, so it appears that the top four journals (Table 10) are well in their way to form a core.

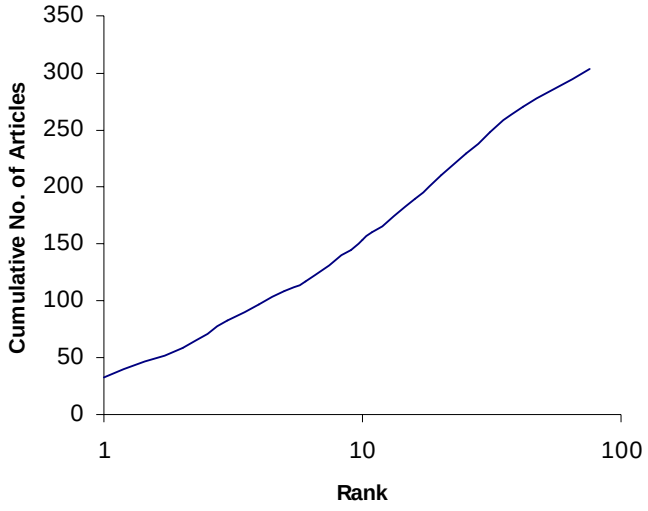

Figure 1. Bradford's scatter plot.

Table 7. Application of Lotka's Law using LLS method

x	y	X	Y	$_X2$	XY	$y_X / \Sigma y_X$	$\Sigma(y_X / \Sigma y_X)$	$_{1/x}n$	$f_e = C(1/x^n)$*	Σfe	D
1	409	0	2.612	0	0	0.667	0.667	1	0.669	0.669	0.002
2	112	0.301	2.049	0.091	0.617	0.183	0.850	0.230	0.154	0.823	**0.027**
3	35	0.477	1.544	0.228	0.737	0.057	0.907	0.097	0.065	0.888	0.019
4	19	0.602	1.279	0.362	0.770	0.031	0.938	0.053	0.035	0.923	0.014
5	11	0.699	1.041	0.489	0.728	0.018	0.956	0.033	0.022	0.946	0.010
6	8	0.778	0.903	0.606	0.703	0.013	0.969	0.022	0.015	0.961	0.008
7	6	0.845	0.778	0.714	0.658	0.010	0.979	0.016	0.011	0.971	0.007
8	1	0.903	0.000	0.816	0.000	0.002	0.980	0.012	0.008	0.979	0.001
9	1	0.954	0.000	0.911	0.000	0.002	0.982	0.009	0.006	0.986	0.004
11	2	1.041	0.301	1.084	0.313	0.003	0.985	0.006	0.004	0.990	0.005
12	4	1.079	0.602	1.165	0.650	0.007	0.992	0.005	0.003	0.993	0.002
13	3	1.114	0.477	1.241	0.531	0.005	0.997	0.004	0.003	0.996	0.000
14	1	1.146	0.000	1.314	0.000	0.002	0.998	0.004	0.002	0.999	0.001
21	1	1.322	0.000	1.748	0.000	0.002	1.000	0.002	0.001	1.000	0.000
Total	613	11.263	11.587	10.767	5.706	1	13.198	1.495			

** n=2.12, C=0.669, D=0.027*

Table 8. Prolific authors producing more than five articles

Name	No. of contributions	Affiliation address
Prasad, R	21	Jawaharlal Nehru University, School of Life Sciences, New Delhi-110 067
Tripathi, AK	14	Banaras Hindu University, School of Biotechnology, Varanasi 221005, Uttar Pradesh
Singh, SP	13	Banaras Hindu University, Centre for Advanced Study of Botany, Varanasi 221005, Uttar Pradesh
Kumar, A	13	Banaras Hindu University, School of Biotechnology, Varanasi 221005, Uttar Pradesh
Rai, LC	13	Banaras Hindu University, Dept of Botany, Varanasi 221005, Uttar Pradesh
Abbasi, SA	12	Pondicherry University, Ctr Pollut Control & Energy Technol, Pondicherry 605014
Gajalakshmi, S	12	Pondicherry University, Ctr Pollut Control & Energy Technol, Pondicherry 605014
Malik, A	12	Aligarh Muslim University, Dept Agr Microbiol, Aligarh 202002, Uttar Pradesh
Singh, UP	12	Banaras Hindu University, Dept Mycol & Plant Pathol, Varanasi 221005 Uttar Pradesh
Mukherjee, KJ	11	Jawaharlal Nehru University, Ctr Biotechnol, New Delhi 110067
Sakthivel, N	11	Pondicherry University, Dept Biotechnol, Pondicherry 605014
Asthana, RK	9	Banaras Hindu University, Ctr Adv Study Bot, Varanasi-221 005, Uttar Pradesh
Sarma, BK	8	Banaras Hindu University, Ctr Adv Study Bot, Varanasi-221 005, Uttar Pradesh
Kumar, HD	7	Jawaharlal Nehru University, Sch Life Sci, New Delhi-110 067
Ahmad, I	7	Aligarh Muslim University, Dept Agr Microbiol, Aligarh-202 002, Uttar Pradesh
Ramasamy, EV	7	Pondicherry University, Ctr Pollut Control & Energy Technol, Pondicherry-605 014
Singh, DP	7	Babasaheb Bhimrao Ambedkar University, Sch Environm Sci, Lucknow-226 025, Uttar Pradesh
Singh, RK	7	Banaras Hindu University, Inst Agr Sci, Varanasi 221005, Uttar Pradesh
Verma, SC	7	Banaras Hindu University, Sch Biotechnol, Varanasi-221 005, Uttar Pradesh
Pandey, VB	6	Banaras Hindu University, Dept Mycol & Plant Pathol, Varanasi-221 005, Uttar Pradesh
Saleemuddin, M	6	Aligarh Muslim University, Fac Life Sci, Aligarh-202 002, Uttar Pradesh
Banik, RM	6	Banaras Hindu University, Inst Technol, Sch Biochem Engn, Varanasi-221 005, Uttar Pradesh
Bhatnagar, R	6	Jawaharlal Nehru University, Ctr Biotechnol, New Delhi-110 067
Gupta, JC	6	Jawaharlal Nehru University, Ctr Biotechnol, New Delhi-110 067
Kayastha, AM	6	Banaras Hindu University, Sch Biotechnol, Varanasi-221 005, Uttar Pradesh
Rai, AK	6	Banaras Hindu University, Dept Bot, Varanasi-221 005, Uttar Pradesh
Singh, A	6	Jawaharlal Nehru University, Ctr Biotechnol, New Delhi-110 067

Table 9. Distribution of journals according to Bradford

No. of journals	No. of articles	Total No. of articles	Rank	Cumulative No. of articles	Bradford zones
1	33	33	1	33	**Zone – 1**
1	25	25	2	58	
1	24	24	3	82	
1	15	15	4	97	
1	11	11	5	108	**Zone – 2**
1	10	10	6	118	
3	9	27	9	145	
1	8	8	10	153	
1	7	7	11	160	
5	6	30	16	190	
4	5	20	20	210	
5	4	20	25	230	**Zone – 3**
6	3	18	31	248	
11	2	22	42	270	
33	1	33	75	303	

Table 10. Ranking of journals in biotechnology

Name of the journal	No. of articles	Impact Factor from JCR 2005
World Journal of Microbiology & Biotechnology	42	0.634
Bioresource Technology	25	1.863
Current Microbiology	24	1.059
Fems Microbiology Letters	16	2.057
Folia Microbiologica	11	0.918
Journal of Microbiology and Biotechnology	11	1.744
Microbiological Research	10	0.862
Applied Microbiology and Biotechnology	9	2.586
Mutation Research-Genetic Toxicology and Environmental Mutagenesis	9	2.188
Biotechnology Letters	8	1.108
Applied and Environmental Microbiology	7	3.818
Antimicrobial Agents and Chemotherapy	6	4.379
Journal of Antimicrobial Chemotherapy	6	3.886
Journal of Applied Microbiology	6	2.127
Journal of Basic Microbiology	6	1.000
Enzyme and Microbial Technology	5	1.705
Mutation Research-Fundamental and Molecular Mechanisms of Mutagenesis	5	3.340
Plant Cell Tissue and Organ Culture	5	1.113
5 journals with 4 articles each	20	2.0114*
6 journals with 3 articles each	18	2.4915*
11 journals with 2 articles each	22	2.2893*
32 journals with 1 article each	32	1.4842*

* *Average Impact Factor*

5.8 Country-wise Distribution of Journals

Country-wise distribution of journals and research output of literature in biotechnology. Table 11 shows the contributions of faculties in central universities, both in Indian and International sources of publications. It can be observed that the faculties of central universities have made 303 contributions published in 75 journals. These journals are published from 16 different countries.

It is obvious that the researchers in central universities of India have preferred to publish their research articles in international journals especially from the Netherlands. It includes 29.04 percent of publications over the study period. US ranks second in order with 28.71 per cent followed by England (20.46 per cent), Germany (6.60 per cent), Czech Republic (3.96 per cent), and Korea (2.64 per cent). The contribution in journals of Singapore and Switzerland is less than 2 per cent whereas countries like Japan, Canada, France, Israel, Italy, Croatia, India, and Poland yield less than 1 per cent. The result shows that the researchers of biotechnology in central universities of India opt for international sources to get international recognition, international standard, and international collaboration. Almost two-third of the articles was published in journals published from the Netherlands and US. In contrast, only 0.33 per cent was published from Indian journals.

6. CONCLUSION

Biotechnology is a relatively new field of study having originated two decades back. Patra and Chand report that only one article was published in biotechnology in 1982 that grew to more than 300 articles in 2003. A large number of researchers is pursuing their research in the field, giving hope that more literature would be published on the subject from universities.

The contribution to the literature on the subject fromthe universities has been steadily growing. It was 15 articles in 1997 and 43 in 2006. BHU is leading from the front with 42.55 per cent contribution. It also leads with the most consistent performance amongst all the universities. JNU comes next followed by AMU. There is a trend towards collaborative research with two-authored papers being maximum followed by three-authored papers. When the author productivity was calculated it was found that 66.72 per cent authors contribute one article and that 11 authors (1.79 per cent) contribute more than 10 articles. Lotka's law was tested and found to fit the data. The credit of publishing the maximum number of articles (21) goes to R.Prasad of JNU followed by A.K.Tripathi of BHU who contributed 14 articles. The data does not fit into Bradford's law regarding the core journals. The articles contributed by the Faculties appeared in journals published from 16 different countries with a maximum from the Netherlands followed by US. Only 0.32 per cent articles were published from India.

REFERENCES

1. Mani, Sunil. Institutional support for investment in domestic technologies: An analysis of the

Table 11. Country-wise distribution of biotechnology related journals

Country	No. of journals	% of journal	Cum. No. of journals	No. of articles	% of articles	Cum. No. of articles
Netherlands	13	17.33	13	88	29.04	88
USA	22	29.33	35	87	28.71	175
England	18	24.00	53	62	20.46	237
Germany	4	5.33	57	20	6.60	257
Czech Republic	1	1.33	58	12	3.96	269
Korea	4	5.33	62	8	2.64	277
Singapore	1	1.33	63	6	1.98	283
Switzerland	2	2.67	65	5	1.65	288
Japan	2	2.67	67	4	1.32	292
Canada	1	1.33	68	2	0.66	294
France	1	1.33	69	2	0.66	296
Israel	1	1.33	70	2	0.66	298
Italy	2	2.67	72	2	0.66	300
Croatia	1	1.33	73	1	0.33	301
India	1	1.33	74	1	0.33	302
Poland	1	1.33	75	1	0.33	303
Total	**75**	**100.00**		**303**	**100.00**	

role of government of India. *Technol. Forecasting Social Change*, 2004, **71**, 855-63.

2. Biotechnology in India: A promising future. *India Economic News XII*, 2002-2003, **Winter**, 1-4.

3. Sevukan, R. *et al*. Research performance in biochemistry and molecular biology of faculty in central universities of India, 1997-2006: A bibliometric analysis. *Lib. Progress Intern.*, 2007, **27**(1), 1-9.

4. Patra, S. & Chand, P. Biotechnology research profile of India. *Scientometrics*, 2005, **63**(3), 583-97.

5. Arunachalam, S. Mapping life science research in India: A profile based on BIOSIS 1992-1994. *Current Science*, 1999, **76**, 1191-1203.

6. Arunachalam, S. Mathematics research in India today: What does the literature reveal? *Scientometrics*, 2001, **52**, 235-59.

7. Powar, K.S. & Panda, S.K. Higher education in India. Association of Indian Universities, 1995, 17-36.

8. Ajiferuke, I; Burrel, Q. & Taque, J. Collaborative coefficient: A single measure of the degree of collaboration in research. *Scientometrics*, 1988, **14**(5-6), 421.

9. Karki, M.M.S. & Garg, K.C. Bibliometrics of alkaloid chemistry research in India. *J. Chem. Inf. Comput. Sci.* 1997, **37**, 157-61.

10. Rowlands, Ian. Emerald authorship data, Lotka's law and research productivity. *Aslib Proceedings: New Inf. Perspectives*, 2005, **57**(1), 5-10.

11. Yueh, Ming; Jou, Shiow-Jem & Ma, Sheau-Shin. Bibliometric study of semiconductor literature, 1978-1997. *Scientometrics*, 2000, **49**, 491-509.

12. Kawamura, M. *et al.* Lotka's law and the pattern of scientific productivity in the dental science literature. *Medical Informatics and the Internet in Medicine*, 1999, 24 (4), 309-15.

13. Lotka, A. J. The frequency distribution of scientific productivity. *Journal of the Washington Academy of Science,* 1926, **16,** 317-23.

14. Brookes, B.C. Bradford's law and the bibliography of science. *Nature*, 1969, 224, 953-56.

15. Katz, J.S. & Martin, B.R. What is research collaboration? *Research Policy*, 1997, **26**(1), 1-18.

16. Glanzel, W. National characteristics in international scientific co-authorship. *Scientometrics*, 2001, **51**(1), 69-115.

17. Gomez, I; Fernandez, M.T. & Mendez, A. Collaboration patterns of Spanish scientific publications in different research areas and disciplines. *In* Biennial Conference of the International Society for Scientometrics and Informetrics, edited by M.E.D. Koeing and A.Bookstein, 187-96.

18. Ding, Y.; Foo, S. & Choudhury, G. A bibliometric analysis of collaboration in the field of information retrieval. *Internat. Inf. Lib. Rev.*, 1999, **30,** 367-76.

19. Glanzel, W. Co-authorship patterns and trends in the sciences (1980-1998): A bibliometric study with implications for database indexing and search strategies. *Library Trends*, 2002, **50**(3), 461-73.

20. Glanzel, Wolfgang. Collaborate or collapse, co-authorship at any price? Invited Plenary Talk. *In* Proceedings of Third International Conference on Webometrics, Informetrics, Scientometrics, edited by Divya Srivastava, Ramesh Kundra and Hildrun Kretshmer, 2007, pp.3.

About the Authors

Dr R. Sevukan is Lecturer in the Faculty of LIS, Indira Gandhi National Open University, New Delhi. He obtained his PhD in the area of Bibliometrics. His areas of interest are library automation, networking, and digitisation. He has contributed to the course material of the various Universities on library automation.

Dr Jaideep Sharma is Reader in the Faculty of LIS, Indira Gandhi National Open University, New Delhi. Earlier he taught at the Department of Library and Information Science, Kurukshetra University, Haryana. He obtained his PhD in Professional Competencies of LIS Professionals and LIS Education in India.